ESSAYS ON FIRMS INNOVATION, INTERNATIONALIZATION AND TRADE POLICY

by

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Abstract

The development of information technologies and the reduction of trade barriers have fostered the international fragmentation of production and the expansion of knowledge networks. Globalization has stimulated an unprecedented economic growth across the globe, shifting the balance in the world economy, with a decline of developed countries and the rise of emerging economies. The response of firms in mature economies to global competition is an increased engagement in internationalization and innovation strategies. In this thesis we investigate first how trade protectionism might not be an efficient instrument to prevent the negative effects of international competition, finding mixed effect of EU anti-dumping measures on Chinese products, with temporary benefit for domestic producers, but a negative impact on importers and long-run perverse effect on productivity. Second, we analyse the role of innovation in fostering the international performance of firms. Our results show that R&D investment, innovation and outsourced R&D improve the export performance of European firms, exporting more products and accessing new and more difficult foreign markets. Only by investing in innovation European firms will be able to positively internalise the externalities linked to globalization, increasing human capital and the stock of knowledge, boosting productivity and creating new value-added jobs.

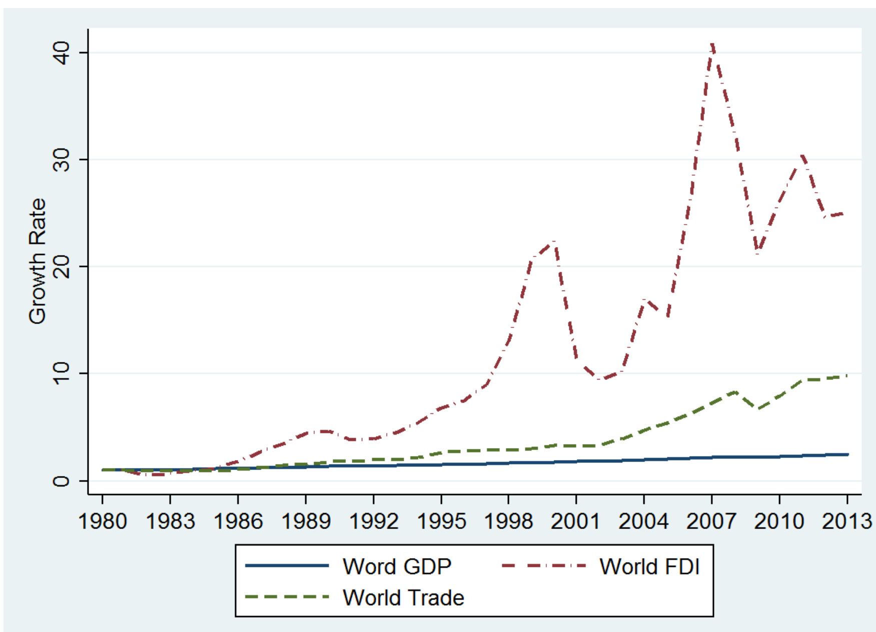
Introduction

Since the end of World War II, and especially in the last two decades, both developed and developing countries have experienced increasing flows of international trade and capital and, to a smaller extent, population migration and cultural interconnections. In particular, the development of new information technologies (IT) and the reduction of distance and cultural barriers have not only fostered the international fragmentation of production, but have contributed to the expansion of complex networks of goods, services and knowledge transactions. As shown in Figure 1, global trade in goods and capital flows have grown faster than global income since 1980, also thanks to the key role played by the GATT, and its successor the WTO, which have successfully integrated the world economy now including more than 160 countries representing 96.4% of global trade.

However, although globalization has stimulated an unprecedented economic growth across the globe by creating jobs, reducing prices and decreasing the income gap between developed and developing countries, the same phenomenon, and especially international trade, has also brought economic, political, and social disruption in different regions. The recent global economic crisis of 2008 has shown how local country-specific economic recessions could rapidly spread around the world given the interconnection of the global economy, with devastating effects in terms of trade reduction, jobs and businesses destruction.

However, the consequences of the 2008 economic crisis have not been evenly distributed globally, highlighting the presence of asymmetric shocks affecting differently the participants in the global market. For instance, even though global trade flows collapsed by almost 20% in 2009, the volume of both imports and exports in most developing countries exceeded their pre-crisis peak after a few years, with East-Asia, and China in particular, leading this expansion. On the contrary, many developed countries, and especially Europe, have experienced serious economic difficulties since 2008 with slow economic growth and declining productivity (UNCTAD 2012).

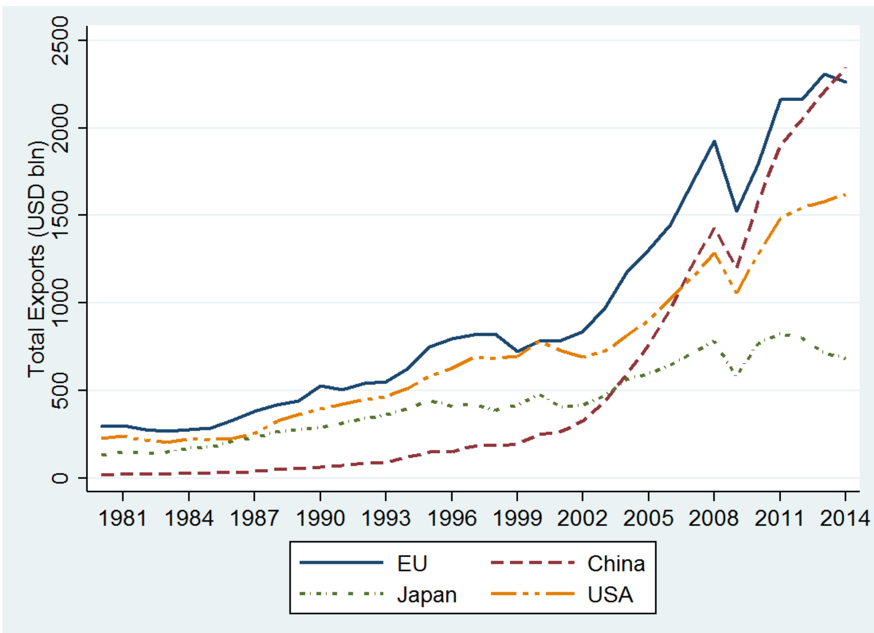
Figure 1: Growth rate of world GDP, international trade and foreign direct investment between 1980 and 2014.



Note: Elaboration based on UNCTAD data between 1980 and 2014.

The global crisis and the uneven trade recovery have reinforced the ongoing shift in balance in the world economy, with a change in the distribution of exports and foreign direct investment (FDI) across countries, a relative decline of developed countries and the rise of developing economies. In 2014 the value of total merchandise exports from all countries of the world was $19 trillion, of which the share of developed countries was only 56% down from 65% in 2005, rapidly eroded by increasingly active developing countries. As shown in Figure 2, this trend has been mainly driven by China, the world largest merchandise exporter in 2014, with a share of world exports jumping in almost 30 years from less than 1% to more than 12% in 2014, outweighing the EU (11%) and ahead of the United States (8%) and Japan (4%) (UNCTAD, 2016).

Figure 2: Total exports of the EU, USA, Japan and China between 1980 and 2014 (USD billion).



Note: Elaboration based on UNCTAD data between 1980 and 2014.

The shift in global balance is also visible in the changing distribution of export destinations, with an increased importance of the "South-South" trade among developing countries, particularly relevant in Asia and linked to the emergence of global supply chains. This phenomenon has been possible thanks to the reduction of international transport and communication costs, the rapid exchange of knowledge and technologies across the world, the lowering of duties and non-tariff barriers to trade and foreign investment and also to the availability of low-cost and highly skilled labour force in developing countries which have allowed a rising proportion of global production of goods and services to be produced globally and traded across borders rather than produced and sold at home (UNCTAD 2012).

However, at a time many developed countries experienced significant economic difficulties, characterised by high level of unemployment, fiscal austerity and complaints of unfair international competition, several economists have stressed the contradictions of globalization, where "the rules of the game have been largely set by the advanced industrial countries - and particularly by special interests within those countries - and, not surprisingly, they have shaped globalization to further their own interests. They have not sought to create a fair set of rules, let alone a set of rules that would promote the well-being of those in the poorest countries of the world" (Stiglitz 2002). After the beginning of the economic crisis the debate about the "globalization race" has become increasingly popular, highlighting in particular the growing pressure experienced by developed countries from the international competition of emerging economies who are able to produce and export quality-goods at lower prices. In fact, corroborating the Heckscher-Ohlin model predictions, we have seen in recent decades a focus of countries' comparative advantages based on the relatively abundant endowments of factors of production, with a re-shaping of industrial organizations especially in developed countries where the low-tech, low-skill sectors have suffered from competitive pressure of low-cost labour force in developing countries, with a consequent loss of jobs due to production lines being shut-down or outsourced abroad. However, the economic and technological development have pushed emerging countries towards the edge of the technological frontier and the high-end of the production function, reducing the productivity gap with developed countries and increasing the competitive pressure by challenging them even in the production of high-tech merchandises and services.

Nevertheless, the response to globalization should not be the recurrence to economic protectionism as predicted by many economists and recently advocated by politicians, affected industries and trade unions. On the contrary, as stressed by Schumpeter, capitalism is by its own nature an evolutionary system which is never static, and has continuously developed thanks to its "fundamental impulse that sets and keeps the capitalist engine in motion [...] the gale of creative destruction which replace in whole or in part inferior innovations across markets and industries, simultaneously creating new products including new business models, and in so doing destroying the lead of the incumbents" (Schumpeter 1942). More specifically, in order to survive and to maximize the benefits related with the competitive globalization race it is "the opening up of new markets, foreign or domestic, and the organizational development [...] the same process of industrial mutation [...] that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in" (Schumpeter 1942).

The implications for the economic development of mature economies is that only countries with a highly-skilled labour force, continuously investing in research and development (R&D) activities and able to access new foreign markets thanks to the incessantly introduction of new innovative products and processes - replacing and destroying the old products and industrial productive processes - will be able to maximize the benefits deriving from globalization and to integrate successfully in the global markets. Thanks to continuous endogenous investment in technology and knowledge, mature economies will be able to fully specialise in high-tech and high-end manufacturing and service industries, positively internalizing the externalities linked to globalization by using in their productive processes intermediate inputs imported from low labour cost countries and then open new outlet markets for the exports of their innovative products.

In this thesis we investigate the previously mentioned predictions for the case of European countries which are a particularly suitable case study given the lively academic and non-academic debate about the consequences of globalisation and free-trade and their role in the amplification of the economic recession, the loss of jobs and the erosion of salaries and welfare state (Strauss-Kahn 2004; Barba Navaretti et al. 2010; Hijzen et al. 2011; Chang et al. 2012; Corcos et al. 2012; Mion and Zhu 2013).

In the first chapter we investigate whether trade protectionism, and in particular anti-dumping (AD) measures, are an efficient instrument to prevent the negative effects of international competition from developing countries. In fact, over the previous few decades, there is an increasing pressure to introduce protectionist measures, especially by developed countries, through the adoption of anti-dumping duties and non-tariff barriers (NTBs) to trade. Although dumping strategies might have a negative effect on international competition, economists and political scientists question to what extent anti-dumping measures are related to "unfair" trade (Zanardi 2006; Evenett and Vermulst 2005; Nelson 2006; Conconi et al. 2015). A lively economic and political literature has analysed anti-dumping policies, both from a theoretical and an empirical standpoint, in order to shed a light on the real effect of these measures on trade flows and on industrial output. Most of the theoretical literature has predicted that anti-dumping policies are for the most part welfare reducing, and cause significant distortions in trade flows, with gains for protected producers which are smaller than the costs in terms of consumers welfare and loss of comparative advantage. It has been proven that the imposition of unsubstantiated AD duties has a negative effect on trade volumes due to externalities associated with trade destruction, diversion and trade deflection. As a consequence, with the disruption of trade flows and the alteration of imported inputs prices, anti-dumping duties affect in turn industrial sectors and individual firms performance both in the domestic and in the trade-partner markets, improving the performance of the least productive firms, and with a reallocation of resources from more to less productive industries.

We provide a comprehensive economic analysis of EU anti-dumping measures on Chinese products, specifically looking at the impact on trade flows and at the contrasting effects of these AD duties on the performance of all the categories of affected firms, including for the first time both domestic producers and importers. We focus on the EU anti-dumping measures imposed on Chinese products both for the increasing role played by China in international trade and for the peculiarity of the EU anti-dumping framework. This is the first study to provide a comprehensive analysis of the effect of AD measures at the product, sector and firm-level, in particular analysing for the first time the different firm-level impact on importers and producers.

Our results suggest that EU anti-dumping measures successfully target Chinese dumped products, pushing for an increase in the level of prices and decreasing imports from China which are in turn substituted by a larger domestic production and by goods imported from other extra-EU countries. Domestic producers are more protected by the unfair dumping competition, experiencing a higher employment growth and a survival probability, but at the cost of a lower productivity. At the same time, a smaller number of importers, but larger in size relatively to domestic producers, are negatively affected by AD measures, forced to divert their imports after the increase of intermediate input prices, and losing productivity with a consequent negative impact on total employment and survival rate. The overall result is a mixed effect of EU anti-dumping measures on Chinese products, definitely bringing a temporary benefit for domestic producers, but with a negative impact on importers and a long-run distorted effect reducing the productivity gap between Chinese and European firms.

In the second and third chapters instead we analyse the impact of R&D and technological development on the performance of firms in developed countries, in particular through the above mentioned process of creative destruction which might allow mature economic systems to create continuously new comparative advantages and to remain competitive in a globalised economy creating new innovative products and opening new foreign markets.

In chapter 2 we analyse the key role played by innovation and technological development in enhancing firms' productivity and trade performance. A substantial literature has established that differences in firm performance are partially explained by the ability of firms to be successful innovators, which further increases productivity and survival rates (Grossman and Helpman 1994a; Eaton and Kortum 2002; Huergo and Jaumandreu 2004; Griffith et al. 2006; Aw et al. 2011; Van Long et al. 2011; Hallak and Sivadasan 2013). Particularly relevant in this regard is the impact of innovation on international trade, and the different ways in which R&D activities affect firm export performance. Identifying the determinants of firm export performance is increasingly relevant to fully understand the trade patterns unobservable at the aggregate level. More recently, the economic performance of new emerging countries underlines the importance of productivity-enhancing activities, such as investment in innovation, as key drivers of firms' ability to successfully compete in international markets, to underpin sustainable economic growth and to create new job opportunities.

In particular, in chapter 2 we investigate the role played by innovation in improving the international trade performance of firms, taking into account different aspects of firms innovation and export strategies. Our main contribution is to decompose the effect of innovation on exports taking into account not only total exports and the probability of being an exporter but also the extensive and intensive margins of trade, such as the average value of firm's shipments, the number of varieties exported and the number of destinations served by each firm. In this way we are able to establish whether innovation activities improve exporters' performance creating new trade links, enriching firms' product mix and opening new export markets, or if they support the intensification of existing flows.

This chapter also assesses the effect of different forms of innovation on export performance, by simultaneously taking into account innovation input and output measures. Measures of R&D output may be more accurate in identifying the connection between innovation and export performance, providing a direct link to connect investment in R&D and the commercial adoption of an innovation. At the same time, by measuring investment in R&D it is possible to evaluate the overall effect of firms' R&D efforts on exports performance, taking into account the possible effect of R&D which do not result in the introduction of new products, processes or patents.

We find that different trade margins respond in different ways to innovation activities. Total investment in R&D has a positive and significant effect across different trade margins, increasing total exports through the export of more products and the targeting of more countries. The introduction of innovative products helps firms to export new varieties to new foreign markets while innovation plays a marginal role in improving the average value of shipments abroad. In particular, the positive effect of innovation on firms trade margins seems to be mainly driven by small and medium domestic firms exporting within the EU relatively small volumes, or exporting to extra-EU countries.

Finally, in the third chapter we investigate the role played by R&D outsourcing in increasing the degree of internationalisation of firms in mature economies, improving their total exports and accessing new foreign markets. Globalization along with the development of new IT have contributed to the expansion of R&D transactions and the creation of internationally integrated innovation networks. Cross-border collaboration between research centres is a wide-spread phenomenon, mainly due to the increasing degree of specialisation of laboratories around the world which have became research leaders in high-tech and high-added value niches. In particular, private firms have gradually evolved from closed innovation systems to open and networked structures, as shown by the increasing share of external innovating activities both in developed and developing countries, leading to a new global distribution of R&D as suggested by Chesbrough (2006) "open innovation" paradigm.

In the last 20 years the total value of external R&D activities in the EU has grown 20 time faster than R&D spending in general, with some companies conducting less than 10% of their R&D in-house, becoming "hunters and gatherers" rather than originators of technology. Nowadays more than 70% of European firms have outsourced part of their R&D activities, opening collaborations not only with organizations located in countries at the edge of the technological frontier, but increasingly offshoring towards developing countries (European Commission, 2014). Generally, the innovation capability of manufacturing sectors is becoming an increasingly important issue in high-wage developed countries, considered as one of the main drivers of the economic recovery and of the improvement of the comparative advantage in respect to newly emerging countries. Most of the policy attention on this topic has focused on a specific subcategory of manufacturing firms, mainly dynamic innovators in high-tech industries dedicating large resources to internal R&D projects. However, recently a growing literature has stressed the relevance of the evolving industrial re-organisation taking place in low-tech manufacturing industries, dedicating an increasing amount of resources to the development of R&D projects in order to challenge the competition from low-cost countries (Hansen and Winther 2014).

Chapter 3 contributes to the empirical literature by assessing the impact of external R&D

activities on firms export performance. This topic is relatively under researched with few theoretical predictions and limited empirical evidence. We consider externalised R&D to be a key strategy for internationalized firms, undertaken to achieve both supply-driven and demand-driven objectives. To the best of our knowledge, this is the first empirical contribution to provide evidence on the role played by external R&D activities in improving firms' export performance, looking both at domestic and foreign owned companies, both in the high and in the low-tech industries.

We take into account several measures of firms external R&D activities, considering both tasks outsourced within or outside the group boundaries, both domestically and internationally. First, we study whether outsourced activities substitute or have a complementary effect with internal R&D on exports, analysing the sustainability of innovative external efforts and firms' internal resources. Second, we examine the different effects of outsourced R&D activities on several indicators of firms export performance in order to assess the role played by each external innovation activity in increasing the value of total exports and in improving firms market access.

Our results show how complementarity does take place between internal and external R&D activities, demonstrating how in-house capabilities still persist once firms start externalizing, and how this joint effect helps firms to improve their export performance. In addition, we find that offshoring R&D activities abroad and outside the group boundaries is a particularly relevant strategy in order to improve firms terms of trade, specifically increasing the value of total exports and pushing firms towards more difficult markets. These results seem to be particularly relevant for domestic firms in low-tech industries, which might use external knowledge not available in-house provided by foreign agents at the edge of the technological frontier in order to increase total exports and their presence in foreign and distant markets. Taken together these results show clearly how external R&D plays a significant role in improving firm's participation in global networks, demonstrating how these strategies are mainly driven by market-demand factors such as customizing products to foreign markets' needs or increasing firms' global footprint.

From this economic analysis of the changing patterns of international trade and the impact on firms behaviour it is possible to derive key policy implications about the potential ways to foster the economic growth of mature European countries. European firms should be positively engaged in innovating activities and international markets in order to face the challenge of the competitive pressure from developing countries. The solution is to increase investment in human capital and knowledge to boost productivity growth and the creation of new jobs. Only by continuously investing in R&D activities and expanding international operations European firms will be able to follow a creatively destructive process, replacing the obsolete products and productive processes and being completely open and integrated in the global value chains of knowledge and production to fully exploit the benefits deriving from globalization.

Chapter 1

EU anti-dumping measures on Chinese products: A curse or a blessing for European firms?

Abstract

Despite growing trends of international trade flows, the last two decades have been characterized by an increasing recurrence to protectionist measures, especially through the adoption of anti-dumping (AD) duties. Dumping strategies might have a negative effect on international competition but previous literature has frequently questioned to what extent anti-dumping measures have actually to do with unfair trade, raising concerns about the possible protectionist abuse of this trade defence instrument. In this chapter we provide a comprehensive economic analysis of the EU anti-dumping measures on Chinese products, looking at their impact on trade flows and at the contrasting effects of these AD duties on the performance of both domestic producers and importers. Our results suggest that EU anti-dumping measures successfully target Chinese dumped products, increasing their prices and consequently decreasing imports from China, which are in turn substituted by a larger domestic production and by goods from other extra-EU countries. On the contrary, EU anti-dumping measures on Chinese product have mixed results on firms' performance, bringing a temporary benefit for domestic producers, but negatively affecting importers with a perverse long-run negative effect especially in terms of productivity.

JEL classification: F13; D22; F14; L25.

Keywords: anti-dumping; China; European Union; firm heterogeneity; trade diversion.

A draft of this chapter had previously been submitted to the *RES 2016 PhD Meeting and Job Market*, the *European Trade Study Group Conference 2015* and the *Chinese Economic Association 2015 Conference* and is available at: `https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=RESPhDConf2016&paper_id=198`.

1.1 Introduction

The last decades have witnessed an increasing degree of globalization and interdependence characterised by growing trends of international trade thanks to the lowering of import tariffs, to a decrease of transportation and IT costs and the inclusion of major trade partners in the WTO system. Nevertheless, especially after the economic crisis in 2008, it has been noticed an increasing recurrence to protectionist measures both by developed and developing countries, especially through the adoption of anti-dumping (AD) duties, one of the few exceptions to free trade allowed in the WTO framework (Vandenbussche and Zanardi 2008; Moore and Zanardi 2011). Dumping strategies refer to firms which export products at a price lower than the price usually charged in their own home market or at a lower price than the cost of production. Dumping is frequently considered as an anti-competitive strategy developed to unfairly knock-out of the market international competitors who cannot face such intense price-competition for prolonged periods. Once the competitors have left the market, the dumping firms are able to set their own monopolistic price since they no longer face any competitive pressure.

According to the WTO rules, governments could impose temporary extra duties on targeted products imported from dumping countries in order to bring prices closer to the "normal value".[1] The imposition of anti-dumping measures is conditional on the demonstration that a dumping strategy is taking place and that is causing a "material" injury to the competing domestic industry. Although dumping strategies might have a negative effect on international competition, economists and political scientists have always questioned to what extent anti-dumping measures have actually to do with "unfair" trade (Zanardi 2006; Evenett and Vermulst 2005; Nelson 2006; Conconi et al. 2015). Calculating the extent of product dumping and evaluating the relevant economic impact on the affected industry might be a particularly

[1] Article VI of the GATT 1994 Anti-Dumping Agreement.

challenging task, leaving room for political leverage. Increasing concerns have been raised about the possible protectionist abuse of this trade defence instrument, especially in developed countries where governments could take anti-dumping actions just in order to defend their mature industries from the aggressive competition of imports from emerging countries.

A lively economic and political literature analyses anti-dumping policies, both from a theoretical and an empirical point of view, in order to shed a light on the real effect of these measures on trade flows and on industrial output.[2] Most of the theoretical literature predicts that anti-dumping policies are in most of the cases welfare reducing, causing significant distortions in trade flows and with gains for protected producers which are smaller than the costs in terms of consumers welfare and loss of comparative advantage (Gallaway et al. 1999; Blonigen and Park 2004; Bown and Crowley 2007; Ruhl 2014; Wu et al. 2014). Moreover, many empirical studies test these predictions highlighting that only in very few cases the imposition of anti-dumping measures is supported by sound empirical evidences (Dutt and Mitra 2002; Knetter and Prusa 2003; Mayda and Rodrik 2005; Blonigen 2006). It has been proven that the imposition of unsubstantiated AD duties has a negative effect on trade volumes due to externalities associated with trade destruction, diversion and trade deflection (Durling and Prusa 2006; Bown and Crowley 2006; Vandenbussche and Zanardi 2010; Egger and Nelson 2011; Besedes and Prusa 2013). As a consequence, with the disruption of trade flows and the alteration of imported inputs prices, anti-dumping duties affect in turn industrial sectors and individual firms performance both in the domestic and in the trade-partner markets. The majority of the empirical papers conclude that AD protection affects the market structure of domestic producers, especially improving the performance of the least productive firms, and lead to a reallocation of resources from more to less productive industries (Konings and Vandenbussche 2005; Konings and Vandenbussche 2008; Pierce

[2]For a comprehensive survey of the literature on anti-dumping see e.g. Nelson (2006), Zanardi (2006), Blonigen and Prusa (2015).

2011).

Following the previous literature, this chapter provides a comprehensive economic analysis of EU anti-dumping measures on Chinese products. Specifically, we will look at the impact on trade flows and at the contrasting effects of these AD duties on the performance of all the categories of affected firms, including both domestic producers and importers. The focus of this investigation is on the EU anti-dumping measures on Chinese products for the increasing role played by China in international trade and for the peculiarity of the EU anti-dumping framework. China is nowadays the largest source of imports for the EU, with total value of almost €280 billions in 2013, and it has become as well the largest target of EU anti-dumping measures after the 2004 EU enlargement as shown in Table 1.1 (European Commission, 2015). At the same time the EU is the world first initiator of anti-dumping cases against China, mainly due to its large bilateral trade deficit and for the loss of comparative advantage of its manufacturing industries vis-à-vis Chinese competitors (Cheong 2007; Rovegno and Vandenbussche 2011). From Figure 1.1 it is possible to notice indeed that despite a decreasing trend in the overall number of products investigated for dumping by the EU during the period 1999-2007, the share of Chinese products investigated over the total has been continuously increasing during the same period, especially after China's WTO accession in 2001, accounting for almost 80% of the total number of products investigated by the EU in 2007. The extent of the coverage of EU AD measures on China is evidently very large also in terms of volumes: in 2013 over 7% of China's total exports to the EU were under anti-dumping examination (Bown and Reynolds 2015). In addition, because of its peculiar characteristics the EU anti-dumping procedure is particularly prone to political and discretionary decisions more based on protectionist reasons rather than technical aspects, especially when considering anti-dumping duties on products imported from emerging countries such as China which put under a tough competitive pressure the domestic European industries

(Evenett and Vermulst 2005; De Bievre and Eckhardt 2010; Nordstrom 2011; Van Aken 2012).

Table 1.1: Composition of EU AD investigations by country (1999-2007).

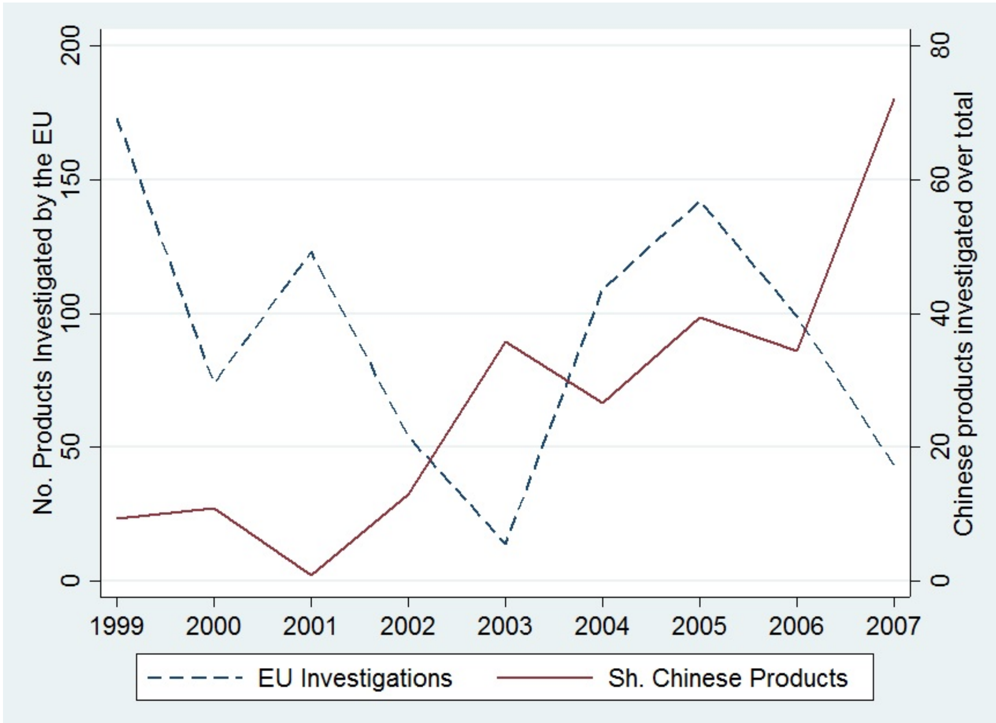
	China	India	S.Korea	Taiwan	R.Asia	Russia	E.Europe	M.E.A.	L.America	ROW	Total
1999	12	5	7	8	16	1	13	3	1	4	70
2000	7	4	2	0	3	3	12	1	0	1	33
2001	2	4	1	1	2	2	10	4	1	2	29
2002	4	1	0	1	6	5	5	3	1	3	29
2003	3	1	0	0	1	0	4	0	0	0	9
2004	10	1	3	3	12	3	2	4	1	2	41
2005	8	1	1	1	8	1	3	2	1	1	27
2006	12	1	2	3	7	3	6	3	0	3	40
2007	8	1	0	0	2	1	1	0	0	1	14
Total	66	19	16	17	57	19	56	20	5	17	292

Note: Statistics based on the World Bank Global Antidumping Database for the period 1999-2007 considering all anti-dumping investigations launched by the EU against third-countries.

Given the heterogeneous productive structure of European countries, our analysis of AD measures on Chinese products is particularly interesting since it takes into account the overall effect on the domestic industry, considering both the impact at the product-level on the bilateral trade flows and the effect at the micro-level on sectors and firms performance. First, using trade data at the HS-6 digit product-level for the period 1999-2007 we are able to assess the effect of EU anti-dumping measures on Chinese product on import flows. Our product-level analysis would not be restricted just to the bilateral flows between the EU and China, but would investigate as well the possible externalities in terms of trade destruction, diversion and deflection. More specifically, we consider the effects on total imports, on the intra-EU trade and at the trade relationships with the rest of the world considering the consequences both on prices and volumes.

Secondly, following the previous literature we are interested in estimating the overall economic effect on the EU industries protected by the imposition of higher duties on the import of dumped Chinese products (Pauwels et al. 2001; Vandenbussche and Wauthy 2001; Crowley 2006). Using 4-digit industry-level data for almost 270 European manufacturing sectors covering the period 1999-2007 we analyse the efficiency of anti-dumping duties in protecting

Figure 1.1: EU anti-dumping investigations on China and the rest of the world (1999-2007).



Note: Elaboration based on the World Bank Global Antidumping Database for the period 1999 to 2007 considering all anti-dumping investigations launched by the EU against third-countries products. Share of Chinese products measured as the ratio between number of EU investigations against Chinese products and the total number of EU anti-dumping proceedings against third-countries.

European producing sectors, estimating the impact of AD measures on the performance of these industries in terms of total production, employment, labour productivity, total exports, investment in R&D and the overall number of European firms operating in these sectors.

Finally, we present a comprehensive micro-level analysis of the impact of these AD measures on firms performance, not only for the protected domestic producers as done by the previous literature, but looking as well at the repercussions of AD duties for domestic importers of the targeted products. Using firm-level data from France we are able to identify the producers in each of the industries protected at the NACE-4 digit level, comparing the effect of the AD measures for firms in the protected industries with other French companies in unaffected sectors (the control group) before and after the imposition of anti-dumping duties. Similarly, using firm-product-level import data from the French Custom Agency we can identify French firms that import dumped products from China, and estimate the effect of higher duties on intermediate inputs on their performance. In this way, we can assess the effect of AD duties on the performance of both French producers and importers, considering specifically the impact on firms' productivity, employment growth, total export, R&D investment and on survival rate. We perform additional in-depth investigations and several robustness checks to estimate the heterogeneous effect across sub-samples of firms. We differentiate between exporters and non-exporters, multi and single-product firms. We also check whether the impact of AD duty varies across the productivity distribution of producers and importers. In addition, using the investigation reports released by the European Commission, we look specifically at the cases in which French producers and importers have petitioned in favour or against the imposition of EU AD duties on Chinese products to briefly analyse the role played by lobbying activities in serving industrial strategic objectives.

To the best of our knowledge, this is the first study providing a comprehensive analysis of the effect of AD measures at the product, sector and firm-level, in particular analysing for the first time the different firm-level impact on importers and producers.

Looking at the product-level imports, we find that EU anti-dumping measures on Chinese products cause an overall trade destruction effect, substantially decreasing EU total imports at the HS-6 digit level due to a generalized increase in the price of dumped products. This impact is mainly driven by a sudden drop in imports volumes of targeted products from China which decrease by almost 70% in the following 2 years. However, the overall impact is partially mitigated by a trade diversion effect with an increase of imports from the rest of the world. Overall these results show how anti-dumping measures on Chinese products push towards an overall increase of targeted goods prices, bringing to a substitution of Chinese imports with more expensive imports from the rest of the world.

The sector-level analysis corroborates the findings published by previous literature. After the imposition of AD measures on Chinese products, European producers are more protected and experience an increase in the domestic production, a stabilisation of total employment and of the number of firms operating in the sectors, but at the cost of a decrease in labour productivity in comparison with unprotected industries.

Finally, the firm-level analysis highlights a contrasting effect of anti-dumping measures on French firms' performance. On the one hand, we find evidence that anti-dumping measures successfully protect domestic producers from the unfair competition of dumped Chinese products, especially for the least competitive firms, increasing by 5% the probability of producers survival and relatively supporting the employment growth with almost 20,000 new jobs created in 3 years, despite a drop in their total factor productivity. On the other hand, anti-dumping measures decrease French importers performance, negatively affecting the most productive firms and lead to a drop of their productivity by 5% on average, cutting down almost 15,000 jobs in 3 years and reducing the surviving probability of importers by 7.5%. These firm-level effects are particularly significant in the cases in which the European Commission registered the petition of French producers or importers, suggesting that industrial lobbying is effective in protecting the interests of domestic producers while does not appear to play any role in preventing the negative impact for importers.

The results are consistent across specifications and robust to different checks on selection bias and endogeneity issues. Specifically, we use a difference-in-differences propensity score matching (DID-PSM) technique in order to select from the sample of untreated observations suitable control groups. Moreover, to cast out any endogenity issue we test the overall goodness of the matching procedure, providing as well additional alternative estimation techniques which corroborate our main results. In addition, we use different definitions of importers and producers to control for selection bias and possible overlap between these two categories.

Taken together, our results suggest that EU anti-dumping measures successfully target Chinese dumped products, pushing for an increase in the level of prices and decreasing imports from China which are in turn substituted by a larger domestic production and by goods from other extra-EU countries. In this way, French producers are more protected by the unfair dumping competition, experiencing a higher employment growth and survival probability, but at the cost of a lower productivity. At the same time, a smaller number of French importers, but larger in size relatively to domestic producers, are negatively affected by AD measures, forced to divert their imports after the increase of intermediate input prices, and losing productivity with a consequent negative impact on total employment and survival rate. The overall result is a mixed effect of EU anti-dumping measures on Chinese products, definitely bringing a temporary benefit for domestic producers, but with a negative impact on importers and a long-run distorted effect reducing the productivity gap between Chinese and European firms.

The rest of this chapter is structured as follows. In section 2 we present a review of the economic literature on anti-dumping measures and their consequences on trade flows and firm performance. Section 3 describes the data used and presents some preliminary statistics. In section 4 we explain the methodology applied for the estimation of the main model and of the alternative controls. Section 5 presents the empirical findings and the robustness checks discussing the results. Finally, section 6 concludes this chapter and presents some policy implications.

1.2 Literature Review

A lively economic and political literature analyses anti-dumping policies, both theoretically and empirically, in order to shed a light on the real effect of these measures on trade flows and on the performance of productive systems. Most of these studies agree that dumping strategies do not seem to constitute much of a problem for international competition, having marginal side-effects on trade flows. However, anti-dumping policies affect aggregate trade flows in a much greater proportion, with a wide degree of politicization and protectionism abuse involved (Nelson 2006). In the next sections, we review the existing literature on this topic, taking into consideration both the economic and the political studies on anti-dumping policies. We look first at the theoretical predictions regarding the motivations and the objectives of the AD measures before moving to the empirical analysis of the effects of these duties on trade flows and the performance of affected industrial sectors and individual firms.

1.2.1 Economic Literature

The economic literature develops and tests general equilibrium models of international trade in order to predict and assess the welfare effects of anti-dumping and other protectionist measures, usually finding evidence of a negative impact on consumers and competition (Zanardi 2006). Most of the economic studies focus on few topics, mainly analysing the impact on trade flows at the aggregate level or looking alternatively at the pricing strategies and the heterogeneous response of affected sectors and firms to anti-dumping measures at the micro-level.

The Macro-level Analysis

A first strand of the theoretical literature models how anti-dumping policies affect world trade flows. Firstly, Prusa (2001) shows how on average AD duties cause the value of product-level imports to fall by 30 - 50 % with respect to the pre-initiation phase, not only because of the imposition of duties, but also for the cases in which they have been rejected. Starting from this preliminary analysis, Bown and Crowley (2007) look at the aggregate effect on trade relations, predicting that the imposition of AD duties might cause a significant distortion in world trade flows. Testing their model using US anti-dumping duties against Japan, the authors find evidence of trade deflection and depression with an overall negative effect on trade flows. Similarly, Vandenbussche and Zanardi (2010) test empirically the effect of AD duties on aggregate world trade flows using a gravity model approach. The authors show that anti-dumping measures have trade chilling effects on aggregate import volumes that spill over also at a more aggregate level to similar products. However, their impacts are heterogeneous across sectors, mainly driven by a few sectors such as iron and steel, textiles, chemicals and agriculture. In addition, the authors look at the differences across countries, focusing in particular on the "new users", countries that have just recently adopted and implemented the AD legislation such as Brazil, India, Mexico, Turkey and China. Their analysis shows that "new users" experience even a stronger negative impact on aggregate imports as a result of the imposition of AD measures, substantially offsetting the increase in trade volumes derived from the recent trade liberalizations adopted. Egger and Nelson (2011) also base their analysis on a gravity model framework in order to establish an empirical baseline for the analysis of deviations from trade patterns equilibrium. More specifically, the authors develop a theoretical model formalizing the causal links between anti-dumping measures and trade patterns, comparing the overall welfare effects across the main sectors targeted by AD policies and different countries in terms of development. Their results show a negative but modest effect of anti-dumping measures on aggregate trade volumes and welfare, with stronger effects in the case of new developing country using AD policies.

Using detailed country-product data other papers investigate instead the externalities associated with anti-dumping measures, by examining their impact not only on trade destruction, but also on trade diversion and deflection towards third countries. For instance, Durling and Prusa (2006) look at the market of a particular homogeneous product such as the hot-rolled steel which has been the subject of numerous anti-dumping complaints. Using a detailed database of bilateral trade at the 6-digit HS level, the authors find strong evidence of trade destruction, but little or no proof of trade deflection and diversion. Nevertheless, their results present some evidence of a possible protectionist abuse of the AD policy. In fact, anti-dumping measures by definition should have a country-product specific nature, being imposed just in the case in which firms exporting a specific good from a specific country have been found to carry on dumping strategies. On the contrary, the rapid emergence of hot-rolled AD cases in different countries seems to have little to do with anti-dumping protection according to the authors, providing a clear evidence of a protectionist abuse in retaliation to AD measures imposed by trading partners. Looking at a specific case study, Cohen-Meidan (2013) studies the imposition of anti-dumping duties in the cement industry finding evidence of regional variation in their impact on domestic prices, sales and imports. Analysing US duties imposed on different trade partners the author shows that just in some cases these led to imperfect substitution with other imports, increasing domestic prices and production, linking the variation across regions to the high exit costs hysteresis. Besedes and Prusa (2013) instead analyse a richer panel dataset of imports of products involved in US anti-dumping cases to look at the overall effect at the product-level over time. The authors find evidence of a strong reduction of imports, highlighting how the first phase of the AD investigation usually has a stronger detrimental effect than the final imposition of duties. Moreover, their results demonstrate how despite their country-product-specific nature, AD duties in reality impose significant externalities also on the trade flows of non-targeted country-product pairs, thus widening the scope of anti-dumping policies.

The Micro-level Analysis

Starting from the first seminal papers on firms strategic responses to endogenous protection (Viner 1923; Bhagwati and Srinivasan 1976; Eaton and Grossman 1986; Dixit 1988; Fischer 1992), another strand of theoretical works examine the dynamic problems regarding the imposition of anti-dumping duties, looking both at the implications for policy-makers and affected firms.

Cheng et al. (2001) for instance theorize firms pricing strategies in reaction to the imposition of AD duties, exploring the design of optimal incentive-compatible measures and considering the weight given to domestic firms' profit and foreign firms pricing strategies. In another paper Blonigen and Park (2004) highlight the key role played by ex-ante expectations in determining the price strategy. The authors show indeed that the pattern of AD duty recalculations mostly depends on the ex-ante expectations of exporting firms on the possible imposition of AD duties by importing countries. The main prediction of their model stresses that the certain enforcement of AD duties can perversely contribute to more aggressive dumping behaviour. In an uncertain enforcement framework instead, firms will choose prices which lead to a decreased probability of being affected by an anti-dumping investigation.

More recently Ruhl (2014) and Wu et al. (2014) develop a general equilibrium welfare analysis to assess firms pricing strategies, the reaction to anti-dumping investigations and the overall effect on affected industries and consumers. In a calibrated model Ruhl (2014) estimates that the U.S. anti-dumping policy has an aggregate impact equivalent to a 6% tariff uniformly applied to all firms, with an overall welfare cost not only linked to higher prices charged after the imposition of the anti-dumping duties, but also to higher prices that all exporters optimally charge in order to minimize the probability of being accused of dumping. Wu et al. (2014) instead in their paper study the welfare implications for exporters of paying anti-dumping duties or of raising their product price to the normal market value. The authors find that welfare-maximizing AD duties crucially depend on the product market value: if considerably high, the optimal rate should fully reflect the dumping margin, otherwise it should be set lower than that.

Another part of the economic literature studies the impact of anti-dumping policies at the sectoral-level, in particular focusing on the real effectiveness in protecting affected industries and on the possible use of AD measures as an instrument of industrial policy. For instance, Pauwels et al. (2001) develop a dynamic model of imperfect competition to analyse the particular effect of EU anti-dumping duties on firm behaviour and compared it with US measures. The authors highlight how the strategic behaviour of European firms widely differs from US companies affected by anti-dumping duties. In particular, US anti-dumping policy seems to be more effective than European one in determining the dumping margin protection, thus performing better in terms of domestic welfare and in terms of protecting domestic value added and employment. In addition, they argue that anti-dumping strategies cannot be considered as a strategic trade policy, given that the level of protection is endogenously determined by the firms involved. In another theoretical paper Vandenbussche and Wauthy (2001) instead show how EU anti-dumping policies may negatively affect European producers through reversals of quality ranking. Using a two-stage model for an industry characterized by vertical product differentiation where quality choice is determined before price competition takes place, the authors show that EU anti-dumping policies protect domestic firms at the price competition stage, but might negatively affect domestic firms once the effect on quality choice is taken into account.

As previously stressed, frequently anti-dumping duties might have been used not as a way to protect domestic sectors by a material injury of dumped imported products, but simply as a tool of industrial policy to boost productivity and investment in infant or mature sectors. In this regard, Crowley (2006) develops a model for the analysis of the use of anti-dumping duties for industrial technology adoption. In this paper the author shows that country-product specific tariffs could have positive welfare effect, inducing both domestic and foreign firms to invest more in R&D activities as a response to tariff increase and accelerating in this way the introduction of new innovations. On the contrary, broadly-applied tariff like safeguards can accelerate technology adoption by import-competing firms, but will slow-down the adoption for foreign exporters of cheap goods. Similarly, Miyagiwa and Ohno (2007) look at the relationship between dumping strategies and innovation in R&D intensive industries. According to the authors innovative firms may need to export greater than normal quantities to signal the introduction of new technologies. If exporters have a poor reputation for innovation or introduced cost-cutting process innovations, such actions lead to sales below cost. As a consequence, anti-dumping duties reduce the costs of signalling, protecting domestic firms, but raising the profit for foreign firms in the pre-duty period.

A recent strand of the empirical literature focuses instead on the firm-level response to anti-dumping duties, mainly looking at the effect on exporters and producers. Konings and Vandenbussche (2005) in their first seminal firm-level study test whether AD protection affects the market power of domestic producers. Using a panel of around 4,000 European firms protected by AD duties, the authors estimate markups before and after the filling of a case with a fixed-effect model to control for potential endogeneity of AD filings. Their results show evidence of a positive and significant effect of AD protection on domestic markups, except for the cases in which import diversions played a significant role. Moreover, in a following paper the authors use instead a difference-in-differences approach in order to compare the productivity of firms protected by anti-dumping measures with those unaffected (Konings and Vandenbussche 2008). Their results show evidence of a general improved productivity for firms in protected EU industries. However, when controlling for firm heterogeneity in terms of productivity levels, the authors find that laggard firms initially distant from the efficiency frontier have significant productivity gains during the protection period, while firms with initial high productivity levels experience productivity losses as a result of the AD protection.

In a related work Pierce (2011) uses plant-level data about US manufacturers to describe the effect of temporary AD duties on the performance and behaviour of protected producers. Using a difference-in-differences propensity score matching technique and quantity-based output data, the author demonstrates how inflated prices and mark-ups could artificially bias the estimation of the effect of AD measures on productivity. On the contrary, these results provide evidence of a negative impact of AD measures on protected firms. First, after the imposition of higher duties US manufacturers show a fall of physical productivity. Secondly, thanks to the AD protection low-productivity plants keep on producing the protected products, slowing the reallocation of resources from less productive to more productive firms. Finally, Lu et al. (2013) expand the firm-level analysis estimating empirically the effect of AD investigation on targeted exporters. Using monthly export data the authors investigate how Chinese exporters react to US anti-dumping measures. The authors demonstrate that the substantial negative impact on export volume at the HS-6 digit product-level is essentially driven by a decrease in the number of exporters. In addition, they find that the most affected firms are mainly the least productive, single-product and direct exporters which are forced to leave the market. On the contrary, surviving Chinese exporters become larger, more productive and multi-market-product oriented during the AD period by acquiring the market-shares of dropping exporters, thus increasing the competition pressure on US manufacturers once the temporary anti-dumping duties would be eventually removed.

1.2.2 Political Economy Literature

A growing part of the literature look at the political economy of anti-dumping, particularly focusing on the institutional aspects and highlighting the discretionary politicization of the implementation mechanism.[3] In this regard, two main streams of research have been followed, the first looking at the factors influencing protectionism in a country and the second focusing particularly on the political determinants of the anti-dumping decisions.

Dutt and Mitra (2002) look at the impact of inequalities in determining trade barrier levels. Within a Heckscher-Ohlin framework, the authors test the predictions of the median-voter approach to trade policy determination that an increase in inequality raises trade barriers in capital-abundant economies and lowers them in capital-scarce economies, as predicted in Mayer (1984). Using cross-country data on inequality and capital-abundance, the authors find support for this prediction, controlling for the effects of political rights and level of education. Similarly, Mayda and Rodrik (2005) investigate the determinants of protectionism with a micro-level analysis based on a factor endowments model which takes into consideration the distribution of human capital and of socio-economic factors. Their results show that pro-trade preferences are significantly correlated with the individuals' level of human capital. Preferences over free trade are also correlated with trade exposure, individuals' relative economic status, but also non-economic determinants play an important role in explaining

[3] For a comprehensive review of the political economy literature see e.g. Blonigen and Prusa (2003) and Nelson (2006).

the variation in preferences over trade, such as nationalism and attachment to local values.

A second strand of the literature instead focuses more specifically on the political and economic determinants of anti-dumping measures. Knetter and Prusa (2003) and Blonigen (2006) for instance look at the relationship between anti-dumping procedures and macroeconomic factors, finding evidence of a significant impact of GDP growth and exchange rates fluctuations on the probability of starting an anti-dumping investigation. These authors stress also the importance of previous experience with AD procedures for a particular industry in order to successfully apply for a temporary protection against dumped products. From their results it is evident that industries which have already applied for anti-dumping protection are more likely to be successful in their new AD application, highlighting the role played in this regard by knowledge of legal AD procedures and suggesting a possible influence of powerful lobbies on political decisions. Evenett (2006) uses a duopoly model to identify the circumstances under which dumping is entirely eliminated and the effects on the profitability of import-competing and foreign firms. The author concludes that US political amendments on AD procedures created distortions in trading patterns, generating price floors for domestic firms and paradoxically increasing the volume of imports. Prusa and Skeath (2002) instead look at the economic and strategic motives for AD filings by countries. Using a non-parametric method the authors find considerable evidence supporting the prediction that AD policies may have been used for strategic motivations, suggesting that the surge in AD activity cannot be solely explained by increasing unfair trading practices.

Other recent studies develop new models estimating the influence of political partisanship on anti-dumping protection, and also testing empirically the political bias of the AD procedures. For instance, Avsar (2014) empirically examines the influence of political partisanship on anti-dumping protection, showing that both anti-dumping initiations and the probability of an affirmative outcome usually increase when there is a left-wing government in power. These results further prove the political bias in AD policies even though these measures should be considered as an administrative protection. Aquilante (2014) studies the determinants of US ITC[4] commissioners' votes on AD procedures using newly collected micro-level data on the ITC final votes and on several individual-level characteristics of commissioners. The author stresses how the decisions of commissioners crucially depend on their political affiliation (selection effect) and on the trade policy interests of key senators within the same political party (pressure effect), varying according to the petitioning sectors involved and the states where these affected industries are located.

The EU Case

Within the political economy analysis, the EU case raises a lively debate in the literature given its particular institutional framework for the AD policy (Nita and Zanardi 2013). In the next sections we first present the peculiarities of the EU anti-dumping mechanism before a review of the key political economy literature related to this topic.

The EU Anti-dumping Mechanism Since the European Economic Community (EEC) Rome Treaty in 1957, the trade policy and trade-defence system in the EU is an exclusive power delegated from the Member States to the European Commission (EC) which is fully responsible for the management of the anti-dumping policy as well. According to the EU legislation, the European Commission is obliged to open an anti-dumping proceeding after receiving a complaint from a group of European producers representing at least 25% of total EU production of the product concerned. In exceptional cases the European Commission

[4]The United States International Trade Commission is an independent, quasi-judicial Federal agency with broad investigative responsibilities on matters of trade, including the investigations of the effects of dumped and subsidized imports on domestic industries.

can also start an investigation on its own initiative. The complaint should not be opposed by EU companies accounting for a larger production volume than the complainants, and should contain evidence of price dumping (e.g. invoices, price offers, publications in specialised press, official statistics, etc.) for products imported from non-EU countries which are causing injury to the domestic industry.

In accordance with EU law, the Commission launches an investigation within 45 days by publishing a Notice of Initiation in the EU Official Journal, specifying the product under investigation, the country/countries to be investigated and the rights and obligations of interested parties to the proceeding. The European Commission is then responsible for investigating the allegations of dumping, inquiring exporters in the countries concerned, producers, importers and users in the EU. Exporters from economies in transition[5] may also receive specific claim forms which they can fill in to show that they are operating under market economy principles in order to avoid the penalizing AD investigation procedures applied to non-Market Economy Status countries. Market Economy Status (MES) is a technical status applied to countries. To satisfy the MES criteria prices, costs and inputs have to be determined by supply and demand, firms must follow one clear set of basic accounting records, production costs and financial tools must not be subject to significant distortions and exchange rate conversions must be carried out at market rates. The absence of these conditions suggests a serious lack of transparency in commercial accounting standards and possible serious state intervention in production, exchange rate controls or commercial finance. These conditions mean it is not possible to accurately determine the genuine costs of production in the economy since these are distorted by the absence of market conditions. The WTO law requires in this situation that an analogue country of similar productive capacity to be used to model costs in market economy conditions, but it has been frequently suggested that

[5]At present these countries are the People's Republic of China, Vietnam, Kazakhstan, Albania, Armenia, Georgia, Kyrgyzstan, Moldova and Mongolia.

non-granting MES to a country makes finding of dumping strategies inevitable (European Commission 2015).

Once companies have replied to the questionnaires, the data is verified by case officers, inspecting records at the companies premises, comparing and verifying the data provided by all participating parties and consulting the EU Member States as well. In particular, the investigation should examine whether a dumping is taking place from the country/countries concerned, if a material injury has been suffered by the EU industry, to what extent the dumped import price undercuts the Community producers' price, the existence of a causal link between dumped imports and the injury and finally if it would be against the economic interests of the EU to impose AD measures in terms of possible negative effects for importers and final consumers.

If within 9 months the investigation shows evidence that there is a dumping strategy by non-EU exporters causing a material injury to the domestic industry in question the European Commission could impose countervailing duties, usually in force for a maximum of 6 months. Alternatively, the Commission could continue the investigation to look for new evidence or could just terminate the investigation without imposing duties. All parties have the right to comment on the provisional findings and receive disclosure of the essential facts forming the basis for the provisional findings.

As it is possible to notice, the European Commission is responsible for the whole investigation process. It has also become the only decision-making body, opening anti-dumping proceedings and effectively imposing the preliminary and final duties. However, the EU Council of Member States retained the power to block the Commission proposals when it comes to the most important decision of imposing definitive duties. Thereafter, not the

European Commission, but the EU Council has the authority to decide whether to impose definitive measures by achieving a qualified voting majority.

The Commission must impose measures or close the case within 15 months of the initiation of the investigation. The measures usually take the form of ad-valorem duties, but could also be specific duties or price undertakings. The duties are paid by importers in the EU and collected by the national customs authorities of the EU countries concerned. Exporting producers may also offer "undertakings" agreeing to sell at a minimum price, and if accepted, anti-dumping duties will not be collected on imports. An assessment is made to evaluate the level of duty needed to remove the injurious effects of dumping. Measures are generally imposed for 5 years and may be subject to review if the circumstances of exporters have changed or if new exporting producers request an accelerated review.[6]

The Political Economy Literature on the EU Case Already from a quick overview of the EU anti-dumping mechanism it is possible to notice its complexity and the potential room for discretionary decision and political abuse of this trade defence instruments for protectionist purposes. First of all, part of the literature points out the complex and somehow contradictory interaction between the different EU institutions playing a role in the definition of the AD procedure. For instance, Evenett and Vermulst (2005) analyse the increasing role played by Member States in the EU anti-dumping system, showing how this increased participation of national governments has pushed towards a higher degree of politicization in the AD decisions, contradicting the supposedly neutral and technical mechanism which should be mainly driven by the "technocratic" European Commission. In addition, Davis (2009) shows that anti-dumping measures have little to do with "unfair" trade especially in the EU,

[6]For a comprehensive review of the EU anti-dumping regulation please refer to the Council Regulation (EC) No. 1225/2009 of the 30th of November 2009 (L 343/51).

providing evidence on how the current EU anti-dumping regulations support the introduction of AD measures especially when the target of the investigations are exporters from Asian emerging countries in sectors where European firms comparative advantage is declining. By carefully analysing the information available about the 332 anti-dumping cases carried out by the EU between 1998 and 2008, the author identifies three main empirical tendencies. First, Asian emerging countries have been the favoured target of EU anti-dumping duties, China and Vietnam in particular. Secondly, targeted products are mainly concentrated in few sectors where European production is declining, in particular raw materials, chemicals, steel and textiles, representing together more than 70% of the products investigated. Finally, most of the investigations initiated have resulted in the adoption of definitive measures, almost in 65% of the cases, with the imposition of AD duty levels which are significantly higher than bound tariffs, in particular in the case of higher-end sectors.

In their study, De Bievre and Eckhardt (2010) review the role played by different interest groups, considering both public authorities such as the European Commission and Member States, and private actors as producers, importers and retailers. The main finding of this study is that a wide reform of the EU trade defence instruments in favour of retailers and consumers has failed despite a declining support among European firms which have outsourced their production abroad and a rise in organisational capacity among importers and retailers. This failure should be ascribed to the increasing power of the traditional group of anti-dumping users, the European heavy manufacturing producers, massively mobilised against any change in the status quo. The authors stress that sector consolidation of market power in few manufacturing companies and the geographical industrial concentration of EU industries in dominant countries played a key role in improving the capacity of import-competing firms to lobby against possible losses in trade defence, supported as well by accommodating Member States and parts of the European Commission opposing the attempted reform of the EU AD procedure.

Given the complex interactions between the different actors involved, part of the literature focuses its attention on the Member States voting pattern within the EU Council on anti-dumping decisions, highlighting the contrasts and the wide internal oppositions between EU countries usually more interested by their national interests rather than the protection of the Community's economic prosperity (Heisenberg 2005; Hayes-Renshaw et al. 2006; Trzaskowski 2009; Van Aken 2012). Using a unique dataset based on Member States votes collected by the Swedish delegate during the EU Council meetings, Nordstrom (2011) demonstrates how the usual voting pattern within the EU Council is strongly correlated with national trade policy preferences, showing a clear distinctions between northern-European liberal countries and southerner states usually more protectionists. Secondly, the author shows how macroeconomic conditions also matter. In fact, national Governments seem to be more likely to support anti-dumping petitions especially when unemployment is rising in some of the EU industries that have mainly suffered from international competition and the financial crisis, such as heavy manufacturers in South-European countries. In addition, this work presents some evidence of Member States apprehension in supporting measures which could negatively affect their national industries. In particular, possible retaliations against EU exporters and negative welfare effects for importers and consumers reduce the likelihood of governments support to the imposition of AD duties. These findings highlight the need to take into consideration the possible controversial effects of anti-dumping measures on different agents in the market and across heterogeneous EU productive systems.

These arguments are supported by the empirical literature looking at the role played by lobbying in influencing the EU anti-dumping policy (Grossman and Helpman 1994b; Veugelers and Vandenbussche 1999; Wittig, 2011). In particular, Nielsen and Svendsen (2012) trace the interest groups actions back to the sectors of origin, demonstrating how lobbying efforts of domestic industries have influenced the political position of national Governments in voting for the adoption of EU anti-dumping policy, in particular in the case of intense petitioning carried out by import-competing companies. Moreover, De Bievre and Eckhardt (2011) argue that producers groups are constantly more successful in lobbying their governments towards the support of AD measures for the protection of domestic industries. On the other hand, importers and retailers, but also outsourcers and consumers, have a smaller political weight in lobbying the national and EU authorities, failing to challenge producers mobilization efforts with arguments on the possible negative consequences on large parts of the EU economy. However, in two recent studies, Eckhardt (2011, 2013) looks closely at the political mobilization and influence of import-dependent firms in the context of the EU trade defence policy, particularly focusing on the case of unfair import competition from China. Firstly, these studies highlight how EU anti-dumping investigations against Chinese textile goods have experienced a rapid increase after the end of the quota regime in 2005, providing evidence of a substitution effect between trade liberalization and anti-dumping measures and how trade defence instruments might be abused for protectionist reasons, as stressed by previous studies (Moore and Zanardi 2011). Secondly, analysing some EU anti-dumping disputes concerning the import of bicycles, clothes and footwear from China, the author argues that under specific conditions import-dependent firms have been recently increasingly relevant in the economic analysis of trade defence effects, becoming particularly successful in mobilizing politically and in defending their anti-protectionist trade interests. In particular, the lobbying power of import-dependent companies seems to have increased in the case of retailers operating in some final goods sectors (i.e. food and clothes) which in recent years have experienced an industrial reorganisation with the consolidation of market power in the hands of a small number of large enterprises. However, an increasing number of European producers in the last decades have outsourced labour-intensive operations to low-cost countries, mainly in

Asia. These European producers turned eventually into importers, experiencing trade defence measures as a burden rather than a blessing, increasingly relying on imports from a relatively limited number of countries, most notably China. As a result, for many European import-dependent companies it is no longer possible to switch easily to suppliers in other countries when facing trade restrictions on Chinese imports. The author stresses how this problem is magnified in the case of import-dependent manufacturers for which imports from China are a key input in their process of production and for which the collective lobbying action capacity still lacks given the high fragmentation of intermediate users across sectors and EU countries.

1.3 Data and Summary Statistics

This study aims to provide a comprehensive analysis of the EU anti-dumping measures on Chinese products, considering the possible impact on trade flows between the EU and China, on the European sectors protected and on the performance of French import-competing and import-dependent firms. The next sections present a summary of the data used at each level of analysis and some preliminary statistics about the products and sectors involved in the EU anti-dumping investigations on Chinese imports, and the distribution and relative performance of French firms producing or importing the affected products.

1.3.1 AD Measures Data

We collected information about all anti-dumping proceedings carried out by the EU during the period 1999-2007 on China and other trade partners from the Global Antidumping Database (GAD) of the World Bank (Bown 2015). This dataset records all measures and duties adopted in the world from 1980 to 2014, providing detailed information about the anti-dumping procedures, such as the products concerned classified at the HS-8 digit level, the dates of initiation and conclusion, the outcome of the investigations, the value of AD duties imposed and the length of the measures. For our analysis we collected just the information about the EU anti-dumping cases against China during the period 1999-2007. We focus on this sample period firstly in order to be consistent with the time frame of the firm-level data and secondly in order to exclude from our analysis any possible statistical disturbance related with the surge in trade protectionism experienced after the beginning of the global economic crisis in 2008 (Vandenbussche and Viegelahn 2011; Bown and Crowley 2013). We then complement this dataset by collecting detailed information on the EU anti-dumping cases on Chinese products from the investigation reports of the European Commission. In this way, we obtain for most of the cases further detailed information about the EU Member States voting pattern, the nationality of the European firms petitioning for AD protection and about the presence of final users and major importers in each EU country. As a result, this analysis considers 46 different EU anti-dumping procedures against Chinese imports between 1999 and 2007, with an overall number of 46 targeted products imported from China and almost 32 different EU sectors at the NACE 4-digit level protected by anti-dumping duties.

1.3.2 Macro-level Analysis

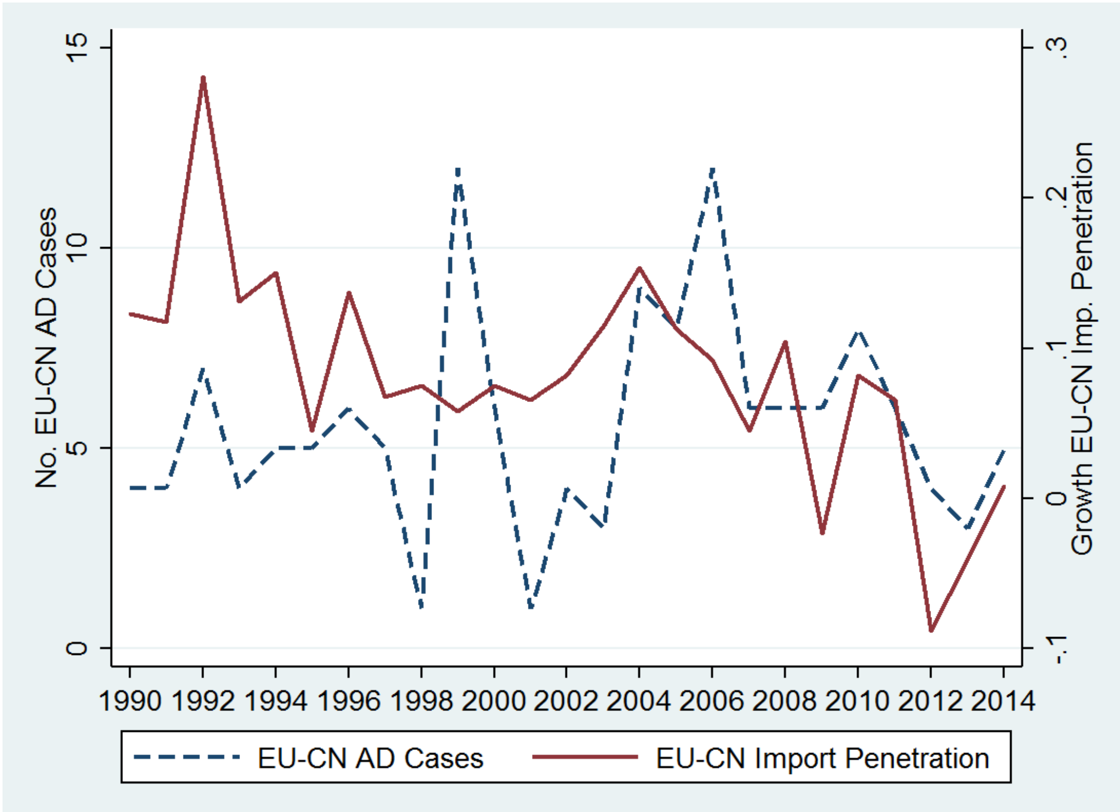
For the analysis on the aggregate trade-flows we use data at the product-level on European imports from China, on intra-EU trade and on imports from the rest of the world. This data provided by the Eurostat COMEXT database presents bilateral import data at the HS6 product-level, including information about the total value in Euros and the volume measured in hundreds of kilos. Consequently, from this data it is possible to derive import prices for all country-product combinations.

For the sector-level analysis we use data from the Eurostat Structural Business Statistics (SBS) database from which we have extrapolated industry-level data at the 4-digit NACE rev.1.1 level about European manufacturing sectors. In particular, this dataset provides information about industrial productivity in terms of added-value (measured as the net income from operating activities after adjusting for subsidies and indirect taxes) and labour productivity (measured as the ratio between turnover and total employment), employment growth, investment intensity (measured as the ratio between total investment and turnover), overall value of production in the sector, total turnover, number of firms operating in the industry, total investment in R&D activities and the export and import values. These data will be particularly useful not only to investigate the effect of anti-dumping duties on protected European sectors, but will be used as well to estimate the likelihood that an import-competing sector receives protection. Thanks to these datasets we gathered together information about 270 different EU manufacturing sectors at the NACE 4-digit level across 9 years in terms of total production, investment, employment, productivity and trade strategies and about the import flows into the EU of almost 6,000 products at the HS 6-digit level.

We start our macro-level analysis by looking at the relationship between trade flows and anti-dumping cases between the European Union and China. Figure 1.2 presents the number of anti-dumping proceedings started by the EU against Chinese products and the growth rate of the import penetration of Chinese goods in the EU, calculated as the share of imports from China over total extra-EU imports, for each year in the period 1990-2014.

From this figure we note that the number of anti-dumping cases opened by the EU against Chinese products has been quite variable during this period, but has consistently followed the growth rate of Chinese import penetration into the EU market during this period. In

Figure 1.2: EU AD proceedings against China and growth of import penetration of Chinese goods in the EU market (1990-2014).



Note: Elaboration based on the World Bank Global Antidumping Database and the Eurostat COMEXT data on bilateral imports for the period 1990-2014. EU-CN AD cases presents the overall number of anti-dumping investigations started by the EU against Chinese products per year. EU-CN import penetration is measured as the annual growth rate of the overall penetration ratio of Chinese imports over total imports in the EU (EU-12 until 1995, EU-15 until 2004, EU-25 until 2007, EU-27 until 2013 and EU-28 in 2014).

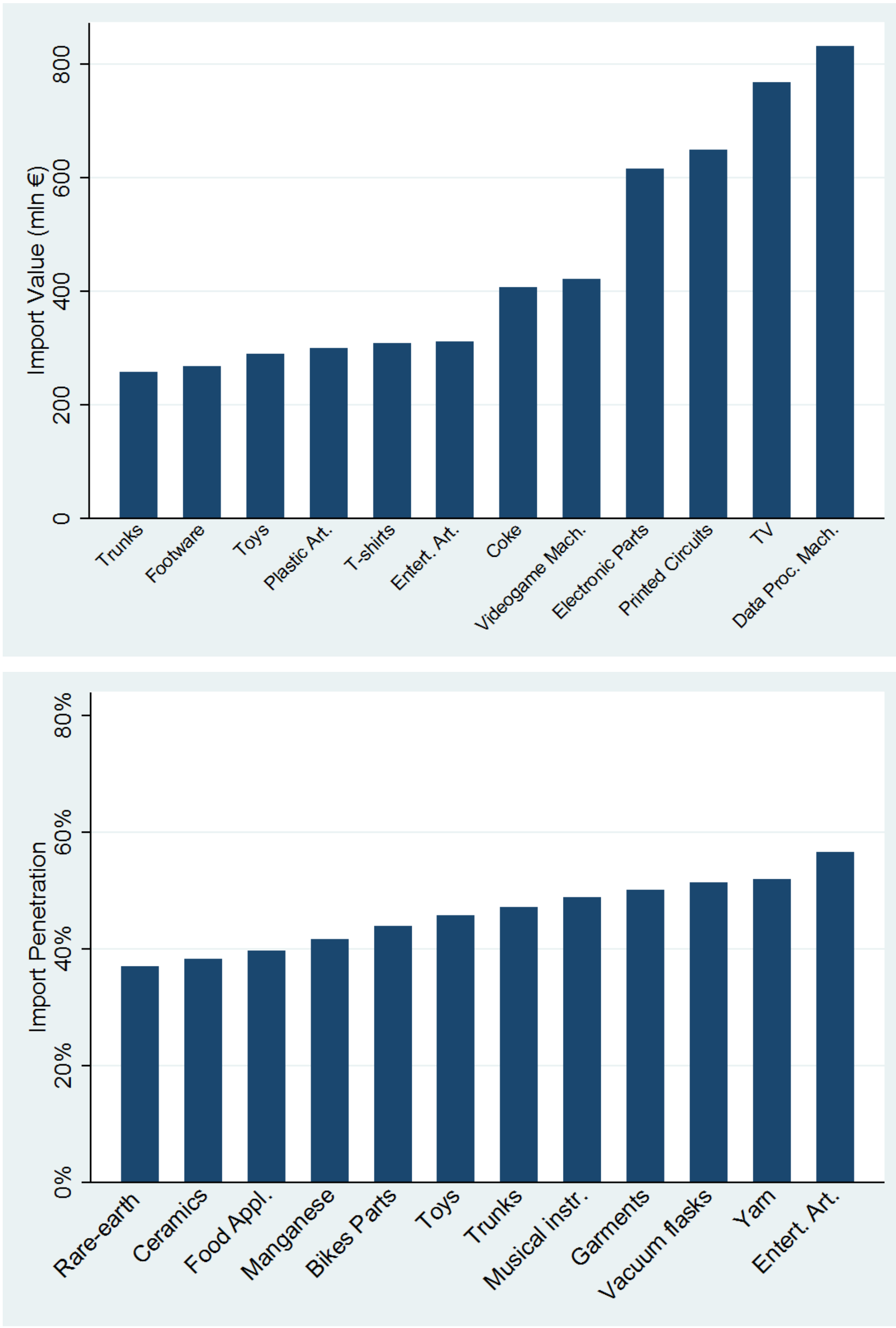
particular, the peak in 1999 could be explained by a rush of European industries in claiming anti-dumping protection by the EU before the trade liberalisation which would have followed the entry of China in the WTO. Actually, it is possible to notice that after China joined the WTO in 2001, the growth rate of Chinese import penetration in the EU has continuously increased until the beginning of the global economic crisis in 2007, followed as well by an increasing number of anti-dumping cases launched by the EU against Chinese products. This evidence seems to support the argument stressed by some previous studies that anti-dumping measures have little to do with unfair pricing competition, serving instead as an instrument of trade defence and protectionist policy.

We focus now on the Chinese import penetration in the EU market, in order to identify a relationship between penetration of Chinese goods and categories of Chinese products mostly affected by EU anti-dumping measures. Figure 1.3 shows the products most imported in Europe from China both in terms of total value and import penetration, defined as the share of imports from China over total imports from outside the EU for each category of products at the HS-4 digit level.

It is possible to notice that in terms of absolute value, the most imported products from China into the EU are data processing machines and televisions followed by imports of printed circuits and other electrical equipments parts. The remaining list of top imports from China includes a large number of final consumer goods, such as toys, garments and other plastic goods. When considering instead the top list of products with the highest import penetration from China the picture changes drastically. Figure 1.3 shows that the sector of entertainment articles has the higher import penetration, with almost 60% of all these products imported into the EU from China. At the same time we notice that products with the highest import penetration from China are more heterogeneous than in terms of import value, including intermediate inputs, machineries but also final goods. The Chinese import penetration in the EU market for these products is on average close to 40%. In addition, as we will see later, most of these products which have experienced a strong import penetration from China have been as well affected by EU anti-dumping investigations, including among others chemicals, final consumer goods, industrial machineries, ceramics, garments and other intermediate inputs.

In Table 1.2 we present an overview of the EU anti-dumping cases against Chinese products between 1999 and 2007, looking at the number of products involved, their sectoral

Figure 1.3: EU imports of Chinese products by import penetration rate and total value (1999-2007).



Note: Elaboration based on the Eurostat COMEXT database on EU bilateral imports averaged over the period 1999-2007. Total import value at the HS-4 digit level expressed in millions of Euro. Import penetration defined as the share of EU imports from China over total EU imports for each product category at the HS-4 digit level. All monetary values deflated using 2010 as a base year.

distribution, the final outcome, the average duty imposed and the petition activity of French firms. It is possible to notice that most of the cases focused on few sectors producing intermediate inputs, mainly chemicals, metals, machineries and telecommunication equipments. Out of 46 total applications almost 32 were finally successfully approved, 11 withdrawn by the European Commission because of the lack of evidence, and just 3 of them were not approved by the EU Council of Member States. In particular, even if most of the cases were focused on the chemical sector, most of the products affected were textile goods, followed then by chemical and metal products.

As previously stressed, most of the products targeted were intermediate goods used as inputs in the production of final goods in Europe. Just in few cases, the EU investigated for dumping Chinese final goods, especially consumption white-goods, textiles, electronic and ITC products. This is a recent phenomenon, since anti-dumping investigations have usually been focused mainly on intermediate inputs and semi-processed goods. In the last years instead the EU started to target increasingly final and consumption products especially from China. This is probably due to the surge of EU imports of Chinese consumption goods after China's WTO accession in 2001, and the subsequent negative shock suffered by EU industries. This evidence might suggest a protectionist abuse of AD measures by European countries, in particular in the case of AD duties on final products imposed to protect the domestic industries which were unable to compete against the flood of cheap Chinese consumer goods in the European single market (Moore and Zanardi 2011; Blonigen and Prusa 2015). Nevertheless, it is possible to notice that the highest anti-dumping duties have been imposed to protect intermediate input sectors, in particular the metal industries followed by agro-food and electrical machineries sectors. Specifically, metal products have been found to be particularly dumped by Chinese firms, not surprisingly given the monopoly hold by China in the production of rare earths and of other raw metals.

Table 1.2: EU-China anti-dumping cases by industry, outcome and products (1999-2007)

Industry	No.Cases	Final	Preliminary	Terminated	No.Products	Final Prod.	Av.AD Duty	MS Against	FR Petition	FR Importer
Food and Bev.	1	1	0	0	3	No	66.9	0	0	0
Textile	3	2	0	1	35	Yes	49.35	1	1	0
Wood	2	2	0	0	2	Yes	52.4	0	1	0
Coke and fuel	1	1	0	0	1	No	60	0	1	1
Chemicals	14	11	1	2	19	No	47.9	6	4	2
Plastic	1	1	0	0	4	No	28.8	1	1	0
Other Minerals	2	1	0	1	7	No	51.5	1	0	0
Metals	5	5	0	0	11	No	52.2	2	2	1
Metal Products	4	4	0	0	14	No	78.3	2	1	0
Machinery	1	1	0	0	4	No	46.7	1	0	1
Elect. Machinery	1	1	0	0	1	Yes	66.1	0	0	1
Telecom Eq.	4	0	1	3	0	Yes	28.3	0	2	0
Optical Eq.	1	1	0	0	1	No	30.7	0	0	0
Transport Eq.	3	0	0	3	0	No	0	0	0	0
Consuming	3	1	1	1	3	Yes	29.6	0	1	0
Total	46	32	3	11	105	0.33	45.91	14	14	6

Note: Statistics based on the World Bank Global Antidumping Database and the European Commission anti-dumping investigation reports for the period 1999-2007 considering all anti-dumping investigations launched by the EU against Chinese imports across industries following the NACE rev.1.1 2-digit level classification. The table presents the number of cases in each industry which have been concluded with the application of final duties,the imposition of preliminary but not followed by final measures or terminated by the European Commission without any proof of dumping. Since each case might include several similar goods, the table report as well the number of products investigated for dumping in each industry and if the investigations affected the import of final goods defined following the United Nations Broad Economic Categories (BEC) classification. The column *Av. Duty* presents the average anti-dumping duty imposed by the EU on Chinese goods for each sector. *MS against* reports the number of cases per industry in which the EU Council did not find an unanimous agreement for the imposition of AD duties on Chinese imports. *FR petition* and *FR importers* show respectively the number of cases in each industry in which at least a French firm petitioned for the imposition of AD measures against Chinese goods and when the European Commission identified at least a French importer lobbying against this trade defence instrument as reported by the European Commission investigation reports.

Thanks to the European Commission investigation reports it is possible to identify in most of the cases the voting pattern of Member States in the EU Council and the companies or industrial associations petitioning in favour or against the adoption of the anti-dumping measures.[7] Thus, in Table 1.2 we show for each industry how many times the Member States did not find an unanimous agreement in the EU Council on the imposition of anti-dumping duties and the number of cases in which at least a French firm petitioned for the imposition of AD measures against Chinese goods and when the European Commission identified at least a French importer lobbying against the trade defence instrument. First, it is possible to notice that in 14 cases the European Commission has been lobbied by French import-competing firms for the imposition of anti-dumping duties against Chinese imports, mainly in the case of chemical products (4 cases), metals (2) and telecommunication equipments (2). On the contrary, in just 6 cases the European Commission has identified major import-dependent firms based in France, again most of them in AD investigations concerning chemical products (2), metals, industrial machineries and electronic equipments. Furthermore, only in 14 of the EU anti-dumping proceedings against Chinese imports the EU Member States did not find an unanimous agreement, imposing final duties just thanks to a simple majority. As stressed by the previous literature, also in the case of AD proceedings against Chinese imports the voting pattern in the EU Council is particularly steady, with Estonia, Finland, Sweden, Denmark, the United Kingdom and the Netherlands frequently voting against the imposition of anti-dumping duties. Interestingly, France instead never abstained or voted against the imposition of AD duties on Chinese imports, not in even in the case in which the European Commission identified major import-dependent French firms and no French company petitioned in favour of the adoption of the trade defence measure. This evidence

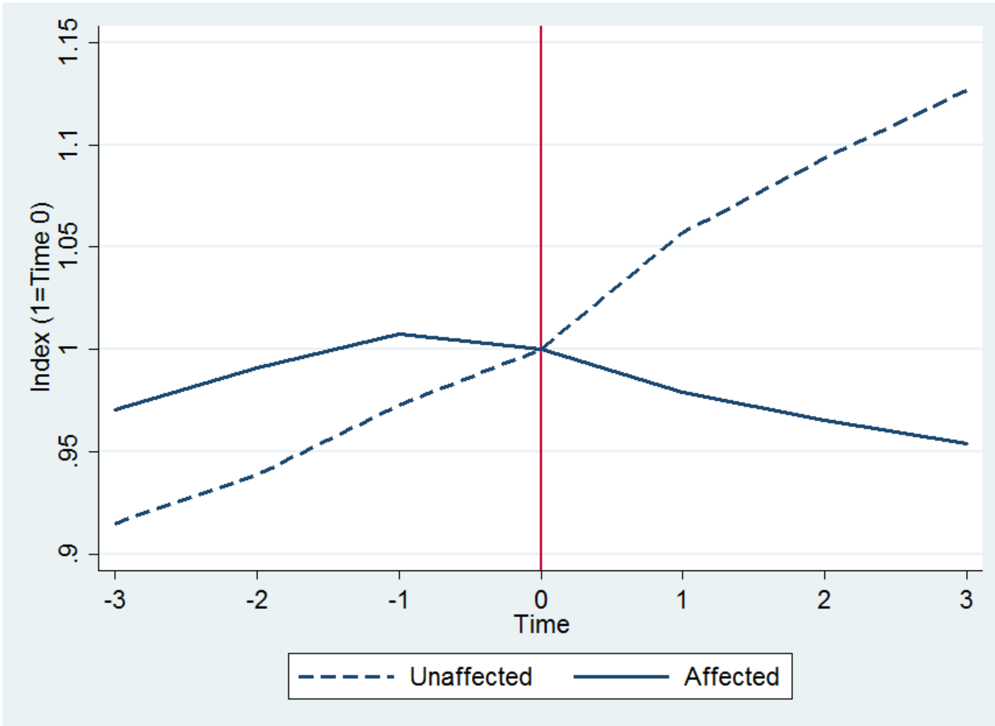
[7]In 3 out of 46 EU-China anti-dumping cases the European Commission has not provided detailed information about the outcome of the investigation, the lobbying activity of European industries and the voting pattern in the EU Council because of confidentiality issues related to possible retaliation by Chinese authorities against Member States and single European companies.

seems to support the findings of the previous literature which argue that producers are constantly more successful than import-dependent firms in lobbying their governments towards the support of AD measures for the protection of domestic industries, in particular in the EU case (De Bievre and Eckhardt 2011; Eckhardt 2011; Eckhardt 2013).

Figure 1.4 presents a preliminary evidence of the effect of EU anti-dumping measures on Chinese imports by comparing the trends of import flows at the HS-6 digit level for goods affected or unaffected by EU AD measures on Chinese products. In this figure we analyse the average imports of affected or unaffected Chinese products to the EU from three years before to three years after the imposition of the anti-dumping measure at time $t = 0$, normalizing the average values to 1 for time $t = 0$. For the unaffected products we consider time $t = 0$ as the median year in our sample. It is possible to notice that after the imposition of AD measures at time $t = 0$ the imports of affected products from China drastically decreased while the imports of remaining unaffected products continued to increase. It is possible to notice as well that, before the introduction of the AD duties, affected imports from China have on average a higher value than unaffected products, highlighting how goods with a relatively higher import value from China are more likely to be affected by AD duties.

For a more in-depth investigation of this different import pattern of affected and unaffected Chinese products, we disentangle Chinese imports to the EU in Figure 1.5 by looking at the import prices and volumes. Also in this case, we analyse the import prices and volumes of affected and unaffected Chinese products to the EU from three years before to three years after the imposition of the anti-dumping measure at time $t = 0$. The Eurostat COMEXT database reports both trade values in Euros and volumes in hundreds of kilos. The import price is calculated by dividing the value with the reported volume. Prices and volumes are then normalized to 1 for time $t = 0$, the year of the imposition of the anti-dumping measure.

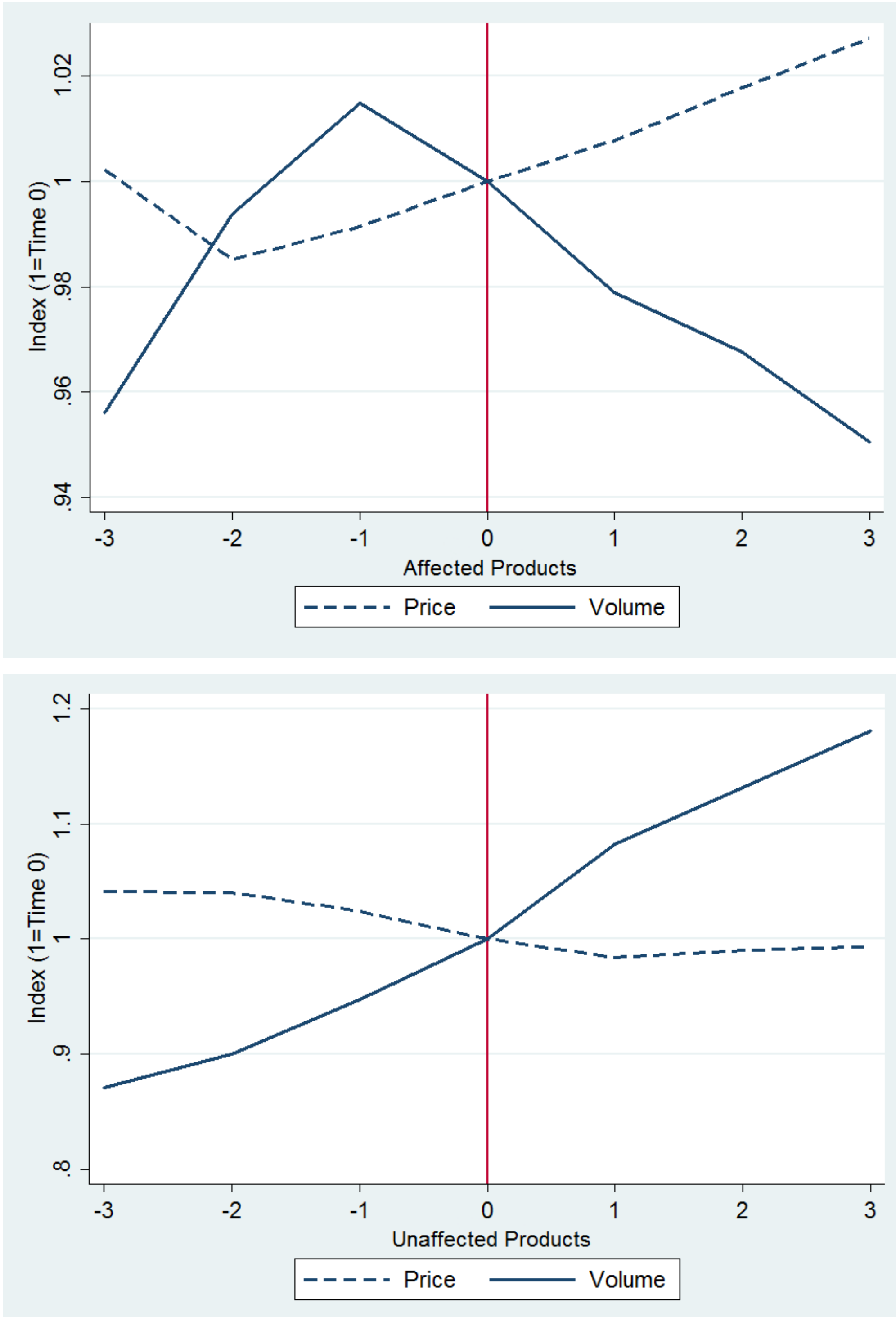
Figure 1.4: EU imports of Chinese goods affected or unaffected by anti-dumping measures (import value).



Note: Elaboration based on the Eurostat COMEXT database on EU bilateral imports for the period 1999-2007. Average total EU import value from China at the HS-6 digit level from three years before to three years after the imposition of the anti-dumping measure at time $t = 0$, normalizing the average values to 1 for time $t = 0$. For unaffected products we consider time $t = 0$ as the median year in our sample.

For the unaffected products we consider time $t = 0$ as the median year in our sample. After the imposition of the anti-dumping duty the price of affected goods imported from China increases significantly, on average above 3% of the pre-duty level, slowing down the overall volume of goods imported. On the contrary, the price of unaffected Chinese goods does not change widely, marginally decreasing but remaining stable overall across the whole period. Nevertheless, we notice a continuous increase in the volume of imported products that are not affected by EU anti-dumping proceedings. Taken together, these preliminary product-level statistics suggest that EU AD duties seem to successfully target Chinese dumped products, making the imports of targeted goods from China more expensive, with a drastic drop in terms of volume in comparison to unaffected products. Targeted products from China might be substituted in turn by a larger domestic production and other extra-EU imports.

Figure 1.5: Prices and volumes of EU imports of Chinese goods affected or unaffected by anti-dumping measures.



Note: Elaboration based on the Eurostat COMEXT database on EU bilateral imports for the period 1999-2007. Average EU import prices and volumes from China at the HS-6 digit level from three years before to three years after the imposition of the anti-dumping measure at time $t = 0$, normalizing the average values to 1 for time $t = 0$. For unaffected products we consider time $t = 0$ as the median year in our sample. Imports volume expressed in hundreds of kilos. The import price is calculated by dividing the imports value and volume as reported by the Eurostat COMEXT database.

Furthermore, using the sector-level data of the Eurostat Structural Business Statistics (SBS) database it is possible to have a first look at the effect of the EU anti-dumping measures imposed on Chinese goods on domestic industries. In Table 1.3 we compare the relative performance of EU sectors at the 4-digit NACE rev.1.1 which have been protected or not by AD measures on Chinese imports before and after the imposition of these duties. We used two complimentary methods to identify the protected sectors in the EU market. First, to determine which sectors produce certain goods, and so to link product-specific AD duties with the domestic import-competing industries producing them, we used the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and the conversion table between HS and ISIC classifications provided by Hoekman et al. (2002). In addition, we have used the European Commission investigation reports which report also the industrial classification of firms petitioning for the adoption of each AD measure.

Table 1.3 presents the differences in sectoral performance before and after the adoption of AD duties in terms of total export value, labour productivity measured as the ratio of turnover on total employment, average size in terms of total employment, number of firms operating in the sector, value added measured as the gross income from operating activities after adjusting for subsidies and taxation, and total investment in R&D. First, it is possible to see that EU AD measures on Chinese products between 1999 and 2007 have protected 21 sectors, almost 10% of all manufacturing industries in Europe. Protected sectors are smaller in terms of number of operating firms despite employing on average a larger number of employees in respect to unaffected industries. Moreover, when looking at sectoral performance it is possible to notice that protected sectors export on average more than unaffected industries, showing as well a higher industrial productivity both in terms of added-value per worker and

Table 1.3: Sector-level characteristics of European industries protected or not by EU AD measures against Chinese products (1999-2007)

	Non-protected		Protected	
	Pre	Post	Pre	Post
No. Firms	1,080	1,086	712	698
	(3409)	(3476)	(841)	(826)
Added Value	6.964	6.931	7.667	7.550
	(1.742)	(1.449)	(1.226)	(1.284)
Labour Prod.	22.795	22.795	23.011	23.203
	(1.361)	(1.334)	(1.253)	(1.206)
Tot. Employment	17,038.21	16,264.93	21,568.68	21,452.6
	(25,146.84)	(24,535.33)	(21,341.96)	(20,386.79)
Tot. R&D	2.829	2.902	3.466	3.124
	(2.304)	(2.413)	(2.066)	(1.908)
Export Value	20.772	20.775	21.677	21.847
	(1.822)	(1.787)	(1.336)	(1.301)
No. Sectors	174	174	21	21

Note: Statistics based on the Eurostat Structural Business Statistics (SBS) database about all European manufacturing sectors at the 4-digit NACE rev.1.1 level in the period 1999-2007. The statistics presented for each variable refer to the average value in the periods before and after the imposition of anti-dumping duties in protection to the European sectors. For unaffected sectors we consider the periods preceding or following the median year in our sample. To identify the protected sectors we link product-specific AD duties with the domestic import-competing industries producing those affected goods, using the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and the conversion table between HS and ISIC classifications created by Hoekman et al. (2002). The statistics show the average number of firms operating in the sectors, the logarithm of the average added-value measured as the net income from operating activities after adjusting for subsidies and indirect taxes, the average labour productivity measured as the ratio between turnover and total employment, the average number of employees in the sectors, the logarithmic value of R&D investment and the logarithm of the average export value in the industries. All monetary values have been deflated using 2010 as a base year.

of labour productivity and investing more on average in R&D activities in comparison to unaffected industries.

1.3.3 Micro-level Analysis

The second part of this analysis focuses on the impact that anti-dumping measures have on the performance of European firms at the micro-level. To carry out this investigation we use French data at the firm-product-level over the period 1999-2007. The motivations for focusing our attention on France as a specific case study of the micro-level impact of EU AD measures towards Chinese dumped products are threefold. First, France is the third largest importer of Chinese products in the EU after Germany and the United Kingdom, mainly importing intermediate inputs rather than consumption goods (Eurostat, 2014). Secondly, France is the second most active Member State in the EU in terms of anti-dumping procedures. Table 1.4 presents the distribution of European firms complaining to the European Commission about dumping strategies across different Member States.

Table 1.4: Home countries of most active complainant industries in the EU (1999-2007)

Ranking	Country	Share	Ranking	Country	Share
1	Germany	47.5%	11	Luxembourg	4.0%
2	France	42.9%	12	Ireland	3.5%
3	Italy	41.9%	13	Slovenia	3.5%
4	Spain	35.4%	14	Sweden	3.5%
5	UK	21.7%	15	Slovakia	3.0%
6	Netherlands	16.2%	16	Greece	2.5%
7	Austria	10.6%	17	Portugal	2.5%
8	Belgium	5.6%	18	Finland	1.5%
9	Denmark	5.1%	19	Czech Rep.	0.5%
10	Poland	4.5%	20	Hungary	0.5%

Note: Statistics based on the European Commission investigation report for the period 1999-2007. The table presents the distribution of European firms complaining to the European Commission about dumping strategies across different Member States. The share represents the number of cases in which at least one of the petitioning firms belonged to the correspondent Member State over the total number of EU anti-dumping cases.

It is possible to notice that in almost 43% of the cases at least a French firm was petitioning for the introduction of anti-dumping measures, second just to German companies. Moreover, the voting pattern of Member States during the EU Council on anti-dumping decisions presented in the political economy literature indicates that French governments have been among the main supporters of AD measures in the EU Council after Portugal regardless of the political party in power, voting in favour of the introduction of new duties in 97% of cases, and never voting against them (Heisenberg 2005; Hayes-Renshaw et al. 2006; Trzaskowski 2009; Nordstrom 2011; Van Aken 2012). Finally, firm-level data about all EU Member States are still poor, with different definition of key variables and not providing a comprehensive coverage of the full sample of European companies. On the contrary, by using the French firm-level data we cover all manufacturing companies in France with more than 20 employees. In addition, thanks to the extremely detailed transaction-level trade dataset we are able to precisely identify the products and the origin of French firms imports at the HS-8 digit level.

To carry out the firm-level analysis on the effect of EU anti-dumping measures on producers and importers, we merged two different micro-level datasets on French firms for the period 1999-2007. First, firms' characteristics are obtained from the Annual French Business Survey (Enquête Annuelle d'Entreprise - EAE) surveyed by the National Institute of Statistics and Economic Studies (INSEE). This database provides detailed balance sheet information for all French firms with more than 20 employees, including total output, domestic and foreign sales, number of employees, salaries paid, cost of intermediate inputs, capital stock and R&D expenditure. Second, to analyse importers' activity and export behaviour, we used transaction-level imports data collected by the French Customs Agency which provides information about trade flows origin or destination country, HS-8 product-level categorization, value and weight of manufacturing imports and exports. This dataset includes all intra-EU shipments over €100,000, and all extra-EU imports over €1,000, covering more than 90% of French total manufactured goods imported.[8] Merging these two databases together, our final sample is an unbalanced panel containing comprehensive data about 30,000 French manufacturing firms over 9 years across 503 different sectors at the NACE 4-digit level in terms of their sector of production and import strategies.[9]

[8]During this period the threshold for intra-EU exports has changed considerably. Initially, it was equal to almost € 38,000 euros until 2001 when it was increased to € 100,000. Finally, it was moved to € 150,000 in 2006. For extra-EU exports the threshold has not been changed during the whole period. Nevertheless, these threshold changes do not affect the quality of our analysis since it has been demonstrated in the previous literature that small exporters account for a relatively small share of the overall French exports (Mayer and Ottaviano 2007).

[9]Less than 6,000 observations have been dropped from the final sample because of missing information about the key variables of interest, mismatch of export variables between the balance sheet and the custom

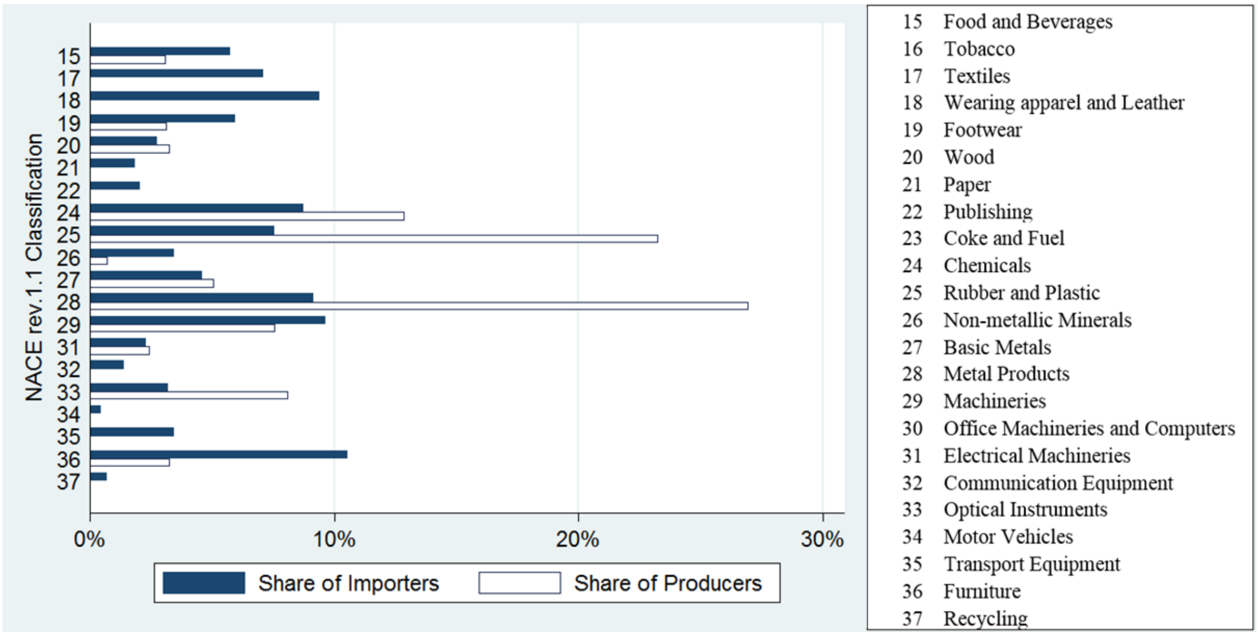
As previously stressed, thanks to this detailed firm-level data it is possible to precisely identify both French producers protected as well as French firms importing dumped Chinese goods affected by the EU anti-dumping measures. First, the EAE balance sheet database indicates the NACE rev.1.1 4-digit level industrial classification of all French firms. In this way, by using the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and by Hoekman et al. (2002) as previously explained, we are able to identify all French import-competing firms part of the domestic sectors protected by the EU anti-dumping duties on Chinese products. Secondly, using the exhaustive transaction-level trade dataset, we are able to precisely identify French import-dependent firms affected by the imposition of EU AD duties on Chinese goods. In particular, the firm-product-level imports data collected by the French Customs Agency provides information about the HS-8 digit-level product classification, the transaction value, volume and the country of origin of all products imported by French manufacturers. By merging this dataset with the Global Antidumping Database (GAD) of the World Bank it is possible to precisely identify all French firms which have imported the targeted dumped products from China and from other trade partners, recording in this way the import behaviours of French firms before and after the imposition of EU anti-dumping measures.

We start our firm-level analysis looking first in Figure 1.6 at the industrial distribution of French producers and importers affected by EU anti-dumping measures on Chinese products across the different 2-digit level sectors.

From Figure 1.6 it is possible to notice that the sectoral composition widely differs between producers and importers. In particular, the diagram shows that more than 40% of

agency datasets or because of single observations available.

Figure 1.6: Industrial distribution of French producers and importers affected by EU anti-dumping duties on Chinese products.



Note: Elaboration based on EAE and Custom Agency database on French firms over the period 1999-2007. Distribution of French producers and importers in each manufacturing industry at the NACE rev.1.1 2-digit level over total number of producers and importers. Producers defined as firms part of the domestic sectors at the NACE rev.1.1. 4-digit level protected by EU anti-dumping duties on Chinese products. Importers defined as firms which have imported the targeted dumped products from China at the HS-8 digit level.

French firms protected by AD duties produce metal or plastic products, each of these two sectors accounting for almost 25% of the total number of protected French import-competing firms. Another important sector frequently protected by EU AD measures against Chinese imports is the chemical industry which accounts for almost 14% of French producers protected. As previously discussed, this is one of the sectors which has been more active in the submission of protection petitions in the case of Chinese dumped products and accounts for a large number of producers in France. The remaining import-competing protected firms seem instead to be mainly located in the sectors for the production of optical and precision instruments, industrial machineries and the industry of basic metals.

The number of French import-dependent firms affected by AD measures on Chinese products instead seems to be more evenly distributed across different sectors. In fact, most of the affected importers are manufacturers of furniture and other final consumer goods, more than 10% each. This evidence might reflect the recent increase in AD measures imposed on final goods imported from China. At the same time, it might indicate that most of the goods imported from China and affected by EU AD duties are widely used by French manufacturers as intermediate inputs for the production of a large and heterogeneous group of final goods. This indicates a possible evidence that EU AD measures on Chinese imports might have a particularly significant and negative effect on a large number of consumers. The rest of French importers affected by EU AD measures on Chinese products seem to be mainly focused in the sectors for the production of industrial machineries, the manufacture of metal products, the production of chemical and other plastic goods and finally in the garment industry, all accounting for less than 10% of the total. Of particular relevance is the garment sector which has experienced a massive import penetration from China in the last decade after the "multi-fiber" agreement expired at the end of 2004. This phenomenon suggests again that AD measures might have been used by the EU as an instrument of trade defence to replace tariff barriers and import quotas (Moore and Zanardi 2011; Eckhardt 2013).

Table 1.5 presents some preliminary statistics about the performance of French firms, taking into consideration import-competing producers protected by anti-dumping duties, import-dependent firms importing the targeted products and the remaining firms completely unaffected by the imposition of EU anti-dumping measures on Chinese products. First, note that during the sample period just a few hundreds of importers have been affected by higher anti-dumping duties, while at the same time almost 3,500 domestic producers have been protected from the unfair competition of dumped-products. Secondly, Table 1.5 shows that importers of dumped products from China are on average larger and more productive in terms of TFP[10] then the rest of our sample, paying higher salaries, investing more in R&D

[10] To have a consistent measure of TFP we followed the De Loecker (2007) approach, which is an extension of the standard Olley and Pakes (1996) methodology, taking into consideration the heterogeneity in terms of

activities and being as well active exporters towards foreign markets.

Table 1.5: Firm-level characteristics of French producers and importers affected or not by EU AD duties against Chinese products (1999-2007).

	Importers			Producers			Untreated		
	Pre	Post	t-test	Pre	Post	t-test	Pre	Post	t-test
No. Firms	406	397		3,363	3,593		27,083	30,659	
Employment	396	388		134	134		128	120	
	(998.96)	(964.47)	3.928	(432.93)	(376.65)	0.788	(746.64)	(711.73)	3.232
Av. Salary	27,005	27,337		24,653	25,056		24,559	25,240	
	(8,373)	(7,936)	2.885	(7,135)	(7,407)	2.123	(8,496)	(9,905)	4.117
log(TFP)	4.934	4.901		4.437	4.505		4.409	4.436	
	(0.778)	(0.738)	0.338	(0.558)	(0.575)	4.810	(0.597)	(0.626)	2.398
R&D Inv.	2,442.37	3,622.57		640.32	639.41		608.13	594.26	
	(21,060)	(29,819)	0.349	(8,536)	(8,512)	1.876	(13,292)	(13,435)	2.475
Tot. Exports	49,948.98	54,309.34		11,050.03	12,705.97		10,906.04	10,938.65	
	(197,665)	(179,554)	1.871	(83,989)	(74,856)	3.125	(240,525)	(234,062)	3.795

Note: Statistics based on the Annual French Business Survey (EAE) for the period 1999-2007. Producers defined as French firms belonging to the sectors protected by EU anti-dumping duties on Chinese products identified by using the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and by Hoekman et al. (2002). Importers identified as all French firms which have imported from China the targeted dumped products according to the transaction-level Customs Agency dataset. We consider as untreated all the remaining French manufacturing firms not included in the previous two categories. The statistics presented for each variable refer to the average value in the periods before and after the imposition of EU anti-dumping duties against Chinese products. For unaffected firms we consider the periods preceding or following the median year reported in the dataset. The table presents summary statistics about the yearly average number of firms in each category, the average number of employees per firm, the average annual salary paid in Euro, the average firm productivity estimated as the log of total factor productivity following the De Loecker (2007) approach, the average investment in R&D activities and the average value of exports in thousands of Euro. T-test reports the t-value of the null hypothesis that the difference between the values before and after the imposition of the AD measures is significantly different from 0 (critical value for significance at the 10% level above 120 degrees of freedom=1.645). All monetary values have been deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

In addition, it is interesting to notice the difference in terms of performance for affected firms before and after the imposition of AD measures on Chinese products. For instance, producers after being protected by an anti-dumping measure register a stable level of employment, paying higher salaries but show a lower level of investment in R&D activities. On the contrary, importing firms facing higher import duties experienced a decrease in their

productivity between exporters and domestic firms and between innovators and non-innovators as explained in the appendix AT.1. In our TFP estimation we have used value added as a proxy for output, including in the estimation total employment as a measure for labour, the total costs of intermediate input as costs of production, an export dummy equal to 1 for exporters or 0 otherwise, and total investment in tangible and intangible assets such as R&D. Once estimated and logged, we remove the top and bottom percentiles without any significant loss of observations, following the ISGEP (2008) approach in order to mitigate the effect of outliers on our analysis.

total employment and productivity, despite an increasing amount of resources dedicated to R&D activities, while they keep a stable level of salaries paid. In addition, total exports of firms in both categories do not seem to be affected by the imposition of AD measures, increasing in proportion even more for affected importers rather than for domestic producers. Furthermore, it is particularly interesting to compare the productivity distribution of import-dependent, import-competing and unaffected French firms. In fact, it is possible to note that the level of productivity widely differs between the three groups. While the level of TFP for import-competing and unaffected firms is quite similar both before and after the imposition of the anti-dumping measures, affected import-dependent firms are characterised by higher levels of TFP in comparison to the other two groups, almost 10% larger on average. As a result, EU anti-dumping measures on Chinese products seem to protect import-competing firms characterised by low levels of productivity, while imposing higher duties on the import of Chinese intermediate inputs of production used by highly productive import-dependent firms. Overall, these preliminary statistics show some first clues about the key role played by productivity in the firm-level analysis of anti-dumping measures. In the next section we will take into account this evidence in our model to properly estimate the firm-level effect of EU anti-dumping measures against Chinese products on import-dependent and import-competing French manufacturers.

1.4 Methodology

The aim of our analysis is to estimate the effect on the overall European economy of EU anti-dumping duties imposed on Chinese products. In particular, we would like to identify the impact of these anti-dumping measures on trade flows and on the performance of European protected sectors. At the firm-level, we will use France as a case study for the rest of the

EU, estimating the effect of EU AD measures against Chinese products on French import-competing producers and on import-dependent manufacturers. Specifically, we are interested in comparing the differences before and after the introduction of AD duties for observations affected or not by the imposition of these measures. However, this kind of estimation is not straightforward. As previously discussed in the literature, the imposition of anti-dumping measures is not an exogenous and randomized treatment, but is very likely affected by a number of endogenous factors influencing the political AD decision process.

In this regard, our analysis might be affected by two different sources of bias, as described by Konings and Vandenbussche (2008) and Pierce (2011). The first is a selection bias in which observations affected by an AD duty are different from those which have not been involved in these procedures. For instance, all products and domestic sectors which are subject to a strong import competition from China are more likely to be protected by AD measures, and as we have seen earlier, most of the EU-China anti-dumping cases have been concentrated in a few specific sectors, namely metals, chemicals and machineries. Another source of bias might refer to the political decision by the European Commission and the Member States of whether to impose or not anti-dumping measures based on factors other than the technical trade defence aspects, such as productivity, employment growth and other macroeconomic trends. Secondly, since we are not working on a natural experiment, the counterfactual of not being treated for an observation which instead has been affected by the imposition of AD duties is not observable, making it even harder to assess the real impact of the imposition of AD measures while controlling for other relevant factors.

Hence, in order to properly estimate the causal effect of EU anti-dumping duties against Chinese products we apply a difference-in-differences propensity score matching technique at the product, sectoral and at the firm-level (Lechner 2002; Leuven and Sianesi 2003). A number of related studies use a difference-in-differences estimation technique to analyse the causal relationship between protection and performance (e.g. Konings and Vandenbussche 2005; Konings and Vandenbussche 2008; Lu et al. 2013). The aim is to assess the average treatment effect on the treated (ATT), in other words to estimate the difference of the outcome variable between the observations which have been affected by anti-dumping measures (the treatment) and similar ones which instead have not been treated. To compare the differences before and after the imposition of the AD duties we rescale the time periods in order to consider time $t = 0$ as the time in which the observations have been affected by the introduction of EU anti-dumping measures against Chinese products. Based on that, we measure the growth rate of the outcome variables over the following three years in comparison to the pre-treatment period, in order to assess the effect of AD measures in the years following the imposition. We define y_t as the outcome variables for all the observations at time t and y_{t+n} for the following n periods. The causal effect of AD duties on the outcome variables at time $t + n$ can be though identified as the difference between:

$$y^1_{t+n} - y^0_{t+n} \tag{1.1}$$

where the subscripts denote whether the observations have been affected by the AD treatment at time t or not. Thus, $y^0_{(t+n)}$ represents the outcome for an observation at time $t + n$ which has not been affected by an anti-dumping duty at time t. We investigate the impact of anti-dumping duties on a number of outcome variables for each level of analysis. In particular, at the product-level we will estimate the effect of the imposition of AD duties on all EU imports volume and prices from China, and we will test as well possible trade diversion and defection effects looking at volumes and prices of EU imports from other extra-EU countries and for the intra-EU trade. At the sectoral level instead, the outcome variables of interest will be the overall value of production in the European sectors protected by anti-dumping measures, their turnover, the employment growth, their labour productivity, the survival rate of firms in these sectors and the export performance. Finally, we will investigate the impact of AD duties on import-competing and import-dependent French companies, using firm-level outcome variables such as TFP, total employment, firm investment in R&D, export performance and their survival rate. Since we are interested in identifying the differences in the outcome variables after the introduction af an anti-dumping measure, we can express the average effect that treated observations would have experienced if they had not been affected by AD duties as:

$$\tau_{ATT} = E\left(y^1_{t+n} - y^0_{t+n} \mid S_t = 1\right) = E\left(y^1_{t+n} \mid S_t = 1\right) - E\left(y^0_{t+n} \mid S_t = 1\right) \tag{1.2}$$

in which τ represents the expected effect on outcome y of the AD treatment in the post-treatment period, relative to the effect of no treatment for the same observation. The fundamental problem is that only one of the two possible outcomes in the previous equation is observed, whether the observation has been affected by an anti-dumping measure or not, while the counter-factual for the same observation could not be observed. Since $E\left(y^0_{t+n} \mid S_t = 1\right)$ is not observable, we will construct at each level of analysis a suitable control group by considering instead the effect of no treatment on similar observations which have not been affected by AD duties, $E\left(y^0_{t+n} \mid S_t = 0\right)$.

Following Pierce (2011) we decide to use a propensity score matching technique in order to select from the sample of untreated observations suitable control groups for which the distributions of observed characteristics are as close as possible to the distribution of treated observations before the imposition of the anti-dumping measures, controlling in this way for the different sources of bias that we have previously considered. Matching methods allow to correct the endogeneity bias thanks to the construction of valid control groups at each level of analysis based on the observable differences between treated and untreated observations. Since we want to estimate the impact of EU anti-dumping measures against imports from China at the product, sectoral and firm-level, we build a treatment and a control group at each of these levels.

To identify the treated observations at the product-level we use data on all imported goods in the EU at the HS 6-digit level distinguishing between different origins. The treatment group will consists of products imported from China and targeted during our period of interest by EU anti-dumping duties. For the sector-level analysis instead we use data about all EU manufacturing sectors at the NACE rev.1.1 4-digit level. In this case, the treated group will consist of all domestic sectors at 4-digit-level which have been protected against the import penetration of specific dumped products from China. To determine which sectors produce certain goods, and so to link product-specific AD duties with the European industries producing them, we used the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and the conversion table between HS and ISIC classifications provided by Hoekman et al. (2002). Finally, as previously discussed, we use detailed French firm-transaction-level data to identify the treated groups for import-competing and import-dependent firms. In particular, to identify the group of treated French producers protected by EU anti-dumping against Chinese products we use the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and by Hoekman et al. (2002) as previously explained to identify all French import-competing firms part of the protected domestic sectors. To build instead the treatment group of French import-dependent firms affected by EU AD duties on Chinese goods we use the detailed transaction-level imports data collected by the French Customs Agency which allows to precisely identify all French firms which have imported the targeted dumped products from China and from other trade partners.

In order to build consistent control groups to be compared with the treated observations we apply a propensity score matching (PSM) approach as introduced by Rosenbaum and Rubin (1983) and Heckman et al. (1997). The aim of matching techniques is to select from the sample of untreated observations a control group for which the distribution of observed characteristics in the pre-treatment period is as similar as possible to the distribution of treated observations (Becker and Ichino 2002). In this way, it is possible to correct the endogeneity bias thanks to the construction of valid control groups based on the observable differences between treated and untreated observations and to identify the causal effect of anti-dumping measures. The first step is to estimate the probability for an observation of being affected (treated) by the introduction of anti-dumping measures, the so called propensity score, based on a set of observable characteristics. We use a logit model to estimate the propensity score of all observations at each level of analysis, using in turn several sets of covariates at the product, sector and firm-level.

At the product-level, we estimate the probability of being subject to an EU anti-dumping measure against Chinese goods by considering a set of product and macro-level variables. First, the product-level propensity score will be conditional on the import penetration of each specific product at the HS-6 digit level imported from China to the EU $IP(China)_{pt-1}$, measured as the ratio between import value from China over total imports, and on the number of previous anti-dumping investigations started by the European Commission on each product at the HS-6 digit level N_{pt-1} as suggested by Blonigen (2006). In this way we will compare treated and untreated products which have experienced similar imports penetrations from China and have analogous record of anti-dumping investigations. Moreover, following Knetter and Prusa (2003) as extra controls we include a year and a HS-2-digit product dummy in order to account for possible macro-level shocks:

$$AD(Product)_{pt} = \beta_0 + \beta_1 IP(China)_{pt-1} + \beta_2 N_{pt-1} + k_p + k_t + \xi_{pt} \tag{1.3}$$

In order to carry out the sector-level analysis, we estimate the probability for EU sectors at the NACE rev.1.1 4-digit level to be protected by EU anti-dumping measure against unfair Chinese competition. The variables used to predict this probability include import penetration from China suffered by each sector $IP(China)_{st-1}$, measured as the value of Chinese imports over total imports in the sector, the sector-level added-value per worker AV_{st-1}, measured as the net income from operating activities after adjusting for subsidies and indirect taxes over total employment, the investment intensity Inv_{st-1}, measured as the ratio between investment in fixed assets and total output, and the employment growth in the sector $\Delta Empl_{st-1}$. In this way, following Pierce (2011) we will compare industries which have experienced similar levels of import competition from China while taking into account as well some measures of performance to detect any possible evidence of recession and economic crisis at the sectoral level. In addition, we include the number of petitions submitted by each sector to the European Commission about anti-dumping investigations N_{st-1} and industry and year dummies:

$$\begin{aligned} AD(Sector)_{st} =& \beta_0 + \beta_1 IP(China)_{st-1} + \beta_2 \Delta Empl_{st-1} + \beta_3 AV_{st-1} + \beta_4 Inv_{st-1} + \\ & \beta_5 N_{st-1} + k_s + k_t + \xi_{st} \end{aligned} \tag{1.4}$$

Finally, we estimate the probability of being affected by EU anti-dumping measures against Chinese goods at the firm-level both for French producers and importers. Since the identification of the two treated groups relies on different techniques, also the estimation of the firm-level propensity score for the two groups will be separated. For the import-competing firms, as previously explained, thanks to the French firm-level EAE balance sheet database we are able to precisely identify all the firms belonging to protected sector at the NACE rev.1.1 4-digit level. Thus, we will be able to compare the performance of import-competing firms vis-à-vis other similar French producers which have not been protected by EU AD duties on Chinese products. The estimation model used to predict this probability score follows the one presented in the above equation, considering the import penetration from China suffered by French sectors at the NACE rev.1.1 4-digit-level $IP(China)_{st-1}$, the employment growth in these industries $\Delta Empl_{st-1}$, the investment intensity Inv_{st-1} measured as the ratio between investment and total output and the added-value per worker of the sector in which French firms operate AV_{st-1} in order to take into account the industry-level factors which affect the decision for the imposition of AD duties. Also in this case we include the number of filing cases submitted to the European Commission about anti-dumping investigations N_{st-1} and industry and year dummies:

$$\begin{aligned} AD(Producers)_{it} =& \beta_0 + \beta_1 IP(China)_{st-1} + \beta_2 \Delta Empl_{st-1} + \beta_3 AV_{st-1} + \beta_4 Inv_{st-1} + \\ & \beta_5 N_{st-1} + \beta_6 Empl_{it-1} + \beta_7 TFP_{it-1} + \beta_8 Exp_{it} + k_i + k_t + \xi_{it} \end{aligned} \tag{1.5}$$

In addition, to build a precise control group for import-competing firms, in the matching process we include firm-level variables in order to also take into account firm-specific characteristics when comparing treated and untreated firms. More specifically, we consider firm size in terms of total employment $Empl_{it-1}$, total factor productivity TFP_{it-1} and the export status Exp_{it}.

With regard to import-dependent firms, we follow a different approach to estimate the probability for French importers to be affected by the imposition of EU anti-dumping duties on the imports of certain goods from China. In particular, the likelihood for an import-dependent firms of being affected by anti-dumping measure depends on the kind of products imported from China, the sector in which firms operate, the import strategy followed and other firm-specific characteristics. For these reasons in the propensity score estimation model for import-dependent firms we included product, sector and firm-level variables to take into account of all the possible factors influencing the probability for a French importer to be affected by EU AD measures on Chinese products. At the product-level, we take into account the import penetration of the product imported from China at the HS-8 digit level $IP(China)_{pt-1}$, measured as the ration between import value from China to the EU over total imports, and on the number of previous anti-dumping investigations started by the European Commission on these products at the HS-6 digit level N_{pt-1}. In addition, we include firm-level variables in order to take into account of firm-specific characteristics which could affect the probability of each single French firm to be targeted by EU anti-dumping measures on imported products from China. In particular, we consider firm size in terms of total employment $Empl_{it-1}$, total factor productivity TFP_{it-1}, the export status Exp_{it} and the value of firms total imports Imp_{it-1} in order to accurately match similar treated and untreated French firms based on their characteristics and also in terms of their import behaviours. Finally, we include year and industry dummies at the NACE rev.1.1 2-digit level in order to take into account of any sector-specific factor concerning French manufacturing industries and any other time varying effect:

$$\begin{aligned} AD(Importers)_{it} =& \beta_0 + \beta_1 IP(China)_{pt-1} + \beta_2 N_{pt-1} + \beta_3 Empl_{it-1} + \beta_4 TFP_{it-1} + \\ & \beta_5 Exp_{it} + \beta_6 Imp_{it-1} + k_t + k_s \xi_{it} \end{aligned} \tag{1.6}$$

In Table 1.6 we present the results of the propensity score estimations at the product, sector and firm levels. In the first column, it is possible to note that products at the HS-6 digit level have a higher probability of being targeted by EU anti-dumping duties if they have registered a large import penetration from China in the recent years and if they have been already part of previous EC anti-dumping investigations. From columns 2 and 3 it is evident that also a strong import penetration of Chinese goods at the sectoral level increases the likelihood for those industries to be protected by EU anti-dumping duties. Moreover, also at the sectoral level the number of previous petitions increases the probability of anti-dumping measures adoption, corroborating the previous predictions about the importance for European industries of lobbying experience in order to decrease the cost of filing petitions and to improve the likelihood of successful applications (Blonigen 2006).

In addition, other industry-level characteristics seem to affect the probability for a sector to be protected. In particular, it appears that more productive sectors are less likely to be protected by anti-dumping measures while a decrease in the number of workers employed in the sectors significantly increases the probability of AD duties adoption. Also the sector-level analysis supports the previous argument that the imposition of anti-dumping measures is affected by factors other than the pure dumping strategy of exporters. From this evidence it seems that the EU is using anti-dumping duties as a sort of protectionist measure in order to protect the most vulnerable European sectors which are more exposed to the import competition of Chinese goods and are hence experiencing decreasing levels of productivity and employment. Column 4 instead shows the probability for French firms to be affected by the imposition of AD duties on their imports from China. Also in this case the penetration ratio and the previous AD investigations of Chinese goods imported by French manufacturers seem to increase the probability of being affected by EU anti-dumping duties. In addition, also importers firm-level characteristics matter, since large, more productive and internationalised

Table 1.6: Propensity score estimation at the product, sector and firm-level (French producers and importers).

	(1) EU Product-level	(2) EU Sector-level	(3) Firm-level French Producers	(4) Firm-level French Importers
$IP(China)_{pt-1}$	4.428***			3.811***
	(0.766)			(0.587)
$FilingCase_{pt}$	1.258***			0.042**
	(0.113)			(0.021)
$IP(China)_{st-1}$		3.089**	7.398***	
		(1.695)	(0.299)	
$FilingCase_{st}$		0.418***	0.452***	
		(0.097)	(0.020)	
$\Delta Employment_{st-1}$		-0.482**	-0.057***	
		(0.249)	(0.006)	
$AddedValue_{st-1}$		-2.187**	-0.174***	
		(0.849)	(0.006)	
$Inv.Int._{st-1}$		0.009	0.071***	
		(0.027)	(0.005)	
$Tot.Employment_{it-1}$			0.269***	0.231***
			(0.031)	(0.082)
TFP_{it-1}			0.159***	0.150
			(0.061)	(0.155)
$Exporter_{it}$			0.570***	1.420***
			(0.068)	(0.339)
$Tot.Imports_{it-1}$				0.427***
				(0.048)
Observations	21,642	1,065	25,036	27,654
Year FE	Yes	Yes	Yes	Yes
Product FE	Yes	No	No	No
Industry FE	No	Yes	Yes	Yes

Note: The estimation model used is a logit with fixed-effects. Unreported year, product (HS 2-digit) or industry (NACE rev.1.1, 2-digit) dummies are included. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. In the first column the dependent variable is a dummy equal to 1 if the product imported in the EU has been subject to an anti-dumping duty on Chinese goods at time $t = 0$ and 0 otherwise. In column 2 the dependent variable is a dummy equal to 1 if a EU industry at the NACE rev.1.1 4-digit level has been protected by EU anti-dumping measure against Chinese goods and 0 otherwise. In column 3 the dependent variable is a dummy equal to 1 if a French firm belongs to one of the protected sectors at the NACE rev.1.1 4-digit level and 0 otherwise. In column 4 instead the dependent variable is a dummy equal to 1 if a French firm has imported one of the affected products from China at the HS-8-digit level during the anti-dumping period and 0 otherwise. The regressors at the product-level are the import penetration at the HS-6 digit from China to the EU measured as the ration between import value from China over total EU imports as reported in the Eurostat COMEXT database, and the number of previous anti-dumping investigations started by the European Commission on each product at the HS-6 digit level as reported in the EC Investigation Reports. At the industry-level the control variables at the NACE rev.1.1 4-digit level include the import penetration from China measured as the value of Chinese imports over total imports as reported in the COMEXT database, the added-value per worker measured as the net income from operating activities after adjusting for subsidies and indirect taxes over total employment, the investment intensity measured as the ratio between investment in fixed assets and total output, and the annual employment growth as reported in the Eurostat Structural Business Statistics (SBS) database and the number of petitions submitted to the European Commission about anti-dumping investigations. The firm-level control variables include French firms total employment, the log of total factor productivity calculated following the De Loecker (2007) approach, an export dummy equal to 1 if the firms is an exporter and 0 otherwise and the log value of firms total imports as reported in the Annual French Business Survey (EAE) and the Custom Agency Trade database. All control variables except the number of petitions filled and the export dummy are lagged one year.

companies have a higher probability to be affected by the imposition of AD duties on their imports from China.

After estimating the probability of being affected by EU anti-dumping measures on Chinese goods at each level of analysis, we proceed by matching within each category the untreated and treated observations based on the estimated propensity scores. In particular, we are interested in matching untreated observations which have estimated probabilities which are as close as possible to those of the observations actually affected by AD duties on Chinese products. Moreover, imposing a common support condition we will drop the treated observations whose propensity scores are larger or smaller than the maximum or minimum of those never affected. Different matching algorithms have been proposed in the literature, mainly varying in terms of how the neighbourhood of control individuals is built around the treated observations, providing different solutions to the trade-off between matching quality and variance (Caliendo and Kopeinig 2008). In this chapter we apply a Kernel matching technique with a strict bandwidth of 0.01 to match just observations for which the distance between their propensity scores is the smallest possible. The Kernel matching estimator associates to the outcome y_{it} of treated individual i a matched outcome given by a kernel-weighted average of the outcome of comparable non-treated observations, where the weight given to non-treated j is in proportion to the closeness between i and j. In other words, using the Kernel technique we are able to down-weight the contribution to the outcome of non-treated individuals which are farer from the treated observations within a certain range (i.e. bandwidth) of the propensity score distribution. Using a weighted smoothed matching estimator, like the Kernel, presents several advantages in respect to other matching procedures, particularly in reducing the median standardized bias between treated and control groups. In addition, it permits to exploit as much information as possible in matching observations from the control group, gaining in this way in precision without losing anything in terms of matching quality (Leuven and Sianesi 2003; Caliendo and Kopeinig 2008). Standard errors have been bootstrapped with 500 repetitions for heteroskedasticity consistency, taking into account the additional source of variability introduced by the estimation of the propensity score in the Kernel matching process (Heckman et al. 1997; Abadie and Imbens 2011).

In order to verify the consistency of the construction of the control groups and the overall quality of the matching procedure, we run several balancing tests to examine the distribution of the propensity score and the quality and the precision of the matching algorithm. To check the propensity score balancing we calculate the mean differences across the treatments and the control groups for a set of observable characteristics comparing them before and after the matching. Even if differences between the treated and the control groups are expected before matching, these differences should be significantly reduced after the matching has taken place. In Tables A.1.4, A.1.5, A.1.6 and A.1.7 in the appendix we present several tests assessing the comparability of the two groups at each level of analysis, in particular testing whether the covariates used to control the probability of being affected by EU anti-dumping measures are not significantly different between the treated and the control groups, and presenting the achieved percentage reduction in the standardised bias after the matching (Caliendo and Kopeinig 2008). According to Rosenbaum and Rubin (1985) the bias after the matching procedure between treated and untreated observations should not exceed the 25% threshold in order to deliver a consistent matching. As it is possible to notice also in Figure A.1.1 the kernel matching technique substantially reduces the bias for most of the regressors, and none of the absolute standardized bias exceed 25%. Also the variance ratios between treated over non-treated indicate a good balance for most of the covariates, with none of them being of particular concern for the quality of the matching. These results indicate that there are no systematic differences in the observables characteristics between treated and control groups, demonstrating that the matching procedure satisfies the balancing property and that the conditional independence assumption is not violated, assigning the appropriate controls to treated observations (Rosenbaum and Rubin 1985). In addition, in Figure A.1.2 in the appendix we check whether the propensity scores for the four different levels of analysis are balanced across the different groups of treated and control observations (Imbens 2004; Garrido et al. 2014). From Figure A.1.2 it is possible to notice that the probability of being affected by EU anti-dumping measures for treated and untreated observations has a similar density distribution, demonstrating how the probability of being treated is sufficiently balanced between affected and unaffected observations.

The combination of matching and difference-in-differences techniques is likely to increase the quality of our empirical analysis. In particular, basing the matching procedure on a number of observable characteristics we are able to compare closely related observations, characterized by similar macro and micro-level factors, and to tackle the endogeneity related to the selection bias (Blundell and Dias 2009). Secondly, the difference-in-differences technique should remove the effects of common shocks and provide a robust estimation of the causal effect of EU anti-dumping measures against Chinese products at the product, sector and firm-level for import-competing and import-dependent manufacturers. In particular, at the product-level we will look at the effect on the growth of trade volumes and prices for affected products imported in the EU from China and from the rest of the world for the following 3 years after the entry into force of the AD duties with respect to the pre-treatment level. For the sector analysis instead we will consider the effect of the protection provided by EU anti-dumping duties against Chinese goods on the performance of European industries, focusing specifically on the sectoral total output, the number of firms operating in the market, the employment growth, the industrial productivity in terms of added-value per worker and the innovative efforts of European manufacturing sectors. Moreover, at the firm-level, we will analyse the effect of AD measures on the performance of both French import-competing and import-dependent firms, estimating the impact on total factor productivity, on employment growth, total R&D investment and on the survival rate in the market of these firms.

1.5 Empirical Findings

1.5.1 Product-level analysis

We start by looking at the effect of EU anti-dumping measures against Chinese products on import flows, considering both the impact on volumes and on prices. In addition, we decompose the analysis of import flows considering not only the bilateral trade relationship between the EU and China, but also looking at the spillover effect on intra-EU trade and on imports from the rest of the world. As stressed by the previous literature, the imposition of AD duties might cause a significant distortion not only for the affected bilateral trade relationship, but for trade flows in general with possible effects of trade deflection and distortion (Konings et al. 2001; Bown and Crowley 2007; Vandenbussche and Zanardi 2010). Table 1.7 presents the impact of AD duties against Chinese goods on the growth of EU import flows, looking both at the impact on volume and prices and comparing the effect for products at the HS-6 digit-level affected or not by the EU anti-dumping measures on imports from China, on intra-EU trade and on imports from the rest of the world for the following 3 years after the imposition of these duties.

As expected, the import volume of Chinese products targeted by EU anti-dumping measures is negatively affected after the imposition of AD duties, and it is reduced by almost 86% in 3 years in respect to the pre-antidumping period. Looking at the effect on prices it is possible to notice that the negative impact on volumes is mainly due to a surge of import prices of Chinese products, increasing by 10% on average in 3 years, suggesting that EU anti-

Table 1.7: Impact of EU AD measures against Chinese products on EU import flows (volume and prices)- ATT effects with Kernel matching.

	PRICE			**VOLUME**		
	t	t+1	t+2	t	t+1	t+2
	CHINA					
ATT	0.0485*	0.0737*	0.102**	-0.448***	-0.779***	-0.869**
b.s.e.	(0.0245)	(0.0438)	(0.0487)	(0.109)	(0.233)	(0.322)
	INTRA-EU					
ATT	0.0138	0.0170	-0.0593	-0.0806	0.0415	0.0281
b.s.e.	(0.0447)	(0.0473)	(0.0745)	(0.0634)	(0.177)	(0.303)
	ROW					
ATT	0.0941***	0.159***	0.148**	-0.0563	0.0350**	0.0293*
b.s.e.	(0.0358)	(0.0569)	(0.0658)	(0.0561)	(0.0176)	(0.0173)
	TOTAL IMPORT					
ATT	0.0621*	0.0625*	0.0324	-0.101*	0.00561	-0.00798
b.s.e.	(0.0365)	(0.0300)	(0.0508)	(0.0593)	(0.189)	(0.310)
Treated	63	63	63	63	63	63
Control	17,765	17,765	17,765	21,642	21,642	21,642

Note: estimation based on Eurostat COMEXT import data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of products included in the common treated and control groups is reported. The dependent variables are the growth of the annual import prices and volumes from China to the EU, for the intra-EU trade, for imports from the rest of the world excluding China and intra-EU trade and for total imports to the EU of the products at the HS-6 digit-level affected by EU anti-dumping duties on Chinese imports. We report the ATT effects of the impact of EU AD measures against Chinese products on EU import volumes and prices against products which have not been affected for the following three years after the imposition of the anti-dumping duty.

dumping duties have effectively targeted Chinese dumped products, increasing their import prices and pushing them up to a fairer market-level and drastically reducing the volume of Chinese goods imported in the EU single market.

Then, we estimate the impact of these AD duties on intra-EU trade, on flows from the rest of the world (ROW) and on EU total imports to investigate whether the import flows of products affected by EU AD measures on Chinese imports from other countries have suffered from any indirect effect. First, we notice that intra-EU trade has not been affected by anti-dumping measures on Chinese products, not showing any significant difference between affected and unaffected products in terms of prices and volumes. On the contrary, the imposition of AD duties on Chinese products seems to marginally increase by almost 3% the import volumes from the rest of the world in the following 2 years after the entry into force of these measures, despite a significant 15% increase in the import prices of affected goods from these countries. This is a clear evidence of trade diversion linked to the imposition of EU AD measures against China, with a shift of EU imports away from Chinese dumped products to more expensive imports from other extra-EU countries. In addition, by analysing the overall impact on EU total imports we find evidence as well of a trade distortion effect linked to a general increase of import prices for products affected by EU AD duties against China. Nevertheless, the higher prices do not seem to disrupt the overall volume of EU imports after a marginal reduction of 10% in the first year.

To sum up, EU anti-dumping duties successfully targeted dumped Chinese products, pushing their import price towards market-levels and decreasing the volume of imports from China. Intra-EU trade does not seem to be statistically affected by the imposition of these AD duties, while extra-EU imports experience a significant increase despite a general growth in import prices, highlighting a trade diversion effect of EU anti-dumping measures on Chinese goods.

1.5.2 Sectoral-level analysis

After the estimation of the impact on EU trade flows at the product-level, we are interested in analysing whether EU anti-dumping measures on Chinese products have been successful in protecting the domestic European industries from the "material injury" caused by the unfair competition of dumped Chinese products. In Table 1.8 we present the results of the DID-PSM estimation of the impact of EU AD duties against Chinese products on the domestic protected industries, looking at the overall number of firms operating in these sectors, the employment growth, the overall domestic production, turnover, labour productivity and

Table 1.8: Impact of EU AD measures against Chinese products on EU manufacturing industries - ATT effects with Kernel matching.

	Tot. Production			**No. Firms**		
	t	t+1	t+2	t	t+1	t+2
ATT	0.0961***	0.0979***	0.0386	-0.00825	-0.0181	0.00375
b.s.e.	(0.013)	(0.0126)	(0.0313)	(0.00921)	(0.0164)	(0.0244)
	Tot. Employment			**Turnover**		
	t	t+1	t+2	t	t+1	t+2
ATT	0.0427**	0.00760	-0.00779	0.234*	0.114	0.229
b.s.e.	(0.0220)	(0.0329)	(0.0696)	(0.129)	(0.243)	(0.475)
	Added-Value			**Tot. R&D**		
	t	t+1	t+2	t	t+1	t+2
ATT	0.0499*	0.0646*	0.0530	0.0545	-0.201	-0.394
b.s.e.	(0.0288)	(0.0347)	(0.0424)	(0.160)	(0.188)	(0.257)
Treated	21	21	21	21	21	21
Untreated	174	174	174	174	174	174

Note: estimation based on the Eurostat Structural Business Statistics (SBS) database between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of European industries at the NACE rev.1.1 4-digit-level included in the common treated and control groups is reported. The dependent variables are the growth of sectoral output value, the number of firms operating in the sectors, the growth of total employment, of sectoral turnover, of industrial productivity in terms of added-value per worker measured as the net income from operating activities after adjusting for subsidies and indirect taxes over number of employees and the growth rate of R&D investment in the industry. We report the ATT effects of the impact of EU AD measures against Chinese products on EU industries against unprotected sectors for the following three years after the imposition of the anti-dumping measure.

sectoral investment in R&D.

First, it is possible to notice that after the imposition of anti-dumping measures the import-competing industries in Europe registered a significant growth of total production, almost 10% larger than the pre-duty period. Also total employment and the industrial turnover of EU protected sectors increase after the entry into force of higher duties on Chinese products, but just with a short-term significant effect in the year immediately following the imposition of these AD measures. However, despite the introduction of AD duties the number of firms surviving in the protected industries does not significantly differ in respect to unaffected sectors, suggesting an inefficiency of the AD measures in protecting injured sectors and in preventing European companies from shutting down as a result of the Chinese import competition. Nevertheless, the overall domestic supply increases in order to compensate for the drop of imports from China which now face higher duties, highlighting how EU AD measures at least successfully helped domestic industries by relaxing the Chinese import penetration, boosting the overall production and slightly increasing the levels of employment in the EU.

Finally, we can analyse the effect of AD measures on sectoral labour productivity, measured as added-value per worker, and total investment in R&D. From Table 1.8 it is possible to notice that the introduction of anti-dumping duties marginally increases the productivity of protected industries by almost 6% in two years, mainly due to the overall increase of domestic sectors total output. On the contrary, after the introduction of AD measures these sectors have not increased their investment in R&D in comparison to unprotected industries. Apparently, domestic sectors do not profit from the protection provided by higher duties on Chinese products to invest in R&D activities which could help especially European mature industries to face and challenge the import competition of China and other rapidly emerging countries.

1.5.3 Firm-level analysis

We focus now on the micro-level analysis of the EU anti-dumping measures against Chinese goods, evaluating both the firm-level impact on producers and on importers of the targeted products. As previously explained, we use French firm-level data and the product-sector correspondence tables provided by the United Nations Statistics Division and by Hoekman et al. (2002) to identify French producers of the affected goods which are part of the industries protected by AD duties at the NACE rev.1.1. 4-digit level. Then, using transaction import data from the French Custom Agency we can identify as well the manufacturing firms importing the targeted products from China at the HS-8 digit-level, estimating in this way the effect of higher duties on intermediate inputs on their performance. We provide for the first time a comprehensive analysis of the effect of this trade policy on the whole sample of domestic firms affected, not only protected import-competing producers but also import-dependent firms which were using and exploiting cheap products imported from China. Applying a difference-in-differences technique with propensity score matching, we compare the impact of AD measures on targeted firms in respect to unaffected companies (the control group) before and after the imposition of the anti-dumping duties. In this way we can assess the effect of the anti-dumping duty on firms' performance, looking specifically at the impact on firms' productivity, on employment growth, R&D investment, total exports and on the survival rate of firms in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. Table 1.9 presents the results of the estimation of the impact of EU AD measures against Chinese products on French import-competing and import-dependent firms.

First, notice that EU anti-dumping measures against Chinese imports seem to have an opposite and contrasting effect on French producers performance. On the one hand, AD duties successfully protect domestic producers from the unfair competition of dumped Chinese products, mainly increasing the probability of producers survival rate and reverting the negative trend in employment in these firms which register an employment growth of 6% two years after the entry into force of the anti-dumping measures. Nevertheless, the EU AD duties do not improve the export performance of French producers and similarly does not significantly affect firms propensity toward R&D investment, despite the opportunity given by these measures to be protected from Chinese import competition and to dedicate more resources on industrial and production re-organization. On the other hand, the AD protection from Chinese dumped products comes at the cost of a sharp decrease of producers' total

Table 1.9: Impact of EU AD measures against Chinese products on French import-competing and import-dependent firms - ATT effects with Kernel matching.

	PRODUCERS			**IMPORTERS**		
	t	t+1	t+2	t	t+1	t+2
	TFP					
ATT	-0.0465***	-0.0379**	-0.0256	-0.125**	-0.0921**	-0.0771
b.s.e.	(0.0136)	(0.0159)	(0.0182)	(0.0540)	(0.0427)	(0.0756)
	Tot. Employment					
ATT	-0.0217**	0.00797	0.0600***	-0.0398*	-0.0899**	-0.00193
b.s.e.	(0.00771)	(0.0102)	(0.0128)	(0.0227)	(0.0416)	(0.0570)
	Tot. R&D					
ATT	-0.0179	-0.0584	0.0618	-0.00986	0.0486	-0.163
b.s.e.	(0.0619)	(0.0692)	(0.0894)	(0.194)	(0.188)	(0.314)
	Tot. Exports					
ATT	-0.190	-0.0432	0.319	-0.145*	-0.199**	-0.148
b.s.e.	(0.149)	(0.240)	(0.247)	(0.0734)	(0.0871)	(0.100)
	Survival Rate					
ATT	-0.0642***	0.106***	0.260***	-0.0496***	-0.0707***	-0.00210
b.s.e.	(0.00415)	(0.0105)	(0.0144)	(0.0119)	(0.0184)	(0.00690)
Treated	3262	3038	1449	403	382	102
Control	18871	18871	16960	27,251	27,251	24,423

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of French import-competing and import-dependent firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. Producers defined as all French firms belonging to the sectors protected by EU anti-dumping duties on Chinese products identified using the correspondence tables between products and sectoral classifications provided by the United Nations Statistics Division and by Hoekman et al. (2002). Importers defined as all French firms which have imported targeted dumped products from China at the HS-8 digit level according to the transaction-level Customs Agency dataset. We report the ATT effects of the impact of EU AD measures against Chinese products on French import-competing and import-dependent firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

factor productivity which decline by almost 4% in the following two years. As stressed in the previous literature, this phenomenon might be explained by a lack of competition pressure from China which could deteriorate a persistent trend of declining productivity for mature manufacturing industries in developed countries (Pierce 2011).

These firm-level results of the impact of AD duties on domestic producers follow the theoretical predictions and the empirical findings of the previous literature on this topic (Konings and Vandenbussche 2005; Pierce 2011). We can now investigate for the first time the impact of EU anti-dumping measures on the importers of Chinese dumped products, thanks to the disaggregated French firms transaction-level import data. For this analysis we consider as treated those firm which have imported dumped products from China then used as intermediate inputs in their productive process, so not considering pure traders. The imposition of AD measures increases the duty to be paid for the import of these targeted products from China, so we expect EU AD measures to negatively affect French importers which would face an increased cost of imports and of inputs of production, thus making it more difficult to cover the average variable costs of production.

As expected, Table 1.9 shows that anti-dumping measures generally reduce French importers performance, negatively affecting their productivity, consistently reducing their total employment and diminishing the probability of surviving in the market. In particular, the increase in the cost of inputs of production negatively affects import-dependent firms total factor productivity, strongly decreasing importers productivity by almost 10% in the following 2 years. As a consequence, it would become more difficult for French importers to cover their costs of production, forcing some firms to reduce the amount of labour force employed in the production process by 9% after two years and pushing some others to drop out of the market as highlighted by the significant negative impact on the survival rate, at the average rate of 6% in the two years following the entry into force of the AD duties. In addition, the aggravation of importers performance affects as well their total exports reduced by almost 20% in 2 years, as expected from the theoretical predictions (Ruhl 2014, Wu et al. 2014), while we do not find any evidence of impact on investment in R&D activities.

However, we expect the impact of EU anti-dumping measures against Chinese products on producers and importers to vary across the distribution of French firms depending on factors which have not been taken into account so far. First of all, some firm-specific characteristics could play a role in the variation of the magnitude of the AD measures impact for individual firms which are more or less exposed to these trade policy shocks and their effects. Secondly, the overall impact of AD duties on French import-competing and import-dependent firms could be influenced by the particular characteristics of these measures, for instance depending on the type of product targeted and the lobbying activity of domestic firms petitioning in favour or against the adoption of anti-dumping duties on Chinese goods. Finally, the impact on domestic firms would not be limited just to the intensive margins, the effect on their firm-level performance, but will as well affect the extensive margins, in other words the allocation of resources across firms which could decide to stop the production of dumped products or might substitute imports of these targeted goods from China.

In the next sub-section we provide an in-depth analysis of the micro-level effect of AD measures on import-competing and import-dependent firms by exploiting the richness of our datasets. First, we will differentiate our analysis based on several firms characteristics, estimating the impact of AD duties according to their export status, the variety of product-mix supplied and the productivity distribution of firms. Secondly, we will look at the variability of the AD measures applied, analysing the impact on French producers and importers of AD measures applied on intermediate or final goods, and considering whether the European Commission AD investigation has been supported by French producers or opposed by import-dependent firms. In this way we will be able to take into account the presence of relevant national interests in the analysis of the effect of AD measures on domestic firms. Finally, we will investigate the effect on the extensive margins of trade, considering not only continuing importers but also those firms who stopped the import of dumped products after the imposition of AD duties, in order to provide a complete picture of the impact of these measures on domestic import-dependent firms.

1.5.4 Heterogeneous Effects

We start this section of robustness checks examining the impact of AD measures on import-competing and import-dependent firms performance by differentiating between several firms characteristics, specifically looking at the differences between exporters and non-exporters and then estimating the impact on single and multi-product firms. The aim is to understand whether exporters and multi-product firms are more or less exposed to these trade policies measures. Following the previous theoretical predictions and empirical evidence (Konings and Vandenbussche 2013; Blonigen and Prusa 2015), we would expect non-exporters and single-product producers to profit from the protection of AD duties to close their productivity and technological gaps with respect to firms at the hedge of the productivity frontier. On the contrary, import-dependent firms that focus just on the domestic market or just in the production of one good should be more exposed to a price increase of the inputs of production. Since we are not able to identify the overall number of goods produced by companies, we define firms as multi-product if they export more than one good at the HS-6 digit level according to the Custom Agency trade dataset. Thus, the analysis of single and multi-product firms will be just focused on exporters. Table 1.10 presents the results of the DID-PSM estimation of the impact of AD measures on French import-competing exporters, non-exporters, single and multi-product firms.

First of all, from Table 1.10 it is possible to notice that our empirical results follow just partially the theoretical predictions. In fact, exporting producers seem to benefit the most from the protection of EU AD measures against Chinese products, showing both an increase in the likelihood of remaining in the market of 12% on average after 3 years and as well in the growth of the labour force employed by 2% in the year of adoption. Nevertheless, as in

Table 1.10: Impact of EU AD measures against Chinese products on French import-competing exporters, non-exporters, single and multi-product exporters - ATT effects with Kernel matching.

	EXPORTERS			**NON-EXPORTERS**			**SINGLE-PRODUCT**			**MULTI-PRODUCT**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP												
ATT	-0.0452***	-0.0295*	-0.0137	-0.0541*	-0.0475	-0.0263	-0.0207	-0.0379	-0.114	-0.0964***	-0.0603**	-0.0255
b.s.e.	(0.0154)	(0.0182)	(0.0210)	(0.0314)	(0.0370)	(0.0433)	(0.0567)	(0.0658)	(0.0704)	(0.0215)	(0.0248)	(0.0273)
Tot. Employment												
ATT	-0.0219**	0.0130	0.0660***	-0.0133	0.00558	0.0220	0.0331	0.0638	0.107**	-0.0288**	-0.00710	0.0308*
b.s.e.	(0.00860)	(0.0114)	(0.0145)	(0.0188)	(0.0252)	(0.0331)	(0.0363)	(0.0465)	(0.0488)	(0.0112)	(0.0150)	(0.0181)
Tot. R&D												
ATT	-0.210***	-0.0723	0.0346	-0.0401	-0.0750	0.285**	-0.0506	-0.00226	0.116	-0.292**	-0.286**	0.0167
b.s.e.	(0.0762)	(0.0846)	(0.109)	(0.0955)	(0.112)	(0.149)	(0.192)	(0.202)	(0.222)	(0.105)	(0.118)	(0.142)
Tot. Exports												
ATT	-0.0929	-0.174	-0.130				-0.647*	-0.164	-0.210	-0.100	-0.0918	-0.121
b.s.e.	(0.0760)	(0.0938)	(0.108)				(0.320)	(0.480)	(0.486)	(0.102)	(0.122)	(0.134)
Survival Rate												
ATT	-0.0598***	0.123***	0.242***	-0.0918***	0.115***	0.329***	-0.0222**	0.116***	0.0908**	-0.0271***	0.0665***	0.159***
b.s.e.	(0.00437)	(0.0115)	(0.0160)	(0.0128)	(0.0308)	(0.0390)	(0.00899)	(0.0411)	(0.0422)	(0.00340)	(0.00979)	(0.0136)
Treated	2770	2594	1209	451	406	229	253	253	101	2164	2102	953
Control	13273	13273	12038	5598	5598	4922	1577	1577	1462	9333	9333	8851

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of French import-competing firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. All French import-competing firms which have registered positive foreign sales according to the EAE database are included in the sub-sample *exporters* or in the category $non-exporters$ otherwise. French import-competing firms which have exported more than one good at the HS-6 digit level are included in the $multi-product$ sub-sample or in the category $single-product$ otherwise. We report the ATT effects of the impact of EU AD measures against Chinese products on French import-competing against unaffected firms for the following three years after the imposition of the anti-dumping measures.

the general case, the protection comes at the price of a lower productivity in terms of TFP, almost 3% lower two years after the imposition of AD duties. For non-exporters instead the introduction of AD duties does not play any significant role except for the probability of surviving in the sector, on average 15% higher in the following three years. Interestingly, the picture is particularly puzzling when analysing the impact on import-competing single and multi-product exporters. Indeed, despite a positive effect on the survival rate which is 15% higher after 3 years, the introduction of AD duties negatively affects the productivity of multi-product exporters as in the general case, while having a positive impact on the level of employment growing by 3% after three years. On the contrary, single-product producers, despite a significant increase in the survival probability, do not show any change in their performance as a result of the protection of EU AD duties on Chinese products.

Table 1.11 presents instead the micro-level analysis of the effect of EU anti-dumping measures against Chinese goods on import-dependent exporters, non-exporters, single and multi-product firms. As predicted by the theoretical literature, multi-product import-dependent exporters are the category of French firms which have mostly suffered the introduction of AD measures. In fact, after the imposition of higher duties on inputs from China these firms, which are usually larger and more productive, experience a decrease in their total factor productivity by almost 10% in the following two years, with a 10% decline in their total employment and a 5% lower probability of maintaining the operations in their sectors. Moreover, import-competing multi-product exporters seem to suffer particularly in terms of export performance, with a sharp decrease in their total exports by almost 40% two years after the entry into force of anti-dumping measures. Thus, these results show how targeted products imported from China have been used by French importers mainly as inputs of production for other goods which are then re-exported towards foreign markets. As a consequence, it appears that EU AD duties on Chinese products negatively affect in particular the largest and

Table 1.11: Impact of EU AD measures against Chinese products on French import-dependent exporters, non-exporters, single and multi-product exporters - ATT effects with Kernel matching.

	EXPORTERS			**NON-EXPORTERS**			**SINGLE-PRODUCT**			**MULTI-PRODUCT**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP												
ATT	-0.123**	-0.0921**	-0.0848	-0.0421	-0.0577	0.461***	0.0334	-0.183	-0.137	-0.132**	-0.102**	-0.0727
b.s.e.	(0.0597)	(0.0425)	(0.0749)	(0.116)	(0.129)	(0.0477)	(0.0816)	(0.172)	(0.242)	(0.0586)	(0.0406)	(0.0776)
Tot. Employment												
ATT	-0.0389***	-0.0908**	-0.00210	-0.0527	-0.0746	-0.101	0.0433	0.122	-0.000736	-0.0431*	-0.101**	-0.00794
b.s.e.	(0.0140)	(0.0438)	(0.0618)	(0.0569)	(0.0786)	(0.0782)	(0.0424)	(0.0792)	(0.0998)	(0.0239)	(0.0447)	(0.0588)
Tot. R&D												
ATT	-0.0209	0.0203	-0.155	0.0769	0.912	0.0319	-0.379	-0.301	0.517	-0.00575	0.0466	-0.229
b.s.e.	(0.198)	(0.181)	(0.302)	(0.149)	(0.579)	(0.0285)	(0.329)	(0.367)	(0.539)	(0.180)	(0.195)	(0.333)
Tot. Exports												
ATT	-0.182	0.0219	0.307				1.439	0.828	-0.214	-0.214*	-0.464**	0.342
b.s.e.	(0.158)	(0.248)	(0.250)				(0.928)	(1.492)	(0.938)	(0.106)	(0.233)	(0.263)
Survival Rate												
ATT	-0.0485***	-0.0700***	-0.00320	-0.0909	0.0244*	0.141***	0.0304	0.0106*	0.0444	-0.0511***	-0.0594***	-0.00436
b.s.e.	(0.0118)	(0.0192)	(0.00734)	(0.0971)	(0.0126)	(0.0144)	(0.030)	(0.00587)	(0.0272)	(0.0120)	(0.0185)	(0.00705)
Treated	391	371	96	12	11	6	11	11	6	392	371	84
Control	19,488	19,488	17,630	7,763	7,763	6,793	2,236	2,236	2,083	13,379	13,379	12,651

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of French import-dependent firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. All French import-dependent firms which have registered positive foreign sales according to the EAE database are included in the sub-sample *exporters* or in the category $non-exporters$ otherwise. French import-dependent firms which have exported more than one good at the HS-6 digit level are included in the $multi-product$ sub-sample or in the category $single-product$ otherwise. We report the ATT effects of the impact of EU AD measures against Chinese products on French import-dependent against unaffected firms for the following three years after the imposition of the anti-dumping measures.

most productive import-dependent firms which use cheap dumped products from China as inputs for the production of their exporting goods. We further investigate the heterogeneous impact on French firms of EU AD measures against Chinese products by looking at the effect across the productivity distribution of French import-competing and import-dependent firms in Table 1.12.

Table 1.12 presents the estimation of the effect of AD duties on import-competing firms performance across the four quartiles of the productivity distribution of French producers. First, notice that anti-dumping measures seem to have a different effect across the productivity distribution. On the one side, these trade defence instruments seem to be more effective in protecting the least productive producers, increasing their productivity, the level of employment and the surviving probability. On the contrary, the negative effect on TFP seems to be particularly strong for producers in the upper quartile of the distribution, registering on average a decrease of 9% in terms of productivity. These results added a further insight to the general analysis of domestic import-competing firms, showing a shift in the allocation of resources from more to less productive firms after the introduction of the AD protection. The effect on import-dependent firms performance across the productivity distribution shown in Table 1.13 seems to be significantly different.

Table 1.13 shows how only the most productive import-dependent firms in the fourth quartile seem to be negatively affected by the imposition of anti-dumping duties, especially in terms of TFP decreased in two years by almost 20%, total employment dropped by 30% and probability of surviving which is almost 5% lower after three years. On the contrary, the least productive firms among French importers seem to be better off 3 years after the introduction of AD measures. These firms experience a marginally positive impact in terms of productivity and survival rate, managing to increase their overall employment and the

Table 1.12: Impact of EU AD measures against Chinese products on French import-competing firms across productivity distribution (quartiles) - ATT effects with Kernel matching.

	Q1			**Q2**			**Q3**			**Q4**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP												
ATT	0.0801***	0.129***	0.0115	0.0553	0.00737	0.0380	-0.0403**	-0.0188	-0.0164	-0.130***	-0.0829**	-0.0675**
b.s.e.	(0.0284)	(0.0389)	(0.0284)	(0.0397)	(0.0376)	(0.0284)	(0.0157)	(0.0397)	(0.0333)	(0.0294)	(0.0347)	(0.0341)
Tot. Employment												
ATT	0.0545***	0.0470**	0.0494**	-0.0204	0.00198	0.00231	0.0150	-0.0115	-0.0643***	-0.0269	-0.0605**	-0.0833***
b.s.e.	(0.0175)	(0.0238)	(0.0204)	(0.0186)	(0.0249)	(0.0231)	(0.0192)	(0.0259)	(0.0191)	(0.0183)	(0.0224)	(0.0221)
Tot. R&D												
ATT	0.337**	0.363**	0.123	0.136	0.0656	0.234*	-0.128	-0.000153	-0.136	-0.409**	-0.275**	-0.156
b.s.e.	(0.160)	(0.174)	(0.162)	(0.135)	(0.149)	(0.133)	(0.112)	(0.124)	(0.129)	(0.164)	(0.105)	(0.202)
Tot. Exports												
ATT	-0.0646	0.204	0.108	0.0423	0.0207	0.0832	-0.122	-0.0187	-0.176	-0.0832	-0.351**	-0.310**
b.s.e.	(0.169)	(0.202)	(0.185)	(0.193)	(0.225)	(0.169)	(0.196)	(0.234)	(0.169)	(0.151)	(0.174)	(0.159)
Survival Rate												
ATT	-0.115***	0.162***	0.472***	-0.0437***	0.139***	0.418***	-0.0492***	0.0825***	0.359***	-0.0483***	-0.0930***	-0.172***
b.s.e.	(0.0108)	(0.0329)	(0.0297)	(0.00693)	(0.0263)	(0.0244)	(0.00732)	(0.0234)	(0.0198)	(0.00727)	(0.0207)	(0.0205)
Treated	777	679	333	789	752	366	827	724	355	824	782	327
Control	4,119	4,119	3,496	4,832	4,832	4,314	4,993	4,993	4,618	4,927	4,927	4,532

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of French import-competing firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. All treated and untreated French firms allocated in the four different sub-samples according to their TFP distribution. We report the ATT effects of the impact of EU AD measures against Chinese products on French import-competing firms against unaffected companies part of the same productivity quartile for the following three years after the imposition of the anti-dumping measures.

Table 1.13: Impact of EU AD measures against Chinese products on French import-dependent firms across productivity distribution (quartiles) - ATT effects with Kernel matching.

	Q1			**Q2**			**Q3**			**Q4**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP												
ATT	0.463***	0.198**	0.192**	0.162	-0.117	-0.276	0.0638	-0.0471	0.0213	-0.218***	-0.212***	0.0644
b.s.e.	(0.104)	(0.106)	(0.091)	(0.0916)	(0.110)	(0.169)	(0.0513)	(0.0721)	(0.126)	(0.0643)	(0.0771)	(0.0914)
Tot. Employment												
ATT	0.0418	0.140**	0.0933***	-0.0364	-0.0467	0.0582	-0.0368	-0.0478	-0.0428	-0.287***	-0.291***	-0.578***
b.s.e.	(0.0523)	(0.0719)	(0.0349)	(0.0390)	(0.0515)	(0.0658)	(0.0324)	(0.0436)	(0.0546)	(0.0541)	(0.0744)	(0.0882)
Tot. R&D												
ATT	0.997***	0.499**	-0.226	0.269	-0.171	-0.796	-0.205	-0.0336	-0.229	0.265	0.378	0.760
b.s.e.	(0.351)	(0.204)	(0.501)	(0.424)	(0.480)	(0.597)	(0.377)	(0.352)	(0.620)	(0.381)	(0.464)	(0.728)
Tot. Exports												
ATT	-0.356	-0.527	0.955*	-0.403	-0.0713	-0.761	-0.109	0.0111	-0.0949	-0.424**	-0.114***	-0.946***
b.s.e.	(0.476)	(0.602)	(0.510)	(0.525)	(0.620)	(0.679)	(0.334)	(0.378)	(0.394)	(0.205)	(0.0345)	(0.361)
Survival Rate												
ATT	0.00752	0.0533**	0.196**	-0.0137	-0.0190	0.0521	-0.0300	0.00361	0.0328	-0.0482**	-0.0524**	-0.0492*
b.s.e.	(0.0934)	(0.0261)	(0.0914)	(0.0137)	(0.0847)	(0.102)	(0.0245)	(0.0380)	(0.0531)	(0.0237)	(0.0266)	(0.0277)
Treated	73	73	24	73	73	24	80	76	26	83	83	28
Control	6,721	6,721	5,912	6,721	6,721	5,912	6,943	6,943	6,943	6,875	6,875	6,875

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of French import-dependent firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. All treated and untreated French firms allocated in the four different sub-samples according to their TFP distribution. We report the ATT effects of the impact of EU AD measures against Chinese products on French import-dependent firms against unaffected companies part of the same productivity quartile for the following three years after the imposition of the anti-dumping measures.

investment in R&D activities during the period in which the AD duties are in force.

We focus now on the second part of our robustness analysis, by looking at the heterogeneous effect on import-competing and import-dependent firms based on the characteristics of the AD measures applied. We first investigate the different effect of AD measures applied on intermediate or on final goods. Table 1.14 presents the results of these estimations differentiating between the impact of AD duties imposed on intermediate or final goods for both French import-dependent and import-competing firms.

From Table 1.14 it is possible to notice that for both producers and importers just AD duties imposed on intermediate goods imported from China seem to have a statistically significant effect on firms performance, further corroborating the results previously estimated for the general case with an overall positive effect for producers and a negative impact on importers. This evidence highlights how anti-dumping measures are still mostly effective if imposed on imports of dumped intermediate products, despite the recent proliferation of AD duties imposed by the EU on final goods imported from China. In addition, it is possible to notice a significant difference between producers and importers. As a matter of fact, most of the French import-competing firms protected by AD duties among producers are companies supplying final goods, highlighting how AD duties are effective in protecting just a small number of intermediate goods producers in France. On the contrary, most of the French importers affected by higher AD duties are specialized in the import of intermediate goods, the category for which the AD negative effect is strongest. As a result, these findings stress that the imposition of AD measures on Chinese products has an overall positive effect on a small number of French producers of intermediate goods, while has a negative effect on most of importers which import intermediate goods from China to be used as inputs of production, with negative consequences for productivity, total employment and export performance as

Table 1.14: Impact of EU AD measures against Chinese intermediate and final products on French import-competing and import-dependent firms - ATT effects with Kernel matching.

	PRODUCERS						IMPORTERS					
	INTERMEDIATE			FINAL			INTERMEDIATE			FINAL		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	TFP											
ATT	-0.0499***	-0.0399**	-0.00891	-0.0366	-0.0416	-0.115**	-0.116**	-0.0884**	-0.0916	-0.0117	0.0228	0.815***
b.s.e.	(0.0138)	(0.0163)	(0.0158)	(0.0390)	(0.0378)	(0.0478)	(0.0482)	(0.0428)	(0.0750)	(0.150)	(0.129)	(0.235)
	Tot. Employment											
ATT	0.0201**	0.0518***	-0.00222	-0.0316*	-0.0143	-0.00775	-0.0473**	-0.0741**	0.000157	-0.0221	-0.129	0.498***
b.s.e.	(0.00793)	(0.0109)	(0.0104)	(0.0191)	(0.0226)	(0.0360)	(0.0230)	(0.0359)	(0.0580)	(0.0712)	(0.132)	(0.168)
	Tot. R&D											
ATT	-0.0573	-0.0291	0.163*	-0.321***	-0.0943	0.110	-0.141	-0.0309	-0.213	0.476	0.526	1.757
b.s.e.	(0.0643)	(0.0729)	(0.0807)	(0.0935)	(0.129)	(0.242)	(0.209)	(0.203)	(0.325)	(0.628)	(0.578)	(1.871)
	Tot. Exports											
ATT	-0.104	-0.0718	-0.0596	-0.191	-0.259	-0.200	-0.156	-0.150	0.326	0.159	0.433	0.428**
b.s.e.	(0.0741)	(0.0877)	(0.0855)	(0.135)	(0.178)	(0.297)	(0.132)	(0.191)	(0.251)	(0.273)	(0.695)	(0.183)
	Survival Rate											
ATT	-0.0657***	0.104***	0.330***	-0.0606	0.127***	0.269***	-0.0253**	-0.0701**	-0.0715***	-0.0455	0.00998	0.000171
b.s.e.	(0.00502)	(0.0109)	(0.0121)	(0.0735)	(0.0204)	(0.0263)	(0.0109)	(0.0356)	(0.0178)	(0.0455)	(0.0117)	(0.0538)
Treated	1098	1096	580	2264	2104	1392	181	169	102	198	93	87
Control	18871	18871	16960	18871	18871	16960	27251	27251	24423	27251	27251	24423

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of French firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. French import-competing firms which have been protected by EU anti-dumping measures imposed on Chinese final goods, as defined by the United Nations Broad Economic Categories (BEC) classification, are included in the producers sub-sample *Final* or in the *Intermediate* category otherwise. French import-dependent firms which have imported final products from China, as defined by the United Nations Broad Economic Categories (BEC) classification, and have been affected by EU anti-dumping measures on Chinese imports are included in the sub-sample *Final* or in the *Intermediate* category if instead have been affected by EU anti-dumping measures on Chinese intermediate goods. We report the ATT effects of the impact of EU AD measures against Chinese intermediate and final products on French firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

previously demonstrated.

Thanks to the data collected from the investigation reports provided by the European Commission, we are able to analyse the effectiveness of EU AD duties on Chinese products differentiating between the cases in which the measures have been supported or opposed by French firms. It is possible to estimate in this way the impact of AD measures on French import-competing and import-dependent firms when different national interests were involved. Table 1.15 presents the estimation of the impact of EU AD measures against Chinese products on French import-competing and import-dependent firms depending on the lobbying activity in favour or against the imposition of the AD duties. In the case of French import-competing firms, we distinguish whether the EU anti-dumping measures has been required by French firms or not. When looking instead at French import-dependent firms we take into account whether the EU anti-dumping measures on Chinese imports have been opposed by French importers or not, as reported in the European Commission investigation reports.

First, it is possible to notice from Table 1.15 that in almost half of the cases investigated by the EU there was at least a French petitioner who filled in a complaint to the European Commission for a material injury suffered from the import of Chinese dumped products. Secondly, as expected, this analysis confirm the general results for French import-competing firms just in the case in which there were French petitioners lobbying in favour of the AD duties during the investigation, showing how EU AD measures are strongly linked with the protection of national interests rather than the re-establishment of a fair international competition.

Moreover, the European Commission in the AD reports includes as well whether major

Table 1.15: Impact of EU AD measures against Chinese products on French import-competing and import dependent firms depending on lobbying activity - ATT effects with Kernel matching.

	PRODUCERS						**IMPORTERS**					
	French Lobby			**No French Lobby**			**French Lobby**			**No French Lobby**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	TFP											
ATT	-0.0711***	-0.0468**	0.0191	-0.0336	-0.0201	-0.0821	-0.146**	-0.103*	-0.109	-0.146**	-0.0971*	-0.0940
b.s.e.	(0.0214)	(0.0237)	(0.0284)	(0.0219)	(0.0301)	(0.0824)	(0.0654)	(0.0531)	(0.0833)	(0.0656)	(0.0512)	(0.0801)
	Tot. Employment											
ATT	-0.0193**	0.0533***	0.0652***	-0.0137	0.0243	0.0129	-0.0883*	-0.0862*	-0.0248	-0.0886*	-0.0905*	-0.0232
b.s.e.	(0.00945)	(0.0187)	(0.0151)	(0.00947)	(0.0159)	(0.0135)	(0.0490)	(0.0465)	(0.0666)	(0.0469)	(0.0508)	(0.0574)
	Tot. R&D											
ATT	-0.0133	-0.100	0.169	-0.216*	0.0256	-0.0736	-0.0412	0.0136	-0.0501	-0.0964	-0.0327	-0.233
b.s.e.	(0.0806)	(0.0929)	(0.131)	(0.118)	(0.176)	(0.142)	(0.199)	(0.221)	(0.314)	(0.215)	(0.203)	(0.325)
	Tot. Exports											
ATT	-0.167**	-0.303***	-0.204	-0.0756	-0.0627	-0.0775	-0.102	0.0710	0.175	-0.130	0.0519	0.343
b.s.e.	(0.0737)	(0.107)	(0.145)	(0.0894)	(0.122)	(0.138)	(0.150)	(0.250)	(0.209)	(0.139)	(0.252)	(0.280)
	Survival Rate											
ATT	-0.0496***	0.109***	0.247***	-0.0753***	0.213	0.0359	-0.0481***	-0.0488***	-0.0692***	-0.00350	0.0004	0.00694
b.s.e.	(0.0066)	(0.0140)	(0.0173)	(0.0085)	(0.230)	(0.228)	(0.0121)	(0.0119)	(0.0254)	(0.0275)	(0.0288)	(0.0267)
Treated	1,093	1,032	653	985	907	819	315	300	180	348	330	176
Control	18,871	18,871	16,960	18,871	18,871	16,960	26,928	26,928	24,185	26,928	26,928	24,185

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of French firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. French import-competing firms which have been protected by EU anti-dumping measures imposed on Chinese goods required by French firms, as reported in the European Commission investigation reports, are included in the sub-sample $FrenchLobby$ or in the $NoFrenchLobby$ sub-sample otherwise. French import-dependent firms which have been affected by EU anti-dumping measures on Chinese imports opposed by French importers, as reported in the European Commission investigation reports, are included in the sub-sample $FrenchLobby$ or in the $NoFrenchLobby$ sub-sample if instead no French importers have lobbied against the imposition of the AD duty. We report the ATT effects of the impact of EU AD measures against Chinese products on French firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

importers or final users from the domestic European industries were involved in the investigation and have lobbied against the introduction of higher duties on imports. Thanks to this information, it is possible to evaluate the overall effect of anti-dumping measures on domestic importers, differentiating between the cases in which relevant French import-dependent firms have lobbied the EC or not. Interestingly, Table 1.15 shows how there is very little difference in the impact of EU anti-dumping measures against Chinese goods on French importers in the two sub-samples, except for a significant negative effect on the surviving probability in the cases in which French import-dependent firms have petitioned against the adoption of these duties. These important results stress once more the overall negative impact of higher duties on French importers, despite the lobbying activity of import-dependent firms and the material injury evaluation of the European Commission. As a result, these findings have highlighted how the political discretion could play a key role in the effectiveness of anti-dumping duties, in particular when the lobbying activity of domestic import-competing firms successfully protects the national protectionist interests. On the contrary, the negative impact of anti-dumping measures on import-dependent firms seems to be widespread across the two sub-samples, demonstrating how the lobbying activity of French importers is not effective and fails to prevent a material injury to the French import-dependent industry despite the interests of this category should have been taken into account by the EC investigation.

So far, in the case of French import-dependent firms, we have investigated the impact of EU anti-dumping measures against Chinese products just on the performance of importers which were importing the dumped products from China at the moment of adoption of the AD duty. We want to analyse now also the effect on the extensive margin, considering the performance of those firms who stopped to import "dumped" products from China after the imposition of the AD duties, in order to provide a complete picture of the impact of these measures on the domestic import-dependent firms. In Table 1.16 we estimate the impact of

EU AD measures against Chinese products on French import-dependent firms differentiating between continuing importers which have imported "dumped" Chinese goods even after the imposition of AD duties, and firms who stop importing once the measures entered into force.

Table 1.16: Impact of EU AD measures against Chinese products on French import-dependent firms: difference between continuing and dropping importers - ATT effects with Kernel matching.

	Continuing Importers			**Droppers**		
	t	t+1	t+2	t	t+1	t+2
	TFP					
ATT	-0.123**	-0.111***	-0.0298	-0.130***	-0.0970***	-0.0664
b.s.e.	(0.0608)	(0.0399)	(0.0636)	(0.0452)	(0.0351)	(0.0650)
	Tot. Employment					
ATT	-0.0464**	-0.119**	-0.0690	-0.0474**	-0.107**	-0.0879**
b.s.e.	(0.0210)	(0.0524)	(0.0433)	(0.0233)	(0.0428)	(0.0392)
	Tot. R&D					
ATT	-0.0155	0.111	-0.141	-0.0827	0.0918	-0.342
b.s.e.	(0.175)	(0.175)	(0.338)	(0.180)	(0.148)	(0.315)
	Tot. Exports					
ATT	-0.208	0.0829	0.636*	-0.250**	-0.0317	0.230
b.s.e.	(0.129)	(0.272)	(0.366)	(0.104)	(0.196)	(0.407)
	Survival Rate					
ATT	-0.0528***	-0.0631***	-0.135***	-0.0413***	-0.0413***	-0.00761
b.s.e.	(0.00138)	(0.0137)	(0.0371)	(0.0115)	(0.0164)	(0.0116)
Treated	372	354	183	140	134	44
Untreated	26255	26255	23491	9561	9561	8234

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of French firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. French import-dependent firms which have kept importing Chinese goods after the imposition of the EU anti-dumping measures are included in the sub-sample *ContinuingImporters*. Import-dependent firms which have instead stopped importing the affected products from China after the imposition of the EU AD measures are included in the *Droppers* sub-sample. We report the ATT effects of the impact of EU AD measures against Chinese products on French firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

Notice from Table 1.16 that the negative effect on import-dependent firms is consistent across the two sub-samples, demonstrating how AD duties are disruptive also for import-dependent firms who do not import dumped products from China any more. As previously shown, anti-dumping measures on Chinese products not only affects imports from China increasing the dumped goods prices, but push for a general increase in the level of prices of targeted products, with negative externalities affecting imports from the rest of the world.

To analyse these externalities, in Table 1.17 we investigate further the effect on French droppers distinguishing between import-dependent firms which after the imposition of AD duties decided to switch the import source of dumped products from China to other countries and firms who stopped importing the dumped goods preferring to substitute them with other intermediate inputs or switched to domestic suppliers.

It is possible to notice that firms who stopped to import the dumped products suffered only a significant negative effect in terms of total employment in respect to continuing importers. Nevertheless, French firms who switched imports source from China to another third country seem still to experience a reduction in the overall level of employment, total exports and total R&D but only in the same year of the AD duties imposition, with a particularly significant negative impact on the probability of surviving decreased by 10% after two years. This evidence corroborates the hypothesis of the presence of negative externalities on international trade flows related to the imposition of AD measures on Chinese products, not only affecting continuous importers of Chinese dumped goods but also other import-dependent firms who moved their sourcing to other foreign suppliers.

Finally, as a further robustness check we use a different definition of import-competing and import-dependent firms in order to control for possible overlaps between these two categories. As a matter of fact, in the previous estimations we might have included French firms which were at the same time domestic producers and importers of the products targeted by EU anti-dumping measures against China. To estimate consistently the effect of these anti-dumping measures on the two categories, we show in Table 1.18 the results of the estimations

Table 1.17: Impact of EU AD measures against Chinese products on French import-dependent firms: difference between dropping China and dropping product - ATT effects with Kernel matching.

	Dropping China			**Dropping Product**		
	t	t+1	t+2	t	t+1	t+2
	TFP					
ATT	-0.0749	-0.0148	-0.0270	-0.0746	-0.0601	-0.0990
b.s.e.	(0.0459)	(0.0500)	(0.0994)	(0.0633)	(0.0633)	(0.0722)
	Tot. Employment					
ATT	-0.0242	-0.0802*	-0.105	-0.0513*	-0.0753*	-0.126**
b.s.e.	(0.0262)	(0.0485)	(0.0652)	(0.0282)	(0.0453)	(0.0629)
	Tot. R&D					
ATT	-0.635*	-0.215	-0.498	-0.135	0.0507	-0.120
b.s.e.	(0.326)	(0.295)	(0.420)	(0.356)	(0.436)	(0.122)
	Tot. Exports					
ATT	-0.316**	0.0717	-0.293	-0.356*	-0.211	-0.0510
b.s.e.	(0.153)	(0.297)	(0.486)	(0.202)	(0.250)	(0.312)
	Survival Rate					
ATT	-0.0119***	-0.104***	0.0189	-0.0510	0.00343	0.00735
b.s.e.	(0.00279)	(0.0120)	(0.0169)	(0.201)	(0.00515)	(0.0140)
Treated	94	91	39	44	42	26
Untreated	8629	8629	7433	2221	2221	1443

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of French firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. French import-dependent firms which have stopped importing the affected products from China after the imposition of the EU AD measures but have switched to another foreign supplier are included in the sub-sample *DroppingChina*. Import-dependent firms which have instead stopped importing the affected products from abroad after the imposition of the EU AD measures are included in the *DroppingProduct* sub-sample. We report the ATT effects of the impact of EU AD measures against Chinese products on French firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

after dropping from our sample those firms which are both producers and importers at the same time.

Notice from Table 1.18 that the general findings are corroborated by this robustness check analysis, identifying a significantly stronger impact on the two categories. In particular, the imposition of EU anti-dumping measures against dumped products from China seems to negatively affect especially the productivity of French import-dependent dropping by 8% on

Table 1.18: Impact of EU AD measures against Chinese products on French firms: net effect dropping overlapping observations - ATT effects with Kernel matching.

	Importers			**Producers**		
	t	t+1	t+2	t	t+1	t+2
	TFP					
ATT	-0.0993**	-0.0741*	-0.0529	-0.0361	-0.0287	0.000838
b.s.e.	(0.0456)	(0.0384)	(0.0653)	(0.0257)	(0.0260)	(0.0189)
	Tot. Employment					
ATT	-0.0511**	-0.109***	-0.0896*	-0.0160*	0.00644**	0.0525***
b.s.e.	(0.0233)	(0.0407)	(0.0508)	(0.00906)	(0.00328)	(0.0125)
	Tot. R&D					
ATT	-0.355	-0.0370	-0.191	-0.118	-0.100	0.0253
b.s.e.	(0.246)	(0.174)	(0.354)	(0.0956)	(0.0993)	(0.0975)
	Tot. Exports					
ATT	-0.127*	-0.216*	-0.180*	-0.242**	-0.0177	-0.203
b.s.e.	(0.066)	(0.129)	(0.0927)	(0.120)	(0.186)	(0.349)
	Survival Rate					
ATT	-0.0436***	-0.0305**	-0.0402**	-0.0331	0.0657***	0.0966***
b.s.e.	(0.0137)	(0.0139)	(0.0188)	(0.0224)	(0.0105)	(0.00649)
Treated	361	341	190	3263	3039	1397
Untreated	26188	26188	23407	18871	18871	16960

Note: estimation based on EAE and Custom Agency data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of French firms included in the common treated and control groups is reported. The dependent variables are the growth in firm-level productivity measured as total factor productivity following the De Loecker (2007) approach, the growth in the number of full-time employees, the growth of R&D investment, the increase of exports value and the probability of surviving in the market measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. After the definition on French import-competing and import-dependent firms as previously explained, we have dropped from the two samples the overlapping observations which at the same time are both included in the protected sectors at the NACE rev.1.1. 4-digit level and have imported Chinese products affected by EU AD measures. We report the ATT effects of the impact of EU AD measures against Chinese products on French firms against unaffected companies for the following three years after the imposition of the anti-dumping measures.

average in two years, while the negative impact on producers TFP does not appear to be statistically significant once we removed the overlapping observations. In addition, employment grows for import-competing firms in the protected industries by 5% after three years, while drops in the same period by almost 9% for import-dependent firms. Despite the AD protection, total investment in R&D activities do not seem to change in the following years, while the increased cost of inputs of production negatively affects also the export performance of French importers, reducing their total exports by almost 18% in three following years. As previously stressed, the overall effect is an increasing survival rate for domestic import-competing firms, which increases the probability of staying opened by 9% after three years, while French importers seem to be more likely to exit the market, more than 4% higher three years after the entry into force of AD duties.

To conclude, the general welfare analysis of the impact of EU anti-dumping measures against Chinese imports on French firms is mixed. First, the imposition of AD measures has an overall positive effect on the survival rate of French firms, more likely to to stay operative in the market by 8% after 2 years despite a negative impact on a small number of import-dependent firms. The overall protection effect in terms of employment is almost negligible: the larger negative impact on a small number of import-dependent firms causing the loss of almost 18,000 jobs three years after the imposition of AD duties is almost compensated by the small increase of employment in a larger number of protected import-competing firms, creating more than 20,000 new job opportunities. French firms R&D investment does not change as a result of EU AD duties, while import-dependent exports are reduced by almost 21% in three years time, losing foreign sales contracts for a value of more than €4,121 million. Finally, as previously shown, EU anti-dumping measures against Chinese imports negatively affect the productivity of both import-competing and import-dependent French firms, with an aggregate drop of almost 4.2% of French firms TFP in the three years following the entry into force of these AD duties and a perverse long-run negative effect which reduces the productivity gap between French firms and their international competitors from emerging countries.

1.6 Conclusions

In this chapter we have analysed the effectiveness of European anti-dumping measures on Chinese products, investigating whether they constitute a curse or a blessing for European firms. Using product, sector and firm-level data from the EU and France we provided a comprehensive analysis of this trade-defence instrument, considering the impact on EU trade flows, on protected European industries and on the performance of French import-competing and import-dependent firms.

At the product-level, we found that EU anti-dumping measures on Chinese products cause an overall trade destruction effect. This impact is mainly driven by the drop in imports volume of targeted products from China, partially compensated by a trade diversion effect with an increase of imports from the rest of the world despite a surge in the price of imported products. Overall these results show how anti-dumping measures on Chinese products push towards an overall increase of targeted goods prices, bringing to a substitution of Chinese imports with imports from the rest of the world and an increase in the domestic production.

In addition, EU anti-dumping measures seem to be successful in protecting the European industries from the material injury caused by the unfair competition of dumped Chinese products. In particular, with a stable number of firms operating in these sectors, total employment increases after the entry into force of higher duties, stimulating as well the overall European production and the productivity in terms of added-value per worker.

Thanks to the firm-level analysis we found evidence that anti-dumping measures successfully protect French producers from the unfair competition of dumped Chinese products, increasing the probability of surviving in the market and supporting the employment growth, despite a drop in their total factor productivity. Nevertheless, these anti-dumping measures decrease French import-dependent firms performance, negatively affecting their productivity and consistently reducing their total employment and the probability of surviving in the market.

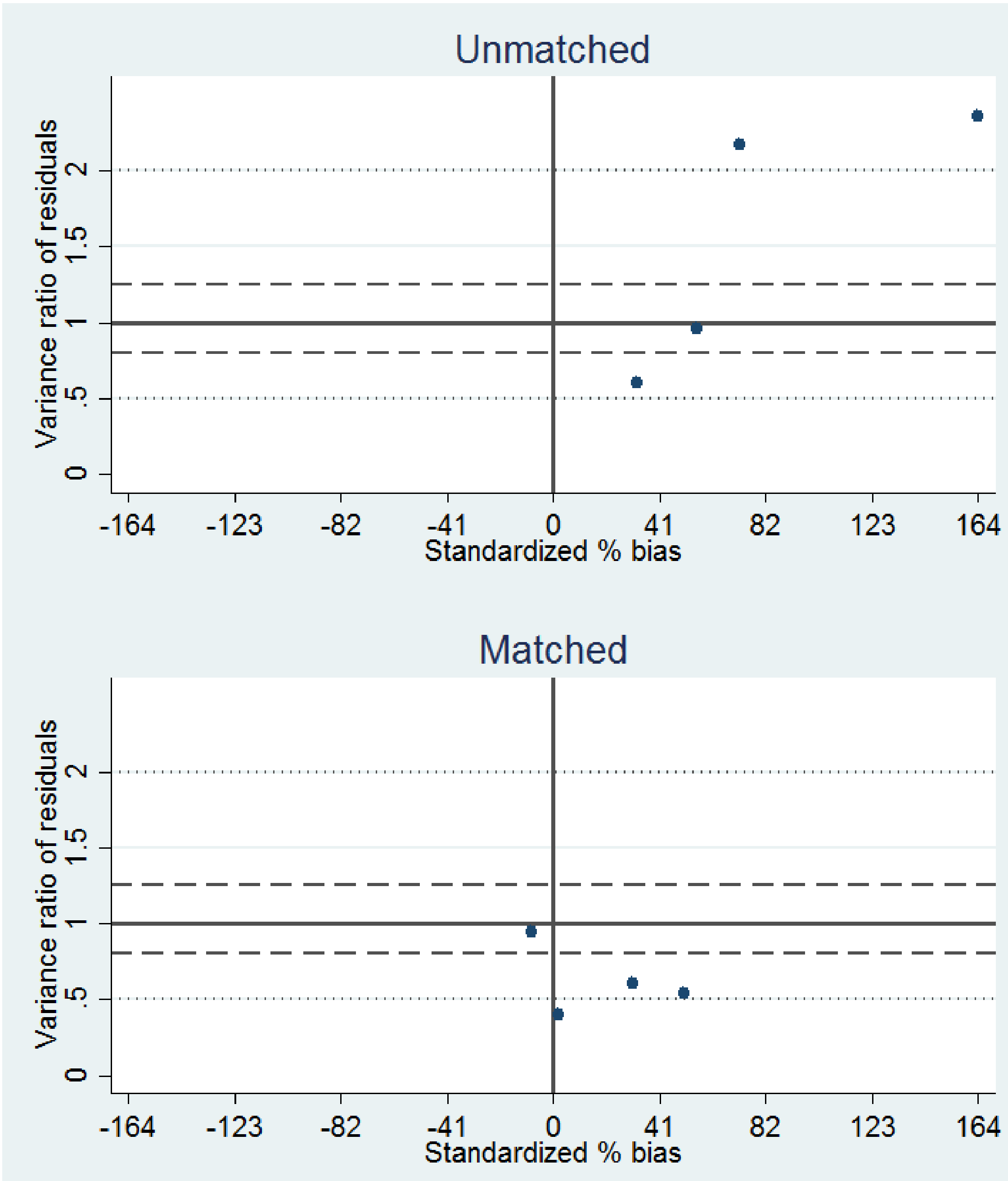
In particular, we found that EU AD measures protect the least productive French producers, while negatively affecting especially the most productive multi-product exporters which were importing dumped products from China to use them as cheap inputs in their production process, reducing in particular their export performance. Moreover, our results stressed that for both import-competing and import-dependent French firms just AD duties imposed on intermediate goods imported from China had a statistically significant effect on their performance, highlighting how anti-dumping measures are mostly effective if imposed on imports of dumped intermediate products, despite the recent proliferation of AD duties imposed by the EU on final goods imported from China. Finally, differentiating between AD investigations supported or opposed by French petitioners we have shown how the political discretion and the lobbying activity of firms could play a role in the effectiveness of anti-dumping duties, successfully protecting the petitioning import-competing firms but failing to avoid the negative effect for import-dependent firms.

Our results are consistent across specifications and robust to different checks. Taken together, the results suggest that EU anti-dumping measures successfully target Chinese dumped products, pushing an increase in the level of prices and decreasing import volumes from China which are in turn substituted by a larger domestic production and by imported goods from other extra-EU countries. European producers seem to be more protected by the unfair dumping competition, experiencing a higher employment growth and larger domestic production. At the same time, larger European importers are negatively affected by AD measures, forced to divert their imports to other extra-EU countries at higher prices, and losing productivity with a consequent negative impact on total employment, export performance and survival rate. The aggregate impact of EU anti-dumping measures against Chinese products on French import-dependent and import-competing firms is mixed, definitely bringing a temporary benefit for domestic producers, but with a negative effect on importers and highlighting a large degree of politicization in the management of this trade defence instrument.

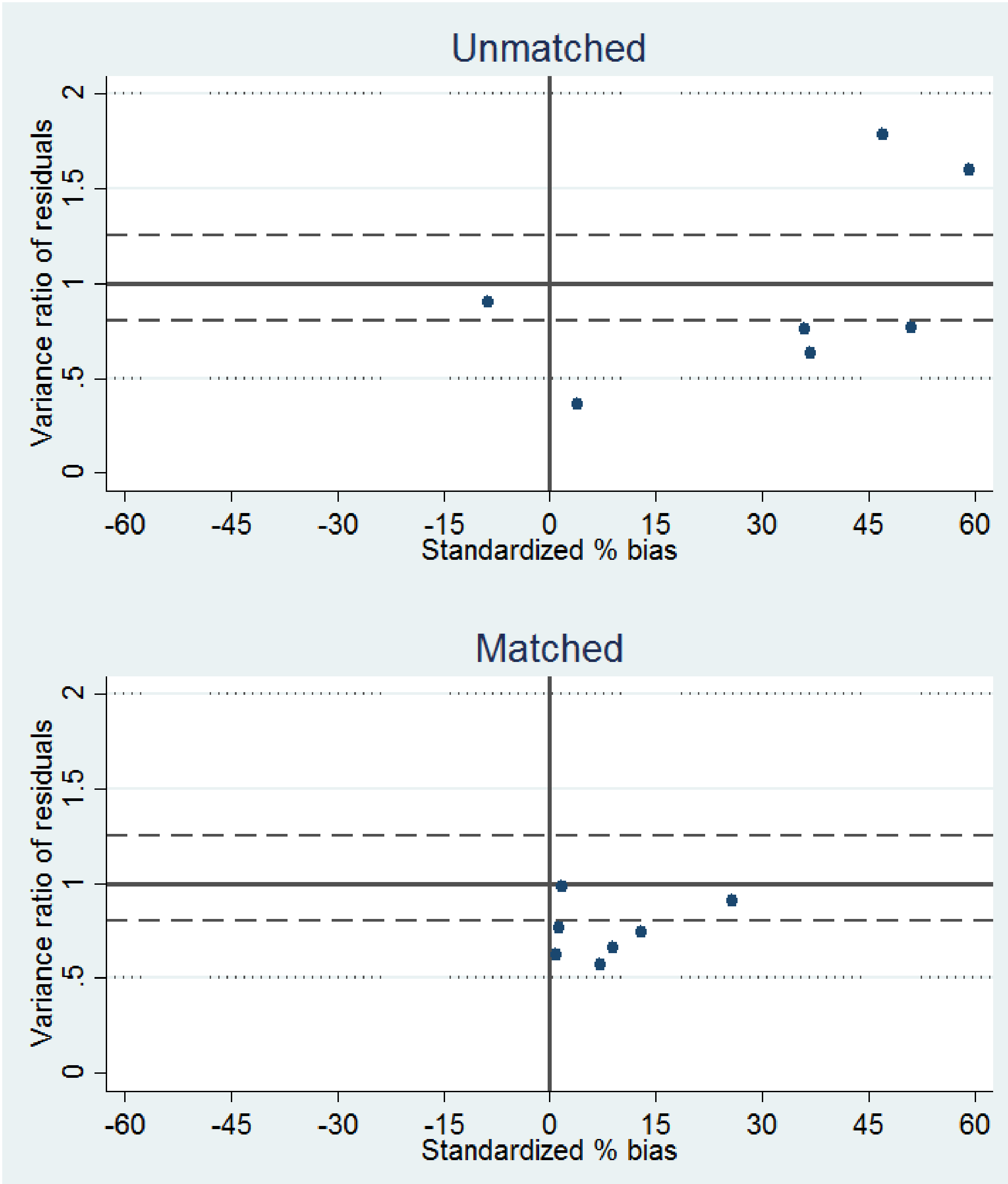
Appendix A1

Figure A.1.1: Propensity scores regressors bias between observations in the treated and control groups before and after the kernel matching technique

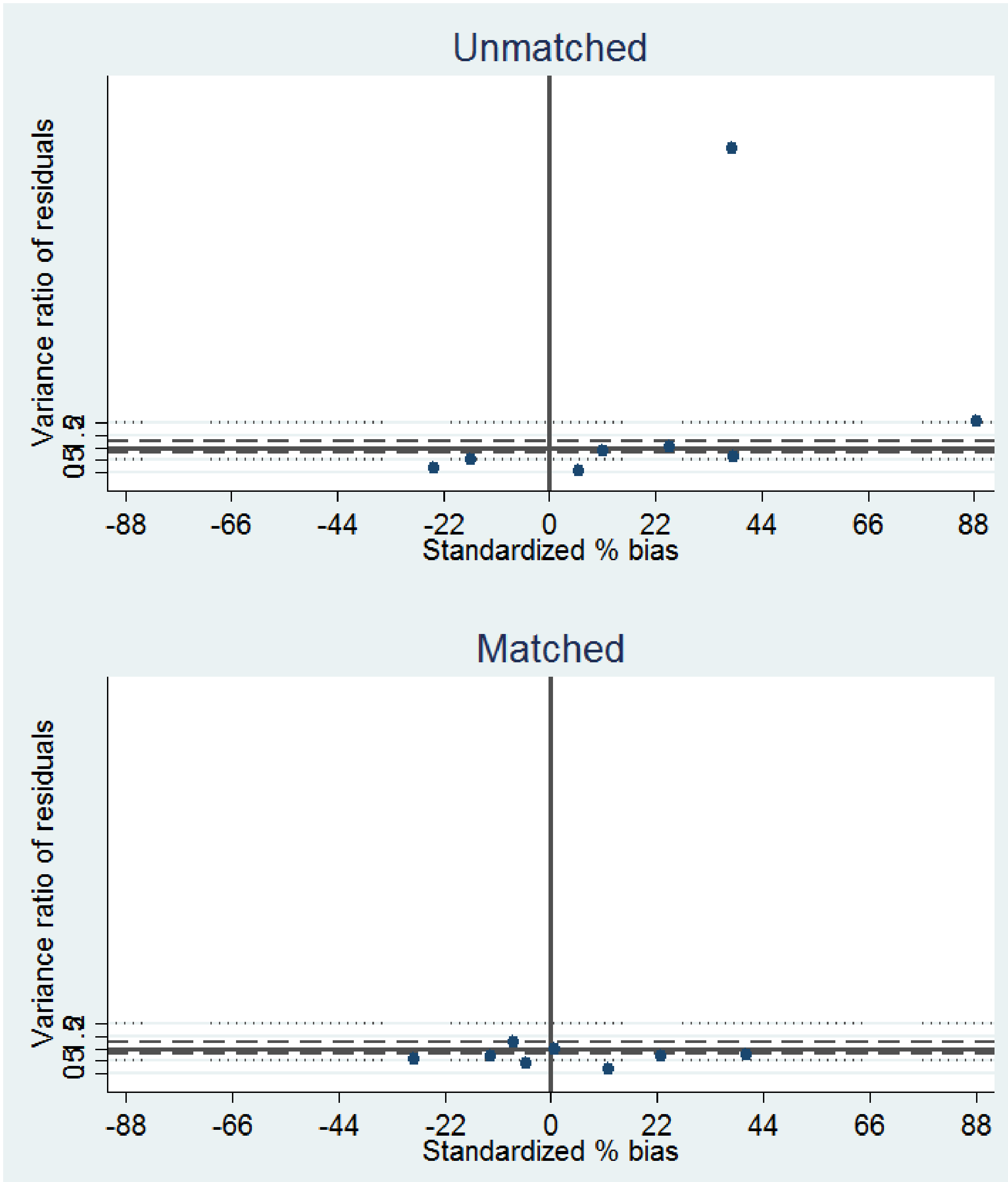
1. Product-level



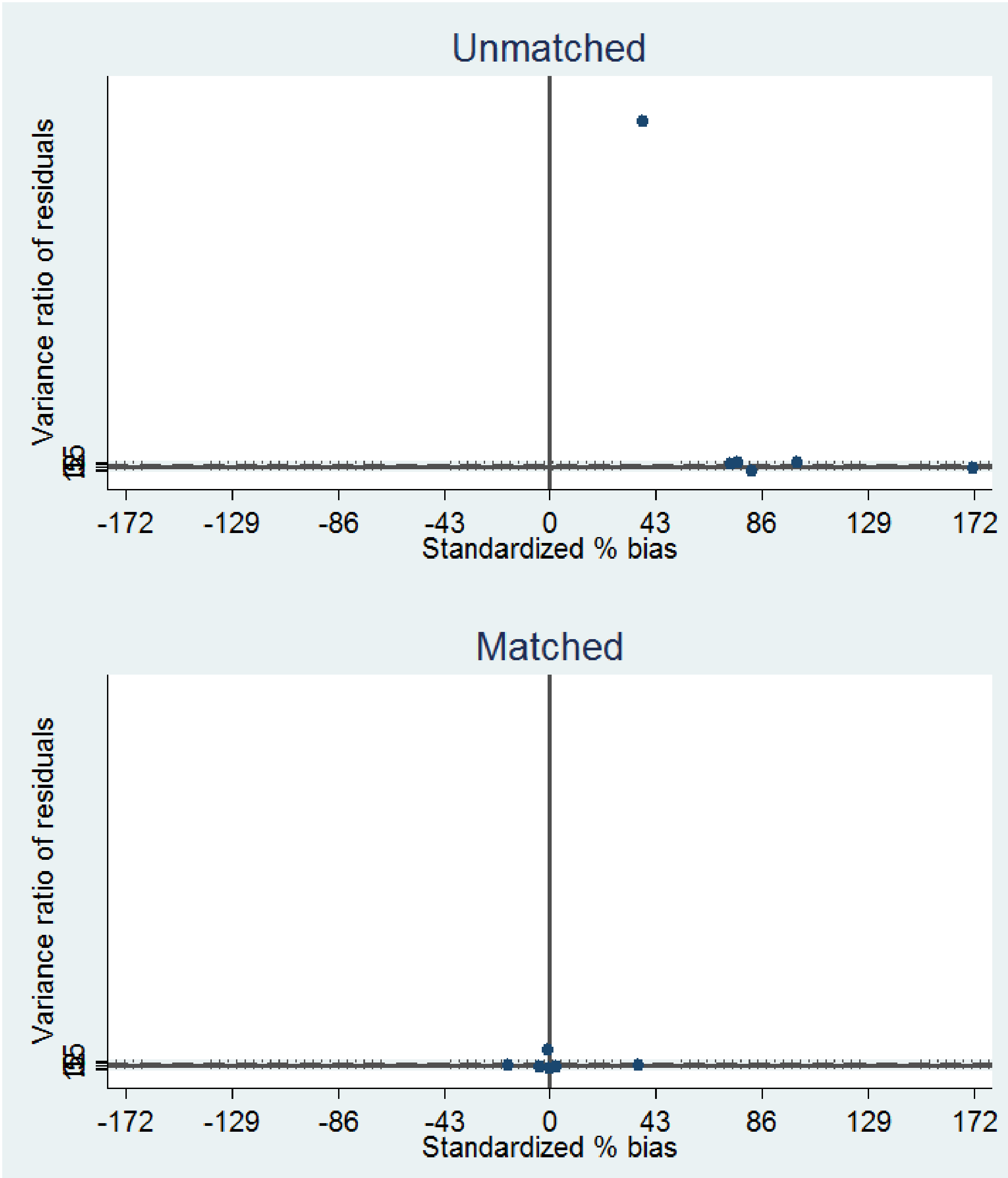
2. Sector-level



3. Firm-level: Producers



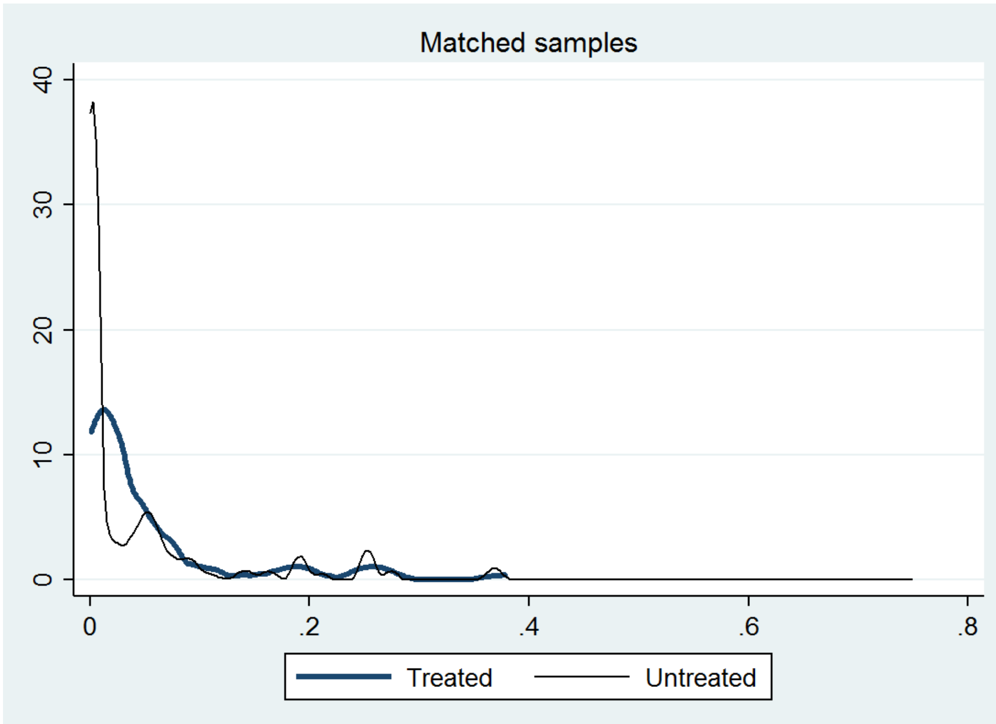
4. Firm-level: Importers



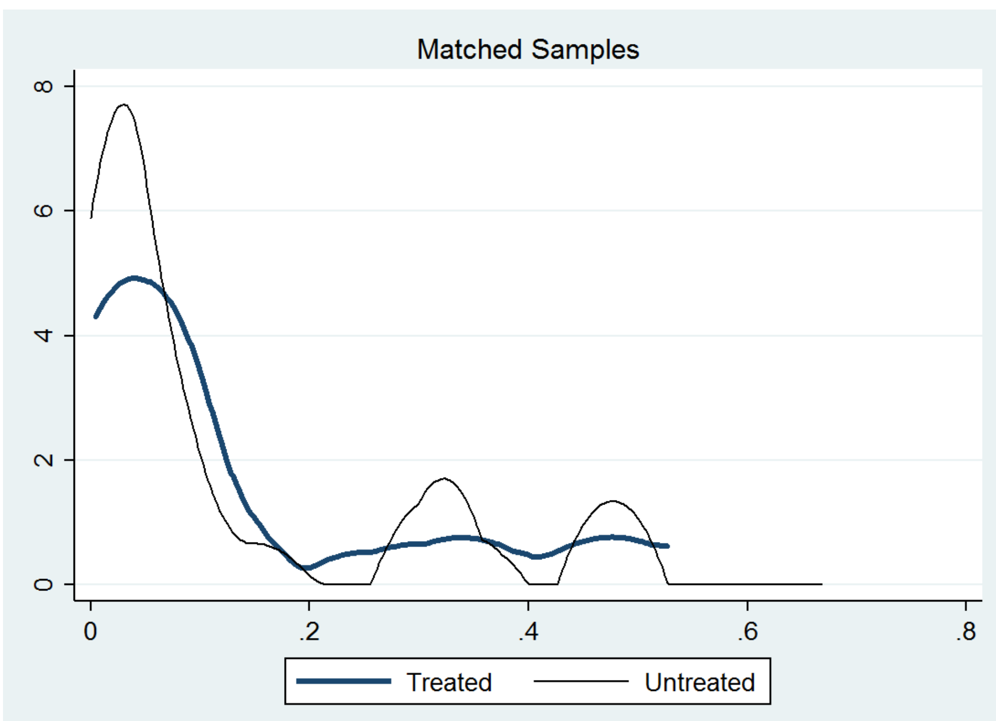
Note: Propensity scores for the level of analysis (product-level, sector-level, producers and importers firm-level) estimated using a logit model. Kernel matching technique applied with a 0.01 bandwidth and imposing a common support condition. Treated observations are in the common support if their propensity score is lower than the maximum and higher than the minimum score of the control units.

Figure A.1.2: Density distribution of propensity scores for observations in the treated and control group

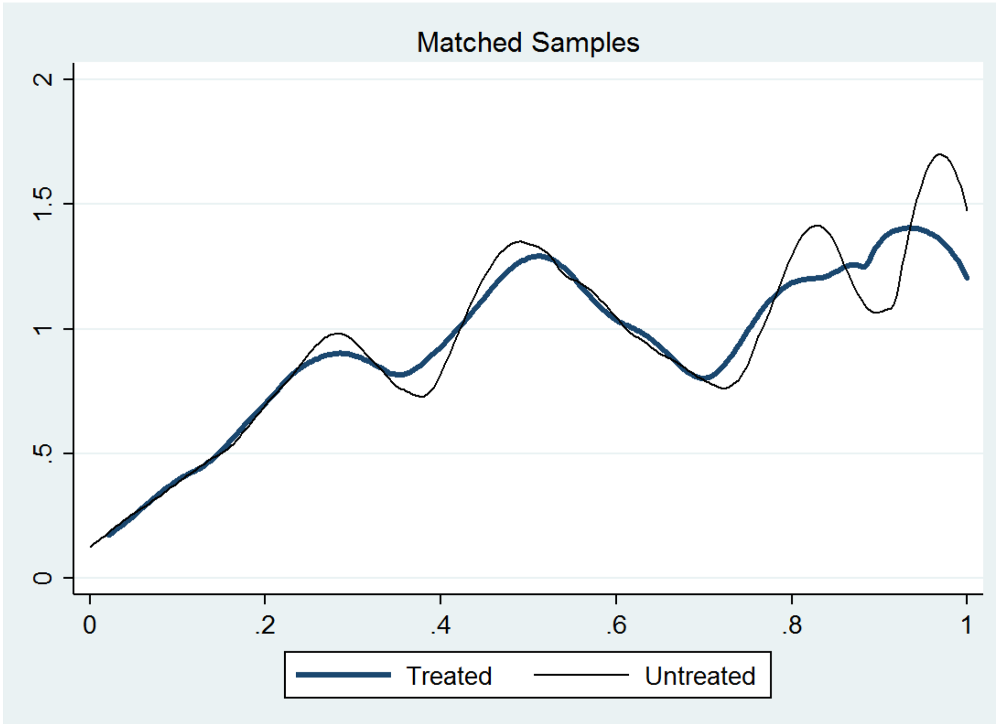
1. Product-level



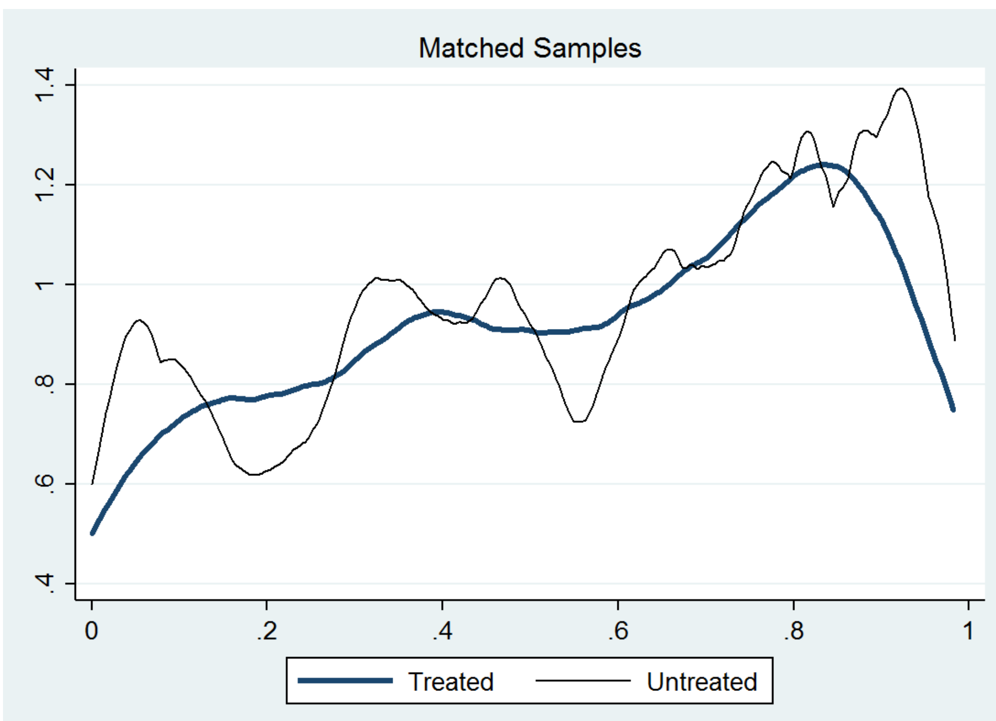
2. Sector-level



3. Firm-level: Producers



4. Firm-level: Importers



Note: Propensity scores for the level of analysis (product-level, sector-level, producers and importers firm-level) estimated using a logit model.

Table A.1.1: Product-level variables summary statistics.

Variable	Mean	S.D.	Min.	Max.	Obs.	No.Firms
Chinese Imp. Penetration	0.050	0.1094159	0	0.989	81,627	6,279
No. Fil. Cases	0.0842	0.365	0	6	81,627	6,279
Val. Imp. China	1980	17300	0	1690000	81,627	6,279
Val. Intra-EU	27400	151000	0	7720000	81,627	6,279
Val. Imp. ROW	14600	197000	0	27500000	81,627	6,279
Val. Tot. Imports	44100	298000	0	31100000	81,627	6,279
Price Imp. China	2614.08	293574	0	60800000	81,627	6,279
Price intra-EU	7390.02	859593	0.579	202000000	81,627	6,279
Price Imp. ROW	10334	751447	0	132000000	81,627	6,279
Price Tot. Imp.	2299.6	780878	0.0832	88200000	81,627	6,279
Vol. Imp. China	5.93	69.24	0	89,700	81,627	6,279
Vol. Intra-EU	200.05	20,000	0	1,170,900	81,627	6,279
Vol. Imp. ROW	235.87	68,700	0	5,649,000	81,627	6,279
Vol. Tot. Imp.	441.86	88,367	0	6,409,000	81,627	6,279

Note: Statistics based on the Eurostat COMEXT data and on the Global Anti-dumping Database for the period 1999-2007. The figures refer to EU bilateral import data at the HS6 product-level on European imports from China, on intra-EU trade and on imports from the rest of the world. Import value at the expressed in million of Euro. Import penetration defined as the share of EU imports from China over total EU imports for each product at the HS-6 digit level. Imports volume expressed in million of kilos. The import price is calculated by dividing the imports value and volume as reported by the Eurostat COMEXT database. Filling cases refer to the number of previous anti-dumping investigations started by the European Commission on each product at the HS-6 digit level, as reported in the EC Investigation Reports. All monetary values deflated using 2010 as a base year.

Table A.1.2: Sector-level variables summary statistics.

Variable	Mean	S.D.	Min.	Max.	Obs.	No.Firms
Chinese Imp. Penetration	0.103	0.151	0	0.849	2,281	243
Employment Growth	-0.792	6.345	-10.0	15.5	2,281	243
Added-value	29.592	10.359	-159.9	61.3	2,281	243
No. Fil. Cases	0.385	2.591	0	89	2,281	243
Export value	3740	7700	0.315	88300	2,281	243
Import value	349000	7700	0.1477	120000	2,281	243
Investment. Int.	12.25	102.12	-476.5	627.4	2,281	243
Tot. Production	17000	28100	3.284	403000	2,281	243
No. Firms	1060.58	3407.89	2	49173	2,281	243
Tot. Employment	16491.18	24026.92	0	188241	2,281	243
Turnover	3058.28	7477.36	-154.5	151145.1	2,281	243
Tot. R&D	126.96	373.88	0	2612	2,281	243
Labour Prod.	55.07	26.883	-39.4	289.60	2,281	243

Note: Statistics based on the Eurostat Structural Business Statistics (SBS) database about all European manufacturing sectors at the 4-digit NACE rev.1.1 level in the period 1999-2007. The statistics show the average number of firms operating in the sectors, the logarithm of the average added-value measured as the net income from operating activities after adjusting for subsidies and indirect taxes, the average labour productivity measured as the ratio between turnover and total employment, the average employment growth and the average number of employees in the sectors, the investment intensity measured as the ratio between investment in fixed assets and total output, the logarithmic value of R&D investment, the logarithm of the average export and import value in the industries, the overall physical output and the turnover in thousand of Euro, the import penetration from China measured as the value of Chinese imports over total imports in the sector and the number of petitions submitted to the European Commission about anti-dumping investigations. All monetary values have been deflated using 2010 as a base year.

Table A.1.3: Firm-level variables summary statistics.

Variable	Mean	S.D.	Min.	Max.	Obs.	No.Firms
Tot. Employment	127.61	708.40	1	111907	211,889	36,694
Av. Salary	25,049	9,280	525.28	935,072	211,889	36,694
TFP	4.450	0.618	-1.863	8.942	211,889	36,694
Tot. R&D	656.16	13524.38	0	1,628,152	211,889	36,694
Tot. Exports	10,985	207,577	0	27,100,000	211,889	36,694
Pr. Exporter	0.72	0.44	0	1	211,889	36,694
Tot. Imports	45,132	503.007	0	64,500,000	211,889	36,694
Survival Rate	0.94	0.22	0	1	211,889	36,694

Note: Statistics based on the Annual French Business Survey (EAE) for the period 1999-2007. The summary statistics refer to the yearly average number of employees per firm, the average annual salary paid in Euro, the average firm productivity estimated as the log of total factor productivity following the De Loecker (2007) approach, the average investment in R&D activities and the average value of exports and imports in thousands of Euro, the probability of being an exporter measured with a dummy variable equal to 1 if the firm has registered positive foreign sales and 0 otherwise, and the survival rate measured by a dummy variable equal to 1 if the firm is still present in the database in the following years and 0 otherwise. All monetary values have been deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

Table A.1.4: Matching balancing test at the product level

		Mean		Bias		Equality of Means		Ratio of
Variable	Sample	Treated	Control	Std. Bias	Red. Bias	t	p>|t|	var. residuals
$IP(China)_{pt-1}$	Unmatched	0.1341	0.0480	72.3		6.28	0.000	2.17
	Matched	0.1341	0.1315	2.1	97.1	0.08	0.934	0.94
$No.Fil.Cases_{pt-1}$	Unmatched	1.190	0.0762	164.1		25.44	0.000	2.35
	Matched	1.1904	0.9475	8.69	69.2	1.6	0.112	0.96
$SampleStat.$	R^2	$LRchi^2$	$p > chi^2$	$MeanBias$	$Med.Bias$	B	R	$\%bad$
Unmatched	0.197	190.18	0.000	81	63.9	195.7	3.4	50
Matched	0.0369	6.49	0.166	23	19.6	45.9	0.65	0

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the logit model before and after the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of observations in the matched sample compared to those in the unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present summary statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index, while the last column shows the percentage of covariates orthogonal to the propensity score before and after the matching algorithm.

Table A.1.5: Matching balancing test at the sector level

		Mean		Bias		Equality of Means		Ratio of
Variable	Sample	Treated	Control	Std. Bias	Red. Bias	t	p>|t|	var. residuals
$IP(China)_{st-1}$	Unmatched	0.2084	0.0989	59.1		3.76	0.000	1.59
	Matched	0.1836	0.1358	25.8	56.4	0.87	0.391	0.91
$\Delta Employment_{st-1}$	Unmatched	9.497	8.861	51.0		2.23	0.025	0.77
	Matched	9.444	9.282	13	74.59	0.47	0.640	0.74
$AddedValue_{st-1}$	Unmatched	3.345	3.375	-8.80		-0.41	0.680	0.9
	Matched	3.3411	3.3166	7.2	18.39	0.21	0.832	0.56
$Invest.Int._{st-1}$	Unmatched	14.923	12.032	3.9		0.14	0.891	0.36
	Matched	15.050	14.425	0.8	78.40	0.22	0.826	0.62
$No.Fil.Cases_{st-1}$	Unmatched	6.000	0.246	46.9		15.62	0.000	1.79
	Matched	1.954	1.805	1.2	97.4	0.17	0.867	0.76
$SampleStat.$	R^2	$LRchi^2$	$p > chi^2$	$MeanBias$	$Med.Bias$	B	R	$\%bad$
Unmatched	0.162	42.63	0.000	34.6	36.7	55	69.55	14
Matched	0.021	1.32	0.987	8.4	7.2	34.1	1.26	0

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the logit model before and after the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of observations in the matched sample compared to those in the unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present summary statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index, while the last column shows the percentage of covariates orthogonal to the propensity score before and after the matching algorithm.

Table A.1.6: Matching balancing test at the firm-level for French producers

Variable	Sample	Mean		Bias		Equality of Means		Ratio of
		Treated	Control	Std. Bias	Red. Bias	t	p>|t|	var. residuals
$ImportPenetration_{st-1}$	Unmatched	0.216	0.080	88.6		62.44	0.000	1.9
	Matched	0.214	0.147	23.4	51.0	15.17	0.098	0.89
$\Delta Employment_{st-1}$	Unmatched	-1.791	-0.464	-23.9		-11.32	0.000	0.21
	Matched	-1.509	-2.150	11.6	51.7	4.349	0.152	0.41
$AddedValue_{st-1}$	Unmatched	30.780	31.991	-16.3		-8.32	0.000	0.52
	Matched	30.768	29.079	22.8	-39.29	9.35	0.277	0.69
$InvestmentInt_{st-1}$	Unmatched	13.88	11.65	5.9		2.54	0.010	0.14
	Matched	13.986	15.334	-3.6	39.5	-6.04	0.111	0.53
$Tot.Employment_{it-1}$	Unmatched	4.168	3.926	24.9		14.26	0.000	1.01
	Matched	4.188	4.374	-19.2	23.1	-6.77	0.133	0.63
TFP_{it-1}	Unmatched	4.458	4.392	11.1		6.14	0.000	0.87
	Matched	4.469	4.561	-15.5	-39.4	-5.74	0.562	0.73
$Exporter_{it-1}$	Unmatched	0.842	0.683	38.20		19.93	0.000	0.62
	Matched	0.849	0.869	-4.8	87.4	-2.34	0.109	1.13
$No.Fil.Cases_{st-1}$	Unmatched	4.331	0.360	38.0		47.88	0.000	14.78
	Matched	1.865	2.002	-1.3	96.5	-1.65	0.289	0.94
$SampleStat.$	R^2	$LRchi^2$	$p > chi^2$	$MeanBias$	$Med.Bias$	B	R	$\%bad$
Unmatched	0.17	3998.45	0.000	30.2	24.4	65.2	0.91	50
Matched	0.045	413.51	0.000	17.3	13.5	51	0.54	3

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the logit model before and after the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of observations in the matched sample compared to those in the unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present summary statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index, while the last column shows the percentage of covariates orthogonal to the propensity score before and after the matching algorithm.

Table A.1.7: Matching balancing test at the firm-level for French importers

Variable	Sample	Mean		Bias		Equality of Means		Ratio of
		Treated	Control	Std. Bias	Red. Bias	t	p>|t|	var. residuals
$ImportPenetration_{pt-1}$	Unmatched	0.238	0.080	100.1		27.18	0.000	1.94
	Matched	0.207	0.199	5.0	95.0	0.62	0.532	1.05
$Tot.Employment_{it-1}$	Unmatched	4.904	4.033	75.8		17.82	0.000	1.98
	Matched	4.905	4.953	-4.2	94.5	-0.46	0.646	0.73
TFP_{it-1}	Unmatched	4.901	4.408	73.40		16.43	0.000	1.74
	Matched	4.912	4.993	-12.2	83.3	-1.54	0.124	1.06
$Exporter_{it-1}$	Unmatched	0.971	0.687	81.59		12.6	0.000	0.16
	Matched	0.970	0.964	1.7	97.9	0.46	0.647	0.84
$Tot.Imports_{it-1}$	Unmatched	15.348	6.656	171.4		25.38	0.000	0.81
	Matched	15.31	15.304	-0.5	99.6	-0.18	0.854	0.42
$No.Fil.Cases_{pt-1}$	Unmatched	5.543	0.41258	37.5		37.86	0.000	83.29
	Matched	2.109	2.238	-0.9	97.5	-0.24	0.808	4.25
$SampleStat.$	R^2	$LRchi^2$	$p > chi^2$	$MeanBias$	$Med.Bias$	B	R	$\%bad$
Unmatched	0.320	1350	0.000	90	78.7	195.1	0.51	33
Matched	0.021	23.32	0.001	10.19	3.4	35.1	1.27	3

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the logit model before and after the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of observations in the matched sample compared to those in the unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present summary statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index, while the last column shows the percentage of covariates orthogonal to the propensity score before and after the matching algorithm.

Chapter 2

The Impact of Innovation on Trade Margins: Evidence from French Firms

Abstract

Innovation and technological development have always played a key role in enhancing firms' productivity and overall economic growth. One important but relatively little researched area is the relationship between innovation and international trade and the ways in which R&D activities improve export performances. This chapter contributes to the existing literature by assessing the impact of innovation on firms' international trade performance, disentangling this effect looking at the impact on the extensive and intensive margins of trade. In addition, we take into account both input and output measures of innovation by controlling for R&D expenditure and indicators of product and process innovation. Applying a difference-in-differences approach to French export data at the firm-product level we find a positive effect of past investment in R&D on exports. In particular, our results suggest that R&D activities increase both total exports and the probability of being an exporter. Secondly, firms that introduce product innovation tend to improve their export performance particularly by increasing the number of products exported and countries served. Overall, from our analysis it appears clearly that R&D is an essential activity for French firms to improve their performance in highly competitive foreign markets.

JEL classification: D22, D24, F14, F23, F61, O31, O33

Keywords: firm heterogeneity, innovation, export, productivity, trade margins

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2.1 Introduction

Innovation and technological development have always been considered central to enhance firms' productivity and trade performance. A substantial literature has established that differences in firm performance are partially explained by the ability of firms to be successful innovators, which further increases productivity and survival rates (Grossman and Helpman 1994a; Eaton and Kortum 2002; Huergo and Jaumandreu 2004; Griffith et al. 2006; Aw et al. 2011; Van Long et al. 2011; Hallak and Sivadasan 2013). Particularly relevant in this regard is the impact of innovation on international trade, and the different ways in which research and development activities affect firm export performance. Even though this relationship has been widely analysed in the theoretical literature, often with very different predictions, few empirical studies have investigated the impact of R&D activities on export flows, especially at the firm level (Cassiman et al. 2010; Caldera 2010; Chen 2013; Becker and Egger 2013; Lo Turco and Maggioni 2015). Identifying the determinants of firm export performance is increasingly relevant to fully understand the trade patterns unobservable at the aggregate level. Particularly nowadays, the extraordinary economic performance of new emerging countries underlines the importance of productivity-enhancing activities, such as investment in innovation, as key drivers of firms' ability to successfully compete in international markets, to underpin sustainable economic growth and to create new job opportunities.

In this chapter we investigate the role played by innovation in improving the international trade performance of firms, taking into account different aspects of firms innovation and export strategies. Our main contribution is to decompose the effect of innovation on exports taking into account not only total exports and the probability of being an exporter but also the extensive and intensive margins of trade. Using transaction-level data we define the intensive margin of trade as the average value of firm's shipments, while as extensive margin we consider three different dimensions, looking at the number of varieties exported, the number of destinations served by each firm and at the average number of products exported by French firms to each foreign market. In this way it is possible to establish whether innovation activities improve exporters' performance creating new trade links, enriching firms' product mix and opening new export markets, or if they support the intensification of existing flows.

This chapter also assesses the effect of different forms of innovation on export performance, by simultaneously taking into account innovation input and output measures. This approach presents a number of advantages. First, measures of R&D output may be more accurate in identifying the connection between innovation and export performance, providing a direct link connecting investment in R&D and the commercial adoption of an innovation. At the same time, by measuring investment in R&D it is possible to evaluate the overall effect of firms' R&D efforts on exports performance, taking into account the possible effect of R&D which do not result in the introduction of new products, processes or patents.

Our analysis is based on export data at the transaction level and detailed information on French firms' innovation efforts for the period 1999-2007. Such rich data allow to investigate the effects of innovation on trade flows across industries and countries. This chapter explores the role of innovation on the capacity of French firms to increase their export performance controlling for a wide range of firm characteristics, and taking into consideration possible endogeneity concerns. We employ a range of econometric approaches including dynamic fixed-effects models, a generalized method of moments (GMM) and propensity score matching techniques to provide a rigorous investigation to the causality debate. This study is particularly relevant for a mature industrialized country such as France which is facing increasing competition in international markets from new emerging countries. Moreover, France is an interesting case study given the lively internal debate on globalisation and its consequences which has stimulated academic and non-academic discussions on its role in the economic crisis, particularly opposing the supporters of free trade and the advocates of national protectionism[1].

To briefly summarise our results we find that different trade margins respond in different ways to innovation activities. For instance, total investment in R&D has a positive and significant effect across different trade margins, increasing total exports through the export of more products and the targeting of more countries. The introduction of innovative products helps firms to export new varieties to new foreign markets while innovation plays a marginal role in improving the average value of shipments abroad. In particular, the positive effect of innovation on firms trade margins seems to be mainly driven by small and medium domestic firms exporting within the EU relatively small volumes or exporting to extra-EU countries. Taken together, our findings show how different innovation activities have different and sometimes contrasting effects on various measures of export performance. Our analysis suggests that policy makers should pay particular attention to the role played by innovation as a driver of internationalization and that policies to encourage innovation and trade should be looked at considering the different trade margins.

The reminder of the chapter is structured as follows. Section 2 provides a discussion of the theoretical and empirical literature. In section 3 the data sources are presented showing the descriptive evidence from an overview of French firms' innovating and exporting strategies over our period of analysis. Section 4 describes our methodological approach. Section 5 presents the results. Section 6 concludes.

[1]For a review of this topic see Strauss-Kahn 2004; Barba Navaretti et al. 2010; Hijzen et al. 2011; Chang et al. 2012; Corcos et al. 2012; Mion and Zhu 2013.

2.2 Literature Review

The last ten years has witnessed a growing literature that examines the export performance of firms in order to fully understand the evolution of changing trade patterns and to identify the drivers of international competitiveness that are otherwise unobservable at the country or industry level (Bernard et al. 2003, Bernard et al. 2006, Bernard et al. 2007; Melitz 2003; Costantini and Melitz 2007; Yeaple 2005). The competitive threat from new emerging countries has served to highlight the importance of productivity-enhancing activities as key drivers of firms ability to successfully compete in international markets (Bekes et al. 2011; Mayer and Ottaviano 2007; Mion and Zhu 2013). In the following sections we provide a comprehensive review of the previous literature on the relationship between international trade and innovation, both from a theoretical and an empirical point of view. We will then look at the different effects of input and output measures of innovations on firms' performance and focusing finally our attention on the literature examining firm trade margins.

2.2.1 Theoretical Background

A recent strand of the theoretical literature examines the potential linkage between firms' engagement in innovation activities and export performance in order to identify the source of exporter heterogeneity. Lileeva and Trefler (2010) for instance theorize that anticipation of future trade cost reductions induce firms to start innovating to be prepared for tougher international competition. Similarly, Rubini (2010), Vannoorenberghe (2011) and Atkeson and Burstein (2010) show that international trade does matter for innovation, highlighting how improved access to foreign markets promotes firms' investment in R&D activities. Several studies using firm-level data find evidence of a positive correlation between exporting and firm innovation efforts, demonstrating how trade cost reductions increase the profitability of investment in R&D which in turn drives more productive firms to enter new foreign markets (Parisi et al. 2006; Harrison et al. 2008; Bøler et al. 2012; Crespo 2012).

The Impact of Trade on R&D

One of the main theoretical perspectives stresses that international activities such as foreign investment, imports or exports, could push some firms to innovate more, triggering a learning-by-exporting effect. In fact, it could be easier for internationalized firms to access different sources of knowledge not available in the domestic market, especially through the interaction with foreign customers, partners or suppliers, facilitating in this way a bidirectional exchange of knowledge across borders. De Loecker (2011) for example emphasizes how the previous theoretical literature might have failed to identify the right direction of the causal link between innovation and exports, not decomposing the aggregate productivity growth into within-firm productivity gains due to innovation and between-firm productivity gains. Looking at the entry and exit patterns from export markets, many studies find evidence of learning-by-exporting phenomena and firm-level adjustments to trade liberalization, further corroborating the idea that a reduction in trade costs related to trade liberalization could induce exporters to upgrade their products and find it more profitable to introduce new technologies (Bustos 2011; Iacovone and Javorcik 2012)[2].

Nevertheless, several studies identify different caveats to the learning-by-exporting theory. For instance, Lileeva and Trefler (2010) while investigating the causal link between exports and productivity gains identify the crucial role played by previous investment in R&D in order to improve firms export performance anticipating future trade liberalization. In addition,

[2]For an extensive treatment of the empirical literature on this topic see for instance Grossman and Helpman (1994a); Clerides et al. (1998); Dai and Yu (2013); Movahedi and Gaussens (2013); Salomon and Shaver (2005); Van Beveren and Vandenbussche (2009); Damijan et al. (2010); Bratti and Felice (2012).

Movahedi and Gaussens (2013) focusing on a sample of French small and medium enterprises (SMEs) identify a relevant learning-by-exporting effect only for persistent and experienced exporters. Similarly, Girma et al. (2008) do not find any proof of this phenomenon for new exporters and for firms with a low exposure to foreign markets, especially for companies based in mature developed economies.

The Interdependence of Trade and R&D

Another strand of the theoretical literature analyses the existence of an interdependence between exports and R&D activities. Particularly relevant in this regard are Aw et al. (2008) and Aw et al. (2011) studies which propose a structural model of the interdependency between R&D, exports and productivity. Their theoretical framework presents a two-way relationship, in which, on one hand innovation increases firms' productivity with the firm self-selecting into export markets, and on the other hand participation in international activities which increases the return on R&D investment. The model suggests a complex interconnection between the two phenomena within firms' boundaries, with a strong cross-persistence of productive firms in both export and R&D activities, during which past R&D investment increase the propensity to export and vice versa. Using firm and plant-level data the authors develop an empirical model which can be estimated in two stages. After constructing a measure of productivity, in the second stage the authors estimate a dynamic discrete choice model of the decision to export and to invest in R&D, conditional on the export markets shocks and the marginal distribution of productivity. The results show that both activities are found to have a positive effect on firms productivity, driving in turn more firms to self-select into both activities. In addition, thanks to a simulation the authors demonstrate that an expansion of the export market seems to increase both exporting and R&D investment, generating a gradual firm productivity improvement (Aw et al. 2011).

Several other studies find empirical evidence to support this complementarity. For instance, Bellone et al. (2009) consider export intensity and two different measures of R&D outcomes, process and product innovation, for a sample of French firms and found that R&D and exports are complementary strategies, which if implemented together improve *ceteris paribus* firms' performance both in terms of productivity, innovation and total exports. Similarly, Harris and Moffat (2011) considering contemporaneously these two strategies find evidence of both learning-by-exporting phenomenon and a large impact of R&D expenditure on the probability of being an exporter. Finally, Esteve-Pérez and Rodriguez (2013), following Aw et al. (2011), find a strong cross-persistence of small and medium Spanish firms in both export and R&D activities, highlighting the key role played by previous R&D investment in increasing the propensity to export, which in turn improves firms' ability to innovate and absorb new technologies from foreign markets.

The Impact of R&D on Trade

Alternative economic theories look instead at the impact of R&D on trade based on the Melitz (2003) and Grossman et al. (2006) open economy growth models, starting from the key hypothesis of innovation-driven exports. From dynamic models with heterogeneous firms à-la-Melitz (2003) we know that investment in firm-specific assets leads to the selection of more productive firms into international markets, with innovation considered a key determinant of a firm's export propensity. Costantini and Melitz (2007) and Atkeson and Burstein (2010) for example extend the previous research and consider both export and innovation activities as endogenous joint dynamic decisions, building models in which firms face uncertainty and sunk costs both for starting to export and to innovate. In these models the performance of heterogeneous firms is endogenous and affected by innovation decisions at the firm level, introducing a trade-off between current costs and possible future returns in terms of export performance. In order to identify this link between innovation and export decisions, Caldera (2010) derives a theoretical framework building on the Bustos (2011) model of heterogeneous firms. Using data on exports and the product and process innovation of Spanish firms, the empirical analysis confirms the theoretical predictions that show how process innovation indirectly helps export performance by reducing marginal costs, while the introduction of new products directly affects firms' export propensity by increasing the demand for their products in existing and new markets. Similarly, Ferguson (2012) develops a model of trade with heterogeneous firms where firms compete with each other by investing in R&D. Firm-level data for the Swedish manufacturing industries validate the model predictions as industries with high rates of R&D intensity are characterized by a larger number of exporters, showing as well how these sectors are usually less sensitive to trade costs. Hallak and Sivadasan (2013) extend the previous theories by developing a model of international trade incorporating two different sources of firm heterogeneity, considering both process and product productivity, the first defined as the traditional productivity, while the second considered as firms' ability to introduce innovative products. Distinguishing between these two different sources of firm productivity and assuming decreasing trade costs when quality is increasing, the model considers export performance as conditional to the ability of firms to upgrade their product quality and to reduce costs of production. They find empirical support for their model for manufacturing plants in developed and developing countries. Overall, these trade theories seem to suggest that export premium may be mainly driven by previous investment in R&D activities, especially when they result in a product innovation.

2.2.2 Innovation Strategies

A number of studies, using firm-level data, test empirically the theories described above, finding evidence of a linkage connecting firms' innovation efforts and export performance, demonstrating how firms more prone to invest in R&D activities might enhance their productivity and hence improve their capacity to engage in international trade. In this section we present the growing empirical literature which analyses the link between innovation and trade performance, in particular focusing on the different measures of innovation used in the economic literature so far.

The first strand of the empirical literature investigates this relationship taking into consideration input measures such as workers training and total investment in R&D. Aw and Lee (2009) for instance applying a random-effect estimation on micro-level data of the electronic industry in Taiwan find that investment in R&D and skill upgrading improves firm productivity by reinforcing the self-selection process of more productive firms into export participation. Cassiman and Golovko (2007) instead explore the innovation-productivity-export link using a non-parametric approach for a panel of Spanish firms. Their results demonstrate the key role played by previous firm's investment in R&D in explaining the positive export-productivity association for a sample of small innovators. Similarly, Egger et al. (2014) compare the flexible relationship between foreign sales, productivity and R&D using both a semi-parametric and a log-linear approach with French firm-level data. They do not find significantly different results between the two approaches, highlighting the robustness of the positive link between R&D investment and exports.

A second and larger strand of the literature focuses on the impact of R&D output measures on firms' exports, in other words considering the impact of the introduction of process and product innovation or the total number of patents registered. This approach has a number of advantages. First, trade theories often consider the adoption of a new technology as a suitable measure to estimate the effect of R&D on export performance, since only the introduction of a product innovation rather than R&D investment is considered to have a direct impact on international trade (Hallak 2006; Hallak and Sivadasan 2013). Secondly, several empirical studies show that measures of patents and product innovation are much more closely associated with the value and the significance of innovation, which in turn is more relevant for international trade (Trajtenberg 1990; Jaffe et al. 2000; Hall et al. 2001). Nevertheless, just considering number of patents and innovations introduced could underestimate the real impact of firms' R&D efforts, since these measures do not take properly into account the possible innovations introduced but not registered as patents, and neglect as well the role of R&D investment in upgrading workers skills and firm productivity (Aw and Lee 2009).

Cassiman et al. (2010) for example deepen the analysis of the innovation-export link considering both product and process innovation measures, but find evidence of the important role played only by product innovation in explaining firm self-selection into export markets. Testing for differences in the probability distribution of starting to export between innovators and non-innovators for a sample of Spanish firms, the authors identify two different channels through which the introduction of a new product affects firms' export strategy. First, product innovation has a direct positive effect on exporters, increasing the demand for the new good abroad and opening new foreign markets. Secondly, successful product innovation increases the likelihood of the firm to start exporting, since fostering productivity-enhancing investment activates indirectly the exporters' self-selection mechanism. Becker and Egger (2013) improve the econometric analysis taking into account the endogeneity of the link connecting R&D and foreign sales and providing a rigorous empirical analysis of the effects of new product and process innovations on export propensity at the firm level. Considering innovations as an endogenous "treatment" and adopting a matching technique approach to innovations and export propensity for German firm-level data, the authors find a greater importance of product innovation relative to process innovation for the decision of starting to export. These results are in line with the new trade theory predictions where product innovation is the key factor explaining market entry while process innovations should just help secure a market position. Similarly, Palangkaraya (2013) adopts a comparable approach using Australian small and medium enterprises data. The results show that exports and innovation are positively linked but depends on the industry and the type of R&D activity. For instance, the joint adoption of product and process innovations has a positive effect on export participation especially in the manufacturing industry, while to a lesser extent previous export experience may lead to innovation in particular in the services industry. However, other findings in the literature point out instead the relevance of process innovation for firms' export performance, especially related to possible extra-productivity growth (Huergo and Jaumandreu 2004; Mairesse 2008). For instance Parisi et al. (2006) using micro-level data on Italy highlight how process innovations not only have a significant impact on productivity, but this R&D activity can further improve export performance by facilitating the absorption of new technologies from foreign markets.

Building on Caldera (2010), Lo Turco and Maggioni (2015) further expand this approach dissecting the impact of innovation on firms' export participation and testing the relationship between different innovation strategies and various exporting markets with different preferences towards product quality and costs. Using a propensity score matching approach in a multiple treatment framework, the authors find that a joint adoption of both product and process innovations encourages Turkish firms to start exporting. Moreover, as predicted by previous theoretical models (Caldera 2010; Hallak and Sivadasan 2013) product innovation seems to have a larger positive effect especially for exports towards low income countries.

On the contrary, Turkish firms should jointly implement product and process innovations in order to increase their exports towards developed countries, not only increasing the product mix quality but also reducing their production costs.

Recently, even policy-based research using micro-level data emphasize a causal effect connecting innovation and exports and stress the importance of firm-level performance in terms of productivity and innovating activities to support countries export performance. Rubini et al. (2012) for instance, using cross-sectional data for the main European countries demonstrate how removing different obstacles such as trade barriers, innovation costs and tax distortions will positively affect firms' decisions over these activities enhancing firms growth. Building on the Haaland and Kind (2008) trade model, the authors demonstrate that the returns from reducing the cost of innovation has a much greater impact on firms' growth than reducing trade costs, suggesting that countries should focus on promoting innovation investment in order to improve firms' export performance. Moreover, Altomonte et al. (2013) analysing a cross-country sample of European firms show how innovation is the main channel through which productivity growth happens in the EU, identifying a casual link between innovating activities and firms' internationalization. Their results suggest that policy makers should focus on the promotion of innovation investment in order to increase firms' sales abroad rather than engaging in difficult, costly and long trade negotiations.

2.2.3 Innovation and Trade Margins

The literature analysed so far focuses on measuring the impact of R&D activities on firms' total exports and trade participation, neglecting other relevant aspects of firms' trade performance. In fact, some recent studies analyse the impact of firms' endogenous activities on different export dimensions, namely trade margins. The trade literature identifies two categories of margins, the intensive and the extensive margins of trade.[3]

One strand of the literature in this area looks at the relationship between the quality of exported goods and the margins of trade. Building on Krugman (1979) model, Hallak (2006) identifies the role played by quality upgrading investment on the demand side, predicting that high income countries tend to import more from countries producing high-quality goods. Montinari et al. (2013) instead explain firm-level heterogeneity based on the impact of innovation inputs and outputs on trade margins. Developing a model of firms' export margins from Luttmer (2007) and Arkolakis and Muendler (2010) the authors predict two different dynamics driving firm exports. On the one hand, the intensive margin appears be correlated with exogenous shocks in the demand side, i.e. preference towards high-quality products, as previously demonstrated by Hallak (2006). On the other hand, the extensive margin of trade depends mainly on investment in R&D and their ability to introduce new process and product innovations. Their model emphasizes the key role of innovation as a fundamental strategy not only to develop firms' portfolio of export products, but also to increase the number of foreign markets supplied.

Following the previous literature, it is possible to disaggregate total exports of firms into different margins of trade, the number of products exported, the number of foreign markets supplied and the average value of each product shipped to each country (Berthou and Fontagne 2008). Thus, total exports for firm i at time t, X_{it}, is the result of the product between the extensive and intensive margins of trade, E_{it} and I_{it}:

[3]The intensive margin refers to the average value of individual shipments, for all products exported by a firm to different countries. The extensive margin instead has been differently defined across the literature, representing the number of exporters per country at the aggregate level, measuring the number of products exported (the product-mix), of foreign markets supplied at the firm-level or the average number of products exported to each foreign market (see for instance Chaney 2008; Bernard et al. 2009; Bernard et al. 2010).

$$X_{it} = E_{it} \times I_{it} = \sum_{g=1}^{N} \sum_{k=1}^{K} n_g n_{kg} p_{gk} q_{gk} \tag{2.1}$$

where the firm-level intensive margin I_{it} is calculated as the average value ($p_{itgk}q_{itgk}$) of all the n_{it} shipments of products g exported by firm i towards countries k at time t:

$$I_{it} = \frac{\sum p_{itgk} q_{itgk}}{n_{it}} \tag{2.2}$$

The firm-level extensive margin E_{it} instead has been usually decomposed in product extensive margin and country extensive margin:

$$E_{it} = n_g \times n_k \tag{2.3}$$

where n_g is the product extensive margin, in other words all the different products g_{it} exported by firm i at time t, while n_k is the country extensive margin defined as the number of destinations k_{it} served by firm i at time t:

$$n_g = \sum g_{it} \qquad n_k = \sum k_{it} \tag{2.4}$$

In this way it is possible to decompose firms' export flows into the extensive and intensive margins of trade, accounting for the value of shipments per product and per exporting market in order to establish which of these specific margins are more relevant for exports' performance and how are affected by R&D activities.

However, to analyse the impact of innovation on the margins of trade it is necessary to identify how different kinds of innovation interact with firms' trade margins. According to previous trade theories, investment in innovation can affect firms' export performance in different ways. First, investing in R&D activities increases the probability of producing new products which directly expands the total number of varieties exported (Krugman 1979):

$$n_g = n(\omega_i)\varphi_i \tag{2.5}$$

where the product extensive margin of trade is function of firm i product innovations ω_i and proportional to firm productive efficiency φ_i.

Second, investment in innovation could help exporters to improve their country extensive margin, increasing the number of markets served with each product. As suggested by Hallak (2006), the number of countries served by each product depends on the quality of the product exported θ_{gk} and on the preference of each country k towards quality γ_k. Previous theories have predicted that high-quality goods would be shipped to countries with higher income, while low-quality products to countries with a different aggregate structure of preferences. Building on these theoretical predictions, we expect the country extensive margin to be positively affected by R&D activities in two ways. First, total investment in R&D v_i could reduce the trading cost of shipments towards country k τ_k, mainly due to an increase in firms' human capital and managerial skills, but also by using R&D investment to improve the knowledge stock of firms about the marketing and operational strategies to apply in order to enter new foreign markets. Secondly, R&D activities might also improve the value of exports θ_g, by improving the processes of production, introducing high added-value new products or increasing the quality of existing goods. As a consequence, the number of countries served n_k would be function of the different levels of quality of the exported products $\theta_g^{\gamma_k}$ and of the cost of trading cost τ_k which may be mitigated by investment in R&D v_i:

$$n_k = n\left(\theta_g^{\gamma_k}\right)\frac{v_i}{\tau_k} \tag{2.6}$$

Finally, following Caldera (2010) it is possible to express the intensive margin, defined as the export value of each shipment $p_{gk}q_{gk}$ of good g to country k, as a function of country k aggregate expenditure E_k, price index P_k, the country's preference towards quality of good g $\theta_g^{\gamma_k}$, firm i production efficiency $\frac{\varphi_i}{c_g}$ and of exporting cost τ_k:

$$p_{gk}q_{gk} = E_k\left[P_k\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\varphi_i}{c_g}\right)\tau_k^{-1}\right]^{\sigma-1}\theta_g^{\gamma_k\sigma(1-\alpha)} \tag{2.7}$$

Note that firms' intensive margin is expected to be positively affected by R&D activities in two different ways. First, as we have seen before, firms' innovation could improve the quality of products exported $\theta_g^{\gamma_k}$ increasing the value of each shipment and affecting in a direct way the intensive margin. Second, process innovation and investment in R&D could affect, in an indirect way, the intensive margin of trade. By improving firms' productivity and the productive efficiency, R&D activities could reduce the overall costs of production of good g $\frac{\varphi_i}{c_g}$, increasing the markup charged for each shipment (Grossman and Helpman 1991; Eaton and Kortum 2002).

Only a small number of empirical studies test the previous theoretical predictions on R&D, product innovation and trade margins. Hummels and Klenow (2005) for instance analyse whether big exporting countries tend to export a wide range of goods, large quantities or higher quality, comparing their results with previous trade model predictions. The authors find that the extensive margin accounts for the larger part of export growth, while the intensive margin plays a relatively small role in driving developed countries exports. Alvarez and Fuentes (2011) instead, using a rich dataset of Chilean firms, study the evolution of the intensive margin when firms start to export. Entering international markets is usually associated with a higher value than average, consistent with the idea that new exporters introduce new and high-quality product in order to compete internationally, even though this phenomenon is not found to persist over time. More recently, Chen (2013) directly links R&D activities and trade margins, trying to understand whether innovation affects exporters' performance expanding the product mix or increasing the value of products already exported. Employing a generalized method of moments (GMM) approach using aggregate data at the industry-level for US imports and the total number of patents registered as proxy for innovation, Chen (2013) finds that innovation has a positive effect on both extensive and intensive margins, especially improving the quality of exports and leading to a higher intensive margin which is driven by the demand-side.

2.3 Data Description

French data at the firm level has been employed for this chapter. The motivation for studying France is twofold. First, France is the second largest exporter in the EU after Germany (10.2% of total extra-EU exports), even if registering a net trade deficit of € 7,150 billion in 2014 (Eurostat, 2015). Moreover, as pointed out in several EFIGE[4] studies on European firms, EU countries seem to be remarkably similar from a firm-level perspective, especially when taking into account exports behaviour (Mayer and Ottaviano 2007; Bekes et al. 2011; Rubini et al. 2012). Second, France devotes considerable resources to research and development activities (approximately € 48 billion in 2014 which represents 2.26% of GDP) ranking second in the EU for total investment in R&D and sixth as a share of GDP (Eurostat, 2015). Specifically, more than 55% of total investment is carried out by the private sector, investing

[4]EFIGE (European Firms in a Global Economy) is a project funded by European Commission under the 7th Socio-Economic Sciences and Humanities Framework Programme designed to help identify the internal policies needed to improve Europe's external competitiveness.

in 2014 around € 31 billion and employing 1.5% of the national total labour force, ranking third among all European countries. Considering innovation outcomes, France ranked eighth worldwide for the number of patents issued, with a total figure of 43,060 patents granted in 2013 (WIPO, 2015). Firms' R&D activities and their subsequent impact on productivity are generally similar across the continent, highlighting how comparable dynamics are taking place in Europe regarding firms' export and innovation strategies (Griffith et al. 2006; Altomonte et al. 2013).

In our analysis we combine data from four comprehensive datasets for the period 1999-2007. First, firms' characteristics are obtained from the Annual French Business Survey (Enquête Annuelle d'Entreprise - EAE) surveyed by the National Institute of Statistics and Economic Studies (INSEE). This data provides detailed balance sheet information for all French firms with more than 20 employees (almost 200,000 firms over 9 years) for the manufacturing (22.26%), service (73.23%) and agriculture (4.51%) sectors. Firm characteristics include total output, domestic and foreign sales, number of employees, salaries paid, cost of intermediate inputs, capital stock and investment in both tangible and intangible assets. This data has been then merged with the LiFi survey on the financial relationships between enterprises (Enquête sur les Liasisons Financières entre sociètés) created by INSEE to identify all the financial relationships in which French firms are involved and to provide useful information about foreign ownership, whether they are part of a French or a foreign owned group and their position in the group hierarchy.

Second, to analyse exporters' activity, we used firm-product-level exports data collected by the French Customs Agency which provides information about destination country, 8-digit-level product, value and weight of manufacturing exports. The information are available for all export transactions of manufacturers exporting at least € 100,000 within the EU or above € 1,000 outside the EU, covering more than 90% of French total manufactured goods exported.[5] Since the Custom Agency data takes into account only trade in goods the analysis in this chapter will be focused just on the manufacturing industry, removing also pure trading firms.[6]

In addition, because the Custom Agency data takes into account only large transactions within the EU plus all the extra-EU exports above € 1,000, in order to carry on a comprehensive analysis of French exporters we rely on the EAE dataset to measure firms' total exports and their participation in foreign trade. In this way it is also possible to include small intra-EU transactions and small exporters. Meanwhile, a disaggregated analysis on the margins of trade will focus only on the data from the Custom Agency on large intra-EU exports and on all extra-EU transactions. For completeness, we provide robustness checks using the Custom Agency data to calculate the value of total exports. In this way, comparing the EAE and the Custom Agency (CA) data we are able to compare the different impact of innovation on the whole sample of exporters and just on the sample of firms exporting large shipments within the EU and to non-EU countries, isolating the effect on firms just exporting small shipments to the rest of the EU.

A final dataset allows us to analyse firms' innovating propensity by merging the previous sample with the annual survey on the resources devoted to R&D activities (Enquête annuelle sur les moyens consacrés à la R&D) collected by the French Ministry of Education

[5]During this period the threshold for intra-EU exports has changed considerably. Initially, it was equal to almost € 38,000 euros until 2001 when it was increased to € 100,000. Finally, it was moved to € 150,000 in 2006. For extra-EU exports the threshold has not been changed during the whole period. Nevertheless, these threshold changes do not affect the quality of our analysis since it has been demonstrated in the previous literature that small exporters account for a relatively small share of the overall French exports (Mayer and Ottaviano 2007).

[6]Pure trading firms are companies usually in the services sector specialised in global business-to-business (B2B) transactions with a strong logistic organization, which do not use the bought goods as input of manufacturing production, but with the final purpose of re-selling and delivering those products to potential customers such as final consumers, businesses or public authorities.

and Research. This data consists of over 7,000 firms that perform R&D activities and invest more than €350,000 on innovation and a sample of the remaining companies that dedicate fewer resources to R&D. The dataset provides a comprehensive description of French firms innovating activities, reporting the overall internal and external resources dedicated to R&D, the number of employees working in the R&D department, public funds and tax rebates received from the government and other public institutions, the number of patents held by the company and a further measure of R&D output considering whether firms have introduced a product or a process innovation in each year. The main problem with this dataset is that some holding companies could report the total investment in R&D performed by the whole group. This could affect our results both overestimating the effect of R&D on the export performance of that particular firm and in addition not considering that other partners could take advantage of R&D done by other affiliates part of the same group.

In order to control for this possible bias, and given that the survey focuses mostly on large innovators, we also compare these data with the information about investment in intangible assets such as R&D that are included in the EAE dataset. When comparing the two datasets, it can be noted that some firms reporting investment in R&D in a given year in the EAE dataset were not included in the R&D survey, especially for firms investing small amounts in innovation and hence are not included in this survey. Conversely, it is also noteworthy that the contrary was true, with cases in which firms included in the R&D survey were not reporting any investment in innovation in the EAE dataset. For these reasons, we base our analysis just on the information about innovating activities collected by the R&D survey which is considered a more reliable source given the quality of the data collected, both for the value of R&D investment and for the measures of R&D output. Furthermore, we dropped from the sample all the observations in which firms report an investment in R&D in the EAE dataset but which were not present in the R&D survey. In a later robustness check we report the effect of R&D investment on total exports and firm's participation to foreign markets using the value of R&D investment included in the EAE dataset rather than the variable from the R&D survey. In this way we are able to compare the effect of using the two different sources of data, and to analyse the variations in the results when dropping from the whole sample the observations with incoherent information from the two different datasets. Using the total R&D variable from the EAE dataset is mainly consistent with the results we found when using the R&D survey data, and it is robust across specifications sequentially pulling out from the sample the incoherent observations.

After merging the four datasets we remove from our sample all the inconsistent observations and the coding errors, such as missing or incomplete data, negative values for total employment or average salary or with contrasting information across the different datasets. All the monetary values are expressed in Euros after applying the Euro-Franc fixed conversion rate for the years 1999 and 2000, and have been deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Our final sample is an unbalanced panel with almost 150,000 observations and contains comprehensive data about 35,000 French manufacturing firms over 9 years, approximately 28,000 exporters, and exhaustive description on the innovation strategies of almost 5,000 French firms. In addition, thanks to the Custom Agency data we are able to provide more detailed data on the trade margins of almost 17,000 French exporters about number of products exported, destinations served and average value of shipments, of which more than 3,700 are innovators as well.

In the following tables we present some summary statistics about the performance, export strategies and R&D activities of French firms in our final sample. We start with the first two tables in which we show a preliminary comparison between all the firms present in our sample in Table 2.1 and those included as well in the Custom Agency dataset in Table 2.2

Table 2.1: Firm performance by exporting and innovating status over the period 1999-2007 (all firms in our sample).

ALL FIRMS	Exporters	Non-Exporters	All Firms
Nb. of Firms	28,467	15,338	35,583
Employment	156	60	129
Av. Salary (EUR)	25,766	23,040	25,006
Tot. Sales (EUR th.)	39,982	9,526	31,489
Tot. Investment (EUR th.)	1,328	329.67	1,050
log(TFP)	4.509	4.281	4.446
Cash-flow	0.036	0.032	0.035
R&D Intensity	0.61%	0.10%	0.52%
Export Intensity	22.21%	0.00%	16.01%
INNOVATORS	Exporter	Non-Exporter	All Firms
Nb. of Firms	4,761	396	4,989
Employment	545	208	531
Av. Salary (EUR)	30,306	27,089	30,171
Tot. Sales (EUR th.)	153,359	39,511	148,594
Tot. Investment (EUR th.)	5,241	1,900	5,101
log(TFP)	4.888	4.702	4.880
Cash-flow	0.051	0.060	0.051
R&D Intensity	5.34%	13.22%	5.67%
Export Intensity	37.97%	0.00%	36.39%

Note: Statistics based on EAE dataset and R&D survey data, average from year 1999 to 2007. Employment calculated as average number of full-time employees. Average salary represents average annual salary of full-time employees in Euro. Total sales calculated as average total sales (domestic+foreign) in thousands of Euro. Total investment calculated as average of firm total investment in fixed tangible assets in thousands of Euro. Productivity calculated as log of total factor productivity following the De Loecker (2007) approach. Cash-flow calculated as the ratio between firm net income and total sales. R&D and export intensities calculated as the ratio of firm total investment in R&D or total exports over total sales. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

for which we have information about their trade margins. In these two tables we focus in particular on firms' performance considering first the whole sample and then focusing just on innovators, discriminating according to their status as exporters or non-exporting firms. The tables report different measures of firms' performance, including employment, the average salary paid, firms' total sales, total investment in fixed capital, total factor productivity (TFP), firm's cash-flow and the R&D and export intensities defined as ratio over total sales.

In both tables innovating firms appear to be larger in terms of employment and also pay higher wages, register larger total sales and tend to invest more in fixed capital. Moreover,

Table 2.2: Firm performance by exporting and innovating status over the period 1999-2007 (only firms matched with CA data).

ALL FIRMS	Exporters	Non-Exporters	All Firms
Nb. of Firms	16,947	13,086	27,865
Employment	178	54	138
Av. Salary (EUR)	26,296	22,719	25,141
Tot. Sales (EUR th.)	46,897	7,815	34,277
Tot. Investment (EUR th.)	1,540	242.73	1,121
log(TFP)	4.596	4.250	4.484
Cash-flow	0.046	0.030	0.041
R&D Intensity	0.61%	0.10%	0.52%
Export Intensity	24.76%	0.00%	16.77%
INNOVATORS	Exporter	Non-Exporter	All Firms
Nb. of Firms	3,719	236	3,919
Employment	566	170	555
Av. Salary (EUR)	30,455	26,185	30,340
Tot. Sales (EUR th.)	162,223	32,991	158,759
Tot. Investment (EUR th.)	5,373	1,298	5,264
log(TFP)	4.920	4.611	4.912
Cash-flow	0.056	0.054	0.056
R&D Intensity	4.71%	20.18%	5.12%
Export Intensity	38.90%	0.00%	37.85%

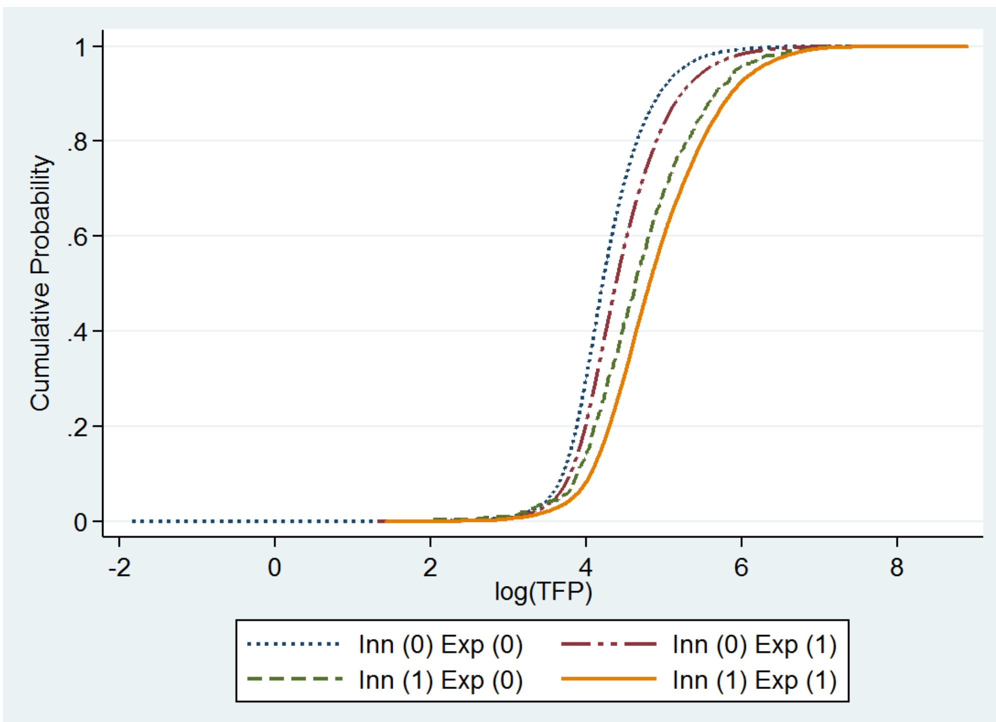
Note: Statistics based on EAE dataset and R&D survey data, average from year 1999 to 2007. Employment calculated as average number of full-time employees. Average salary represents average annual salary of full-time employees in Euro. Total sales calculated as average total sales (domestic + foreign) in thousands of Euro. Total investment calculated as average of firm total investment in fixed tangible assets in thousands of Euro. Productivity calculated as log of total factor productivity following the De Loecker (2007) approach. Cash-flow calculated as the ratio between firm net income and total sales. R&D and export intensities calculated as the ratio of firm total investment in R&D or total exports over total sales. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

innovators show a higher export propensity accounting for larger total exports in relation to total sales. In addition, it is clear that exporting firms outperform non exporters according to all indicators, being larger, more productive, investing more and paying higher salaries. On the contrary, it is not possible to notice any relevant difference in terms of cash-flow, calculated as the ratio between firms net income and total sales, which is used to measure the liquidity available for companies activities. Comparing exporters and non-exporters within the sub-sample of innovators the results are even more striking. Firms who innovate and export at the same time show on average the best performance according to all indicators, consistent with the trade theories of super-productive firms self-selecting into exporting and innovating activities. However, non-exporting innovators appear to have a higher propensity towards R&D investment than exporters in both samples. This phenomenon might be related to the specific case of big French state-owned groups which operate in high-tech intense sectors but are mainly oriented towards the domestic market such as nuclear energy, transports and infrastructures equipment, microelectronics, recycling, processed food and defense.

These summary statistics appear to show that innovation is clearly correlated with firm performance. Even if exporters show a better performance in both samples, the predominance of non-exporting innovators over the average general exporters may indicate the possibility that the returns from R&D investment could be in general greater than the returns from being an exporter. In addition, the figures suggest that firms who innovate have an advantage in foreign markets with respect to non-innovating exporters. These phenomena suggest that innovation could be a complementary strategy with exports, which if implemented could have a strong correlation with firms' export performance. Finally, comparing Tables 2.1 and 2.2 we can stress again that our analysis should not suffer from a sample-selection bias when focusing on trade margins. In fact, it is possible to notice that the two samples are very similar in terms of firm productivity, export performance and innovating strategy, with firms included in the Custom Agency dataset slightly larger in terms of employment and total sales but not showing any significant difference in terms of export and R&D intensities.

In Figure 2.1 we focus more on firm productivity summarising the (TFP) distribution of all the firms in our sample according to their export and innovation status. To have a consistent measure of TFP we followed the De Loecker (2007) approach, which is an extension of the standard Olley and Pakes (1996) methodology, taking into consideration the heterogeneity in terms of productivity between exporters and domestic firms and between innovators and non-innovators as explained in the appendix AT.1. In our TFP estimation we have used value added as a proxy for output, including in the estimation total employment as a measure for labour, the total costs of intermediate input as costs of production, an export dummy equal to 1 for exporters or 0 otherwise, and total investment in tangible and intangible assets such as R&D. Once estimated and logged, we remove the top and bottom percentiles without any significant loss of observations, following the ISGEP (2008) approach in order to mitigate the effect of outliers on our analysis.

Figure 2.1: TFP cumulative distribution of French firms according to exporter and innovator status.



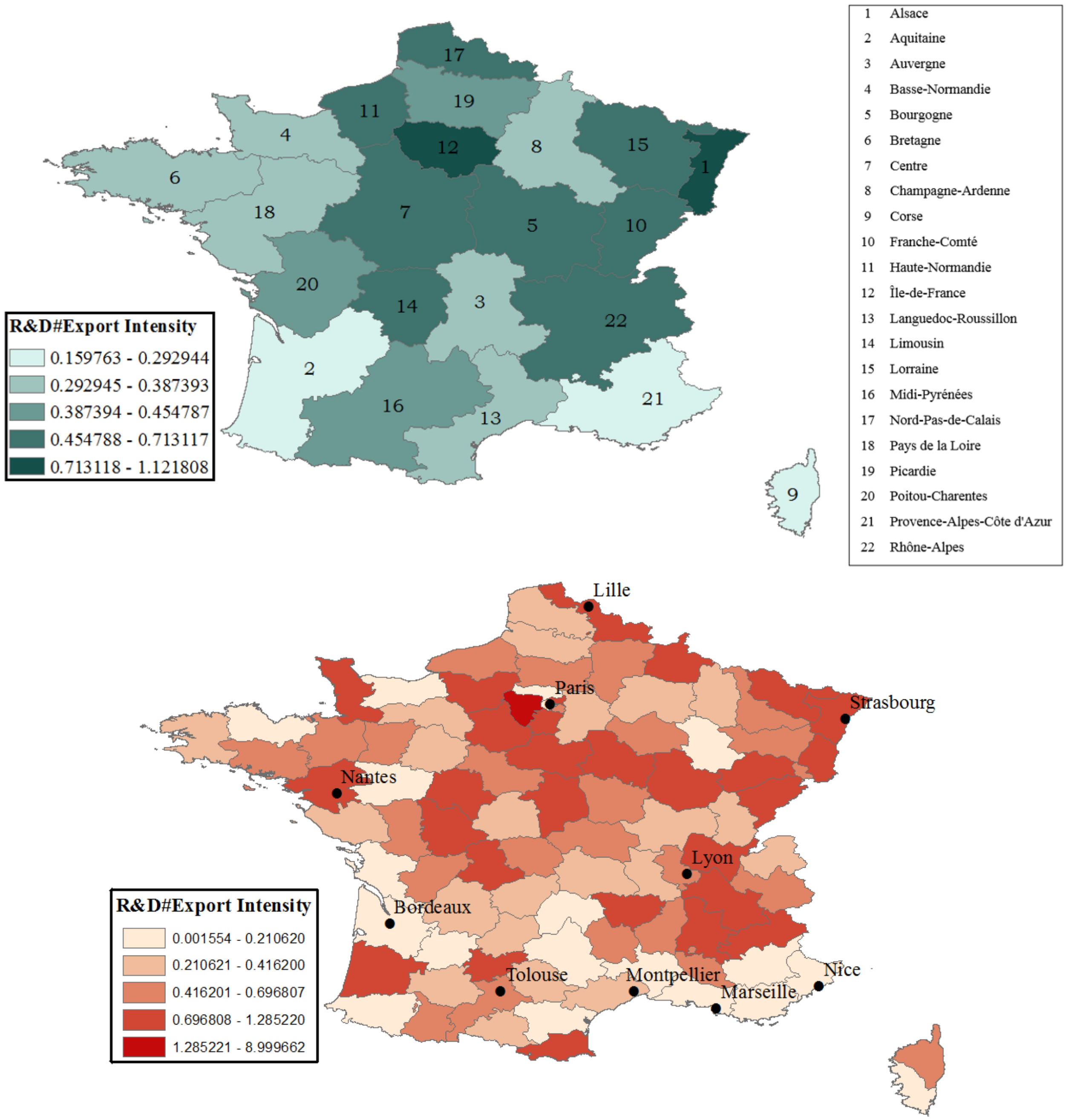
Note: Elaboration based on EAE dataset and R&D survey data, average from year 1999 to 2007. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Log(TFP) calculated following the De Loecker (2007) approach taking into consideration the heterogeneity in terms of productivity between exporters and domestic firms. Innovators are firms included in the Annual Survey on the Resources Devoted to R&D Activities collected by the French Ministry of Education and Research and having invested more than €350,000 on innovation per year or being part of a sample of companies dedicating fewer resources to R&D. Firms not included in this dataset are considered to be non-innovators. Exporters are firms that report having sold abroad manufactured products during the year as declared for tax purposes in the EAE dataset. Firms Classification: Inn (0) Exp (0): Firms neither innovating nor exporting; Inn (0) Exp (1): Non-innovating Exporters; Inn (1) Exp (0): Non-exporting Innovators; Inn (1) Exp (1): Innovating Exporters.

Notice in graph 2.1 that the cumulative distributions of exporting-innovators in our general sample always lays to the right of the distribution, meaning that for any percentile exporting-innovators are characterised by higher productivity than other firms. It is interesting as well to compare the productivity of firms which are alternatively exporters or innovators. From the graph it is possible to identify how the total factor productivity of non-exporting innovators strictly dominates the TFP distribution of non-innovating exporters, laying always to the right except for the very bottom percentiles where there is almost no difference between the two distributions. This evidence seems to suggest a stronger correlation between productivity and innovation rather than exports, identifying a precise TFP distribution ranking according to the innovation and exporting strategies followed by firms.

Figure 2.2 provides a further evidence of the correlation between export and R&D performance in France from a geographical perspective, presenting the quantile distribution of the interaction between R&D and export intensities across regions and departments, where firms' export and R&D intensities are measured as the ratio of total exports and R&D investment over total sales clustered by administrative body.[7] A strong relationship between R&D and exports is apparent from the darkly shaded areas in the two maps. In particular, both export and R&D intensities seem to be particularly high in the Ile-de-France, the region surrounding Paris, where most of the multinational enterprises (MNEs) and of research centres are located (IFA 2012), or in Alsace, the region bordering Germany, consistent with a cluster of exporters and innovators near high-income trade partners. Finally, it is possible to observe different concentration points around the cities of Lille, Lyon, Nantes and Toulouse where very large industrial clusters are located (aeronautics, transports, chemicals, agro-food and energy).

[7]Metropolitan France is divided in three different levels of administration: the national level, 22 regions and 96 departments. French regions have been officially created by the Law of Decentralisation on the 2nd of March 1982, which also gave regions their legal status. Region's primary responsibility is the management of public schools, infrastructural spending, public transport, research and assistance to private business. The main responsibility areas of the 96 departments instead include social policies and welfare, local transports, and maintenance of local infrastructure.

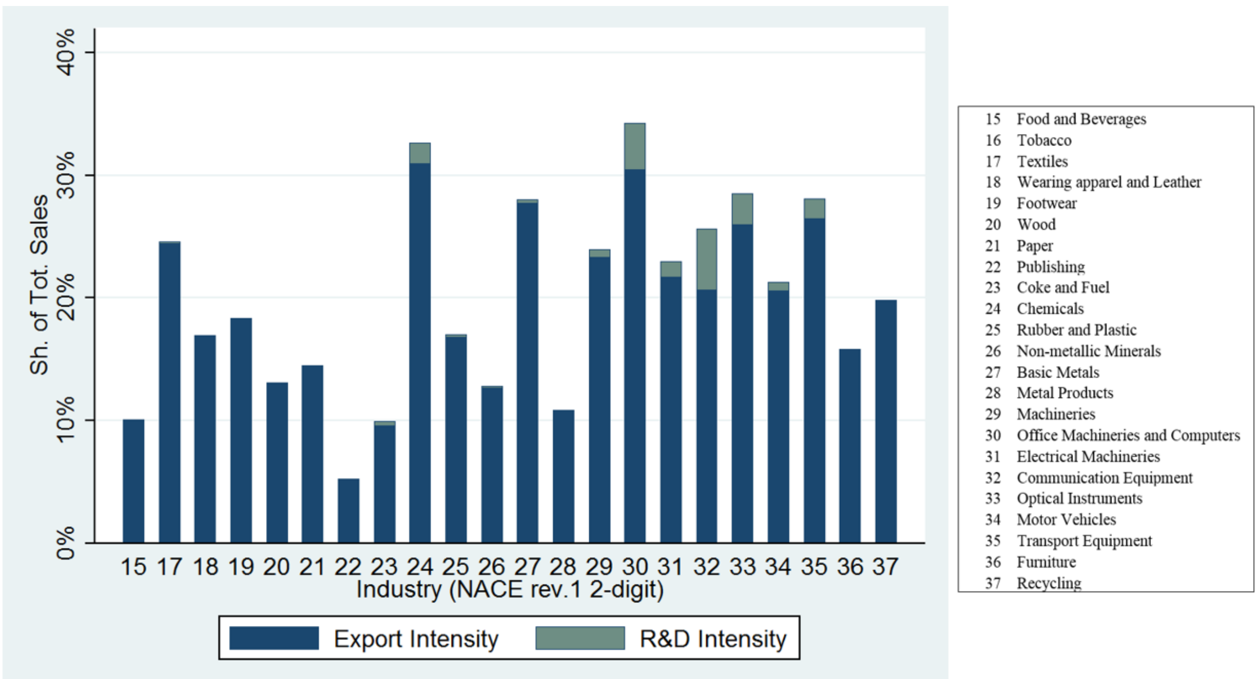
Figure 2.2: Quantile distributions of the interaction between R&D and Export intensities across departments and regions in France.



Note: Elaboration based on EAE dataset and R&D survey data, average from year 1999 to 2007. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. R&D#Export intensity represents the interaction between R&D and export intensities at the departmental and regional level in France. R&D and export intensities calculated as the ratio of total investment in R&D or total exports over total sales.

Moreover, Figure 2.3 shows that a small number of specific sectors are responsible for most of the export and R&D intensity in France. In particular, the leading sectors are computers and ITC equipment with the highest intensity both in terms of R&D and exports, followed by optical and precision instruments, electrical machineries, chemicals and transport equipment. In addition, the motor vehicle industry exhibits a high propensity towards export and innovation, even if the production is clustered in a restricted number of firms.

Figure 2.3: Cumulative export and R&D intensities across France manufacturing sectors.



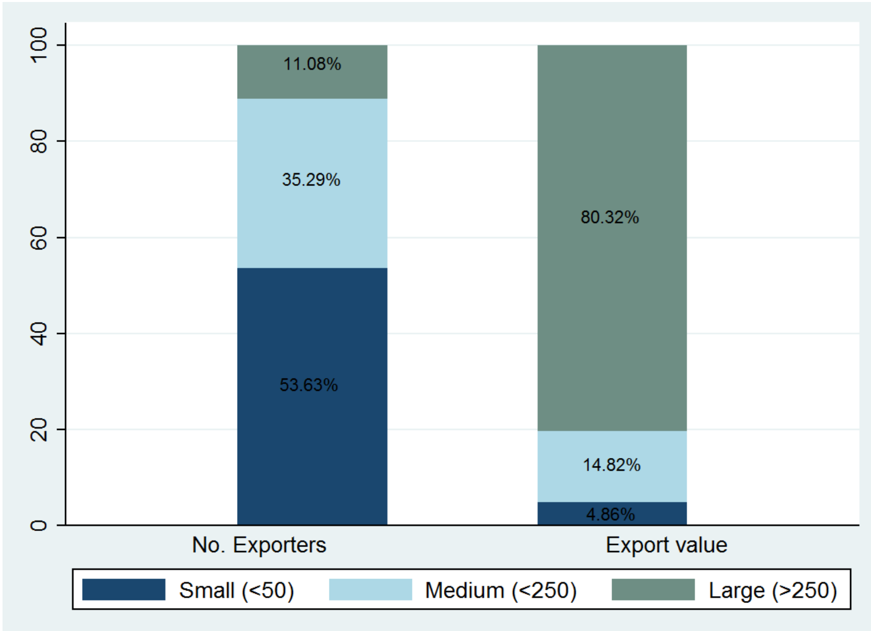
Note: Elaboration based on EAE dataset and R&D survey data, average from year 1999 to 2007. Manufacturing sectors according to the NACE rev.1 2-digit level industrial classification. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. R&D and export intensities calculated as the ratio of firm total investment in R&D or total exports over total sales.

Figures 2.4 and 2.5 show the evolution of the number of French exporters and of their total exports in our sample of firms included in the EAE dataset during the period studied. Note that in France 40% of largest exporters (those with more than 50 employees) account for more than 95% of French total exports in terms of value, once again corroborating the theory that aggregate exports are mainly driven by a small number of large exporters, the so called "happy few" (Mayer and Ottaviano 2007). This sample provides a comprehensive picture of French exporters activity, and based on the previous evidence we can safely reject any concerns about possible selection bias. Even if we are mainly focusing on firms with more than 20 employees the previous findings have shown how these top exporters account for more than 90% of France total exports, representing the core of French exporters.

Table 2.3 provides a summary of the export performance of firms included in our sample collected from the Custom Agency dataset. We present the trend from 1999 to 2007 for the total value of exports and the number of French exporters, the average value of exports by firm, the total number of shipments made, their average value (the intensive margin), the average number of countries served and the average number of products exported. We provide detailed information on the trade margins of almost 17,000 exporters in total, 10,500 exporters on average per year, less than 15% of the overall sample of exporters registered by the Custom Agency, but accounting on average for more than 57% of total exports over our sample period. Focusing on innovators the figures are even more striking. Even though the 3,700 exporters in our innovating firms sample represent just 2.3% of total number of exporters, they are responsible for almost 35% of total French exports, giving a comprehensive illustration of France's total exports.

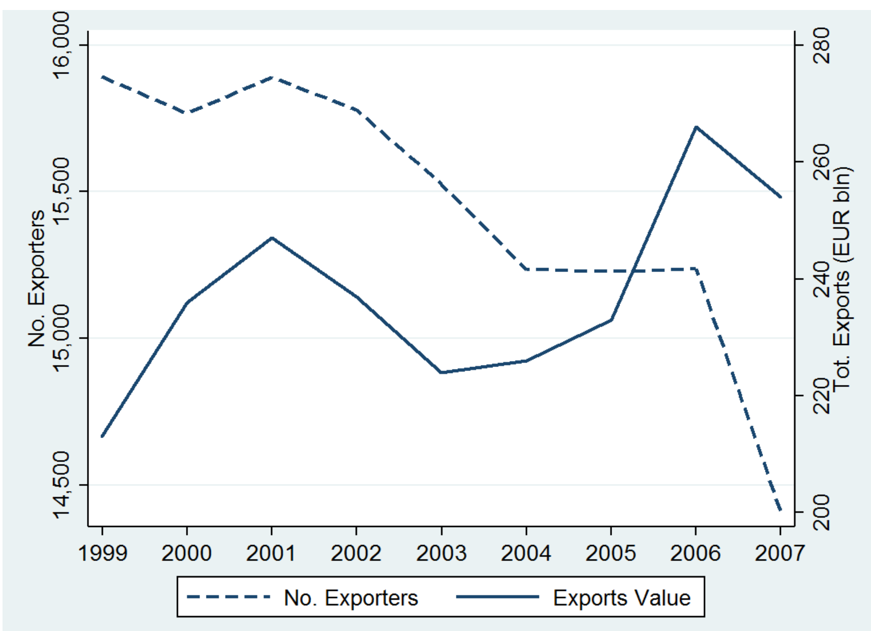
Table 2.3 provides an additional insight on the average trade performance of exporters in our sample per year. In fact, exploiting the Custom Agency data we are able to calculate at the firm-level three different trade margins, considering both the intensive margin, calculated as average value of shipments for each exporter, and the extensive margins distinguishing between the number of different products exported, the number of foreign markets served by French exporters and the average number of products exported to each foreign market. Also in this case we compare the general and the innovating samples. First, innovators tend to export

Figure 2.4: Distribution of French manufacturing exporters according to firms' size and export value.



Note: Elaboration based on EAE data, average from year 1999 to 2007. Firms Classification (EU Recommendation 2003/361): Small: employees $<$ 50, turnover $\leq$ EUR 10 million; Medium: employees $\leq$ 250, turnover $\leq$ EUR 50 million; Large: employees $>$ 250, turnover $>$ EUR 2 million.

Figure 2.5: Time series of number of exporters and of total exports value in French manufacturing sectors between 1999 and 2007.



Note: Elaboration based on EAE data from year 1999 to 2007. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

Table 2.3: Export performance evolution of all French firms and innovators included in the CA data over the period 1999-2007.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Tot. Sample
All Firms in Customs Agency Data										
Tot. Exports (EUR bln)	202	243	252	258	260	284	306	349	369	2,523
No. Exporters	61,803	65,337	67,657	69,901	70,275	72,709	75,374	77,481	79,910	160,762
All Firms matched in our sample										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	Tot. Sample
No. Exporters	9,307	9,568	10,000	10,317	10,503	10,723	11,053	11,438	11,115	16,947
Sh. Tot. Exporters	15.05%	14.64%	14.78%	14.75%	14.94%	14.74%	14.66%	14.76%	13.90%	10.54%
Sum Tot. Exports (EUR bln)	135	161	168	156	137	145	152	187	184	1,430
Sh. Tot. Exports	66.83%	66.25%	66.66%	60.46%	52.69%	51.05%	49.67%	53.58%	49.86%	56.67%
Av. Tot. Exports (EUR mln)	14.50	16.80	16.80	15.10	13.10	13.50	13.80	16.40	16.50	15.20
Av. Intensive Margin (EUR)	172,913	186,807	198,962	201,844	201,707	202,398	215,687	244,001	260,552	210,887
Av. No. Shipments	63.58	63.85	62.83	61.43	59.05	61.46	61.24	64.40	66.69	62.74
Av. No. Destinations	15.17	15.25	15.23	15.19	15.02	15.28	15.30	15.86	16.04	15.38
Av. No. Products	17.04	17.16	17.02	17.05	16.29	16.38	16.10	16.82	17.27	16.78
Av. No. Prod-Country	2.93	2.94	2.92	2.94	2.88	2.93	2.90	2.96	3.02	2.93
Innovating Exporters in our sample										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	Tot. Sample
No. Exporters	1,328	1,171	1,414	1,422	1,528	1,633	1,494	1,813	1,957	3,719
Sh. Tot. Exporters	2.14%	1.79%	2.08%	2.03%	2.17%	2.24%	1.98%	2.33%	2.44%	2.31%
Sum Tot. Exports (EUR bln)	79.5	90.4	98.9	98.4	79.2	83.8	85.0	111	110	836
Sh. Tot. Exports	39.40%	37.20%	39.24%	38.13%	30.46%	29.50%	27.77%	31.80%	29.81%	33.13%
Av. Tot. Exports (EUR mln)	59.90	77.20	70.00	69.20	51.80	51.30	56.90	61.50	56.00	60.80
Av. Intensive Margin (EUR)	304,818	344,336	343,515	371,327	332,198	334,004	385,705	440,043	411,538	367,313
Av. No. Shipments	181.62	193.19	176.04	176.63	158.62	155.72	168.19	157.06	161.36	168.31
Av. No. Destinations	34.05	33.17	33.82	32.16	31.48	33.24	31.43	31.89	32.75	32.66
Av. No. Products	38.56	41.24	38.30	38.85	35.28	34.07	36.23	34.99	35.67	36.76
Av. No. Prod-Country	3.88	4.03	3.91	3.91	3.71	3.72	3.89	3.83	3.87	3.85

Note: Statistics based on Custom Agency data between 1999 and 2007. Sum total exports calculated as sum of exports of all firms included in each sample in each year in billion of Euro. Average total exports calculated as average of firms exports in each sample in each year in million of Euro. Total exports include data on all intra-EU shipments over € 100,000 and extra-EU over € 1,000 collected by the French Custom Agency. Intensive Margin calculated as average value of firms shipments abroad. Product extensive margin calculated as average number of products exported by French firms each year. Country extensive margin calculated as average number of foreign markets served by French firms each year. Average number of shipments instead is the average number of products shipped to each country by French firms in each year. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

more products to more countries, two times larger than non-innovators exporters, registering a higher average value per shipment as well. In addition, it is interesting to notice that while the extensive margins of French exporters have marginally improved in general during the period 1999-2007, the same is not true for French innovators in our sample which have experienced a small decrease in the number of destinations and products exported. Nevertheless, the intensive margin has increased substantially during the same period, both in the general and in the innovators sample. This evidence might suggest that French innovators during this period have decided to focus their attention just on a small number of products and in exporting to a relatively smaller number of foreign markets, but dedicating instead their resources in improving the quality of products and to increase the average value of shipments.

However, while we acknowledge an increase both in the total value of exports and the total number of exporters part of our samples in the Custom Agency dataset, previously in Figure 2.5 we have noticed a marginal decrease in the total number of French exporters present in our sample in the EAE dataset during the same period despite the overall value of France's total exports has steadily increased. These apparently contradictory phenomena could be explained by a slow growth in the average value of exports but a stronger increase in the number of shipments per firm exporting more products to more countries, consistent with an increase in total exports despite a reduction of the number of exporters. Secondly, we need to keep in mind that as previously stressed only large transactions within the EU plus all the extra-EU exports above € 1,000 are registered by the Custom Agency in France, while the EAE dataset includes all firms with more than 20 employees. Thus, these just apparently contradictory phenomena might be explained with a decrease in the numbers of French firms exporting small shipments in favour of an intensification of the export participation of large firms with an intense export activity.

We now focus on R&D activities. Table 2.4 analyses the behaviour of French innovating firms according to various indicators of firms' R&D strategy and activity, discriminating by export status. In particular, we analyse the resources dedicated by French firms to R&D activities, the number of workers and researchers employed in the R&D department, the average salary paid to researchers, the amount of public funds received to stimulate innovative activities and different measures of R&D output, namely the number of patents registered and the frequency of new product or process innovations. First, it appears that even if exporters invest significantly larger funds in innovating activities relative to non-exporters they surprisingly register a lower R&D intensity ratio than innovating non-exporting firms. This fact might be explained by the second term of the ratio, total sales, that as we have seen before are on average higher for exporters. Another explanation could be the high propensity toward investment in R&D shown by certain state-owned business groups which are instead mainly oriented towards the internal market as previously stressed. In fact, looking at the industrial distribution of export and R&D intensities in Figure 2.3 we can remark that some of the top sectors in terms of R&D investment register a very low propensity towards exports, such as the production of coke, petroleum and nuclear fuel, the agro-food sector or the publishing industry. Secondly, exporters seem to be more capable than non-exporters in attracting funds provided by public authorities to sustain private firms R&D activities. One of the possible reasons explaining this issue might be related with the requirement by public authorities to form international co-operations and joint-ventures to access public R&D funding, especially in the case of EU funding projects. Exporters in this case might have a relative comparative advantage in securing these funds, exploiting in particular the international knowledge network of foreign suppliers, customers and partners.

Moreover, it is possible to identify that exporters are generally more successful than non-exporters in translating R&D investment into new innovations, both in terms of new

Table 2.4: R&D indicators for French firms in our sample over the period 1999-2007 according to export status.

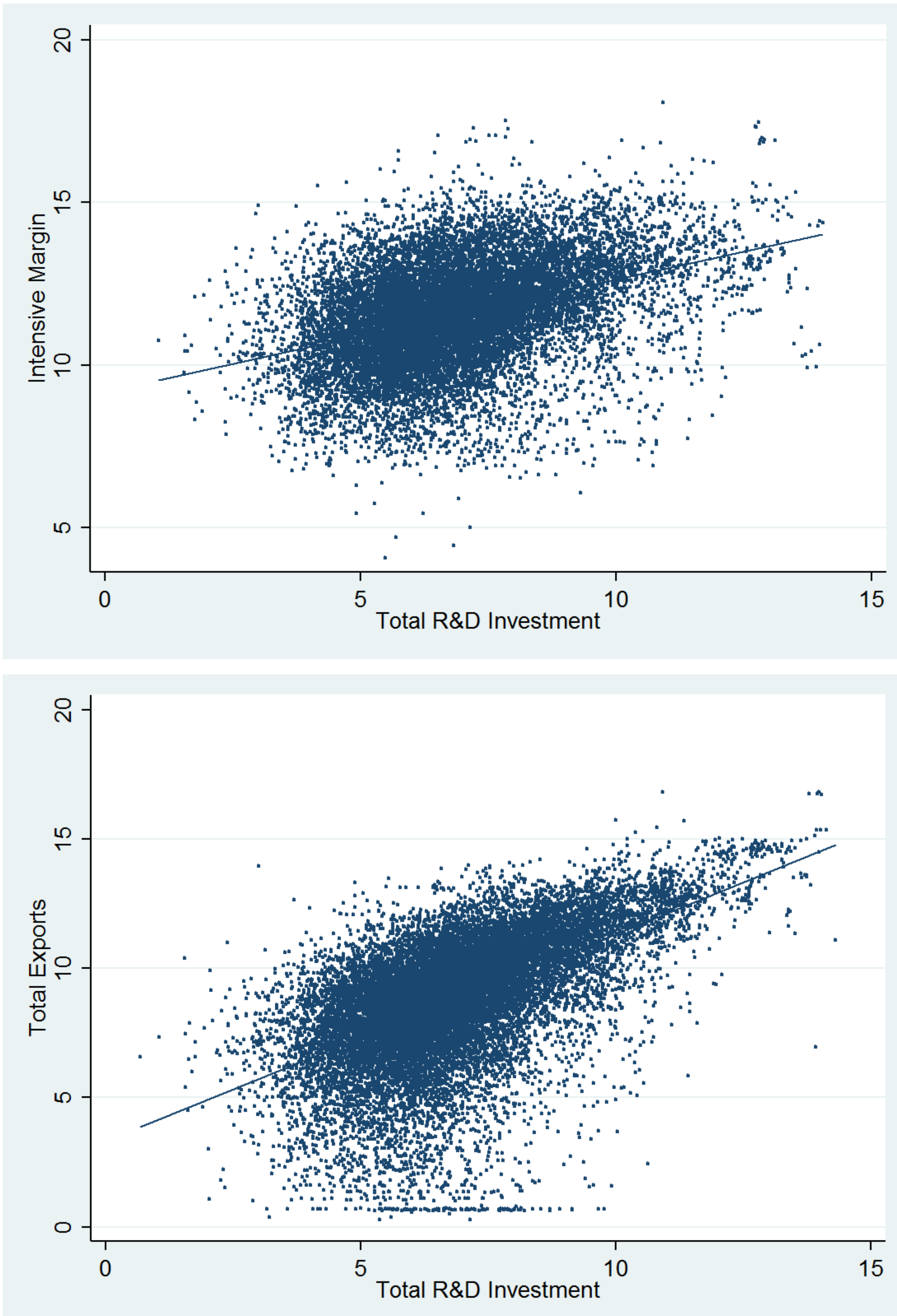
	All Firms	Exporters	Non-Exporters
Tot. R&D Investment	7,880.24	8,149.77	1,710.08
R&D Intensity	5.67%	5.34%	13.22%
Employment in R&D	53	55	13
No. Researchers	27	28	6
Av. Salary Researchers	39,867	41,210	21,084
R&D Public Funding	1,079.36	1,125.16	235.07
No. Patents	8.82	9.14	1.56
Freq. Product Inn.	67.97%	68.33%	59.55%
Freq. Process Inn.	54.73%	54.80%	53.13%

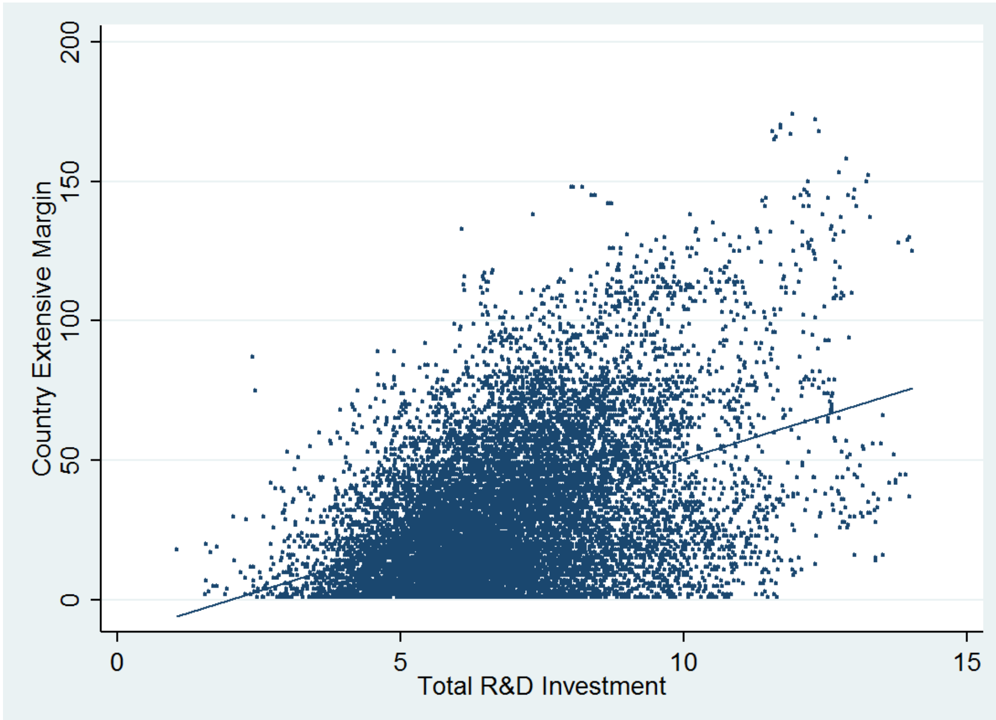
Note: Statistics based on R&D Survey data, average from year 1999 to 2007. Total R&D investment in thousands of Euro. R&D intensity calculated as average ratio of firms total investment in R&D over total sales. Employment in R&D considers the average number of full-time personnel employed in the R&D departments. No. researchers is the average number of researchers employed by French firms in the R&D department. Average salary takes into consideration just the yearly salary paid to researchers. R&D public funding calculated as the average funds received by French, foreign and international public authorities to stimulate private firms innovative activities in thousand of Euro. Number of patents considers the average number of patents registered at the national (INPI), European (EPO) or US (USPTO) patent office. Freq. Product and Process Innovation reports the average frequency of the introduction of new product or process innovations in French firms during the period of interest. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

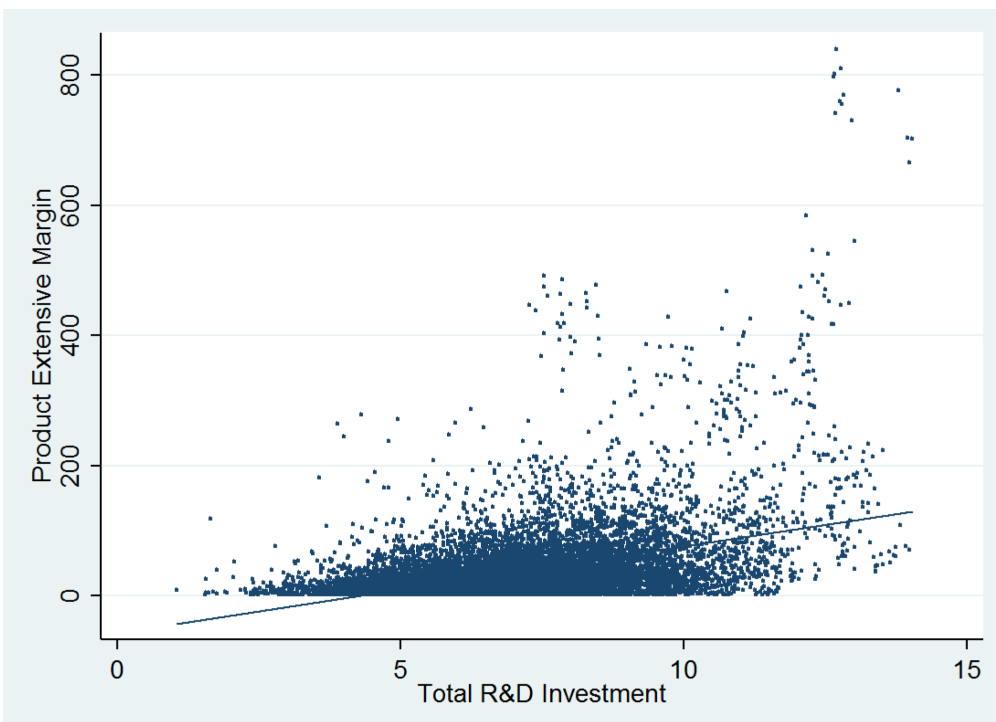
products introduced and total patents granted. In addition, exporters on average employ more researchers and personnel in their R&D activities, paying as well higher wages. The possibility for exporters to attract high-skilled expertise offering higher salaries translates generally in a considerable larger number of patents registered by exporters in respect to non-exporting firms, while the figures relative to product and process innovations confirm this trend but with a smaller magnitude. Possibly also for these reasons, patent activity seems to be driven by exporters which may be more interested in protecting their property rights when operating in foreign markets than non-exporting firms developing new products just for the internal market.

Finally, in Figure 2.6 we further investigate the relationship between export and innovation strategies by plotting a measure of firms' R&D propensity (the total investment in R&D) on the horizontal axis and several margins of trade on the vertical axis (namely total

Figure 2.6: Correlation between trade margins and R&D total budget.







Note: Elaboration based on EAE dataset, R&D survey and Custom Agency data from year 1999 to 2007. Total Exports calculated as firm total foreign sales according to the EAE dataset. Intensive Margin calculated as the average value of firm shipments abroad from CA dataset. Product and country extensive margins are count variables for the number of products exported or number of foreign markets served by each exporter according to the CA dataset. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

exports, the extensive and the intensive margins of trade).

Looking at firms' total exports and at the intensive margin of trade, we observe a strong positive relationship between those two measures of trade on the one hand and firms' total R&D expenditure on the other. The distribution of French firms' total exports seems to increase when R&D funds are larger. This suggests the presence of a self-selection mechanism which clusters very few productive firms in the top distribution of R&D and export intensities. In particular it appears that investment in innovation is principally correlated with the value of total exports and the average value of exported products, consistent with the trade theory predicting an improved export performance driven by an increase in exports value consequent to investment in R&D (Hallak 2006; Montinari et al. 2013). Moreover, it is possible to identify a similar trend also observing the relationship between R&D expenditure and the country extensive margin. French firms seem to export to a larger number of destinations when their investment in R&D increases.

2.4 Methodology

In this chapter we focus on the impact of R&D activities on export performance at the firm level. First, in order to understand whether firms who innovate obtain an export premium we investigate the impact of R&D activities on the probability of being an exporter and on the volume of exports. Second, we disentangle the effect of innovation on exports by examining the impact of R&D on the extensive and the intensive margins of trade. This way of proceeding bring two main advantages. First, it enables us to establish whether different R&D activities improve exporters' performance by creating new trade links, for instance exporting new products and opening new export markets, or intensifying the existing flows increasing the average value of exports. We would be able, in this way, to identify the most important margins through which R&D activities affect exports growth.

2.4.1 Innovation Measurement

To measure the innovating strategies of French firms we also disaggregate the effect of R&D activities by including different measures of innovation. In the previous literature either measures of R&D input or output have been used as proxies for firms' innovation capabilities. This approach has both advantages and drawbacks. The most popular innovation indicator used so far is total R&D expenditure, a variable collected at regular intervals and easily comparable across countries thanks to the international harmonized standards. Nevertheless, the evaluation of total R&D budget could be misleading if not properly compared with the results of this investment (Mohnen and Hall 2013). In addition, R&D expenditure tends to underestimate the real innovative effort of firms not considering other informal R&D activities such as product design, market analysis or training of employees, especially for small firms (Kleinknecht et al. 2002).

Recently, several empirical studies look at measures of R&D output such as the number of patents or innovation introduced thanks to new indicators available in recent innovation surveys based on firm assessment. On the one hand these indicators represent a direct measure of successful innovation, evaluating the innovations introduced into the market and generating a cash-flow (Kleinknecht et al. 2002). On the other hand considering just R&D output measures could alter the estimation of innovation efficiency given the complexity of patent application procedures and the subjective assessment on product and process innovations[8].

[8] For an exhaustive review of this issue see e.g. Wakelin (1998); Kleinknecht et al. (2002); Cassiman and Golovko (2007); Chen (2013); Becker and Egger (2013).

In addition, not including total R&D expenditure means we would underestimate the overal effect of innovation on total exports, in particular not considering the possible positive effect of R&D investment which has not resulted in the introduction of a new innovation but which have had anyhow improved firms' stock of knowledge and of human capital.

Hence, we include in our model both measures of R&D input and output, in order to take into account both aspects of the same phenomenon. Including both R&D expenditure and product and process innovations raises possible collinearity concerns. In fact, as shown in Table A.2.3 in the appendix, the correlations between R&D input and output measures are relatively high, in particular between investment in R&D and product innovation variables, ranging between the 71% and 77%. However, Kleinknecht et al. (2002) using factor analysis demonstrate that there is little correlation between the various R&D indicators, arguing that they represent different aspects of the innovation effort. In particular, the results of the factor analysis suggest that there is a clear difference between two groups of indicators. On the one side total R&D expenditure and patent applications appear to describe the same process, while on the other side the authors group together different measures of R&D output indicators. According to the authors, different innovation indicators present their own strengths and weaknesses depending on what is being investigated, but each should be taken into account in order to identify the contribution of all the different effects of the overall R&D efforts on firm performance. In our results we show the robustness of our decision to include both R&D input and output measures in the estimation of the effect of innovation on export performance.

2.4.2 Baseline Model

We employ a range of different econometric techniques to estimate the role of innovation on exports performance. In order to assess the impact of different innovation activities on trade margins while controlling for firm heterogeneity we follow the previous literature and begin with a basic model given by:

$$X_{it} = \alpha_0 + \alpha_1 Z_{it-1} + \alpha_2 R_{it-1} + \alpha_3 I_{it} + k_j + k_t + \epsilon_{it} \tag{2.8}$$

In the above specification the dependent variable X_{it} represents all the different measures of export performance of firm i at time t, such as total exports, exporter status and extensive and intensive margins of trade. Z_{it-1} is a vector of firm i specific indicators of size and performance at time $t-1$, such as size in terms of employment, average wages, total investment, cash-flow, share of foreign ownership and TFP. The key explanatory variables are R_{it-1} and I_{it}. R_{it-1} represents the lagged measures of firm i total investment in R&D, linking past total expenditure in R&D with present trade performance. The decision to lag firms' total investment in R&D is corroborated by previous literature and anecdotal evidence which shows how investment in R&D usually takes longer to complete and to generate returns (Cassiman and Golovko 2007; Aw and Lee 2009). I_{it} expresses the different indicators of firm i innovation output: in the main specifications those will be represented by two dummy variables taking a value equal to one when firm i introduces a new product or process innovation at time t and 0 otherwise. The R&D output measures are not lagged in the main specification since the variable in the data denotes the introduction of a new product during the year ready to be sold, as well as the introduction of a new process used in the same year (for example to cut down the costs of production). We assumes that these two variables immediately affect firms' export performance, especially for very large multi-products firms which characterize our sample and continuously introduce innovative products (Becker and

Egger 2013; Lo Turco and Maggioni 2015). Year k_t and industry fixed effects at the NACE 2-digit-level k_j are included in all specifications in order to account for any year and industry specific characteristics and to capture macroeconomic dynamics. In addition, we distinguish between firms according to size and ownership structure, in order to estimate the different effect R&D activities might have on the sub-samples of small, large, domestic and foreign firms.

To estimate the different parameters we use a fixed-effect panel model to consider the within-firm variation. In particular, for the extensive margins of trade we apply a panel fixed-effects poisson regression model given the count nature of the data. In fact, in both the product and the country extensive margins the observations have only positive integer categorical values where the count represents the number of items belonging to each category (Hilbe 2011). In addition, for the product-country extensive margin we apply a panel OLS model since we are looking at the average number of products exported to each foreign market served by firm i. Finally, in order to analyse export status and the role played by innovation in influencing this strategy, we use a fixed-effect logit model which has been proven to be the best estimation strategy for binary choice models, explicitly controlling for unobserved firm heterogeneity across time (Wooldridge 2005a; 2005b). Including fixed-effect in our logit model will result in the estimation of the impact of innovations just on those firms which have switched from non-exporters to exporters or vice-versa, dropping out firms with a stable status throughout the period and reducing significantly the number of observations.

In further appendix tables discussed later we also present two alternative estimation procedures. Following a fixed-effects approach we have focused only on the within firm variation. But it might be the case that the variation across firms is random and has an influence on the dependent variables, namely the different trade margins. For this reason, we decided to implement a random-effects model as a robustness check to estimate the different effect of innovating activities across firms in our sample. Different estimating techniques have been applied according to the dependent variables, always including year and industry dummies. To estimate the impact of innovation on firms' total exports, the intensive margin and the product-country extensive margin we have used a random effects panel tobit due to the censored structure of the dependent variables. For the country an product extensive margins instead a panel poisson regression has been applied given the count nature of these variables. In addition, in order to analyse the role played by innovation in influencing firms to engage in export, we have used a random-effect probit to estimate binary choice models controlling for unobserved firm heterogeneity across time.

In addition, we implement a dynamic system GMM instrumenting the possible endogenous variables with their three-periods lagged values plus the total amount of public resources used to fund the R&D activities. We consider the variables measuring innovation as predetermined and therefore not correlated with the error term but expected to influence firm's export performance. System GMM has been found to be more efficient compared with difference GMM, particularly in the presence of heteroskedasticity (Arellano and Bond 1991). To evaluate the overall goodness of fit of the GMM models we report the Sargan and the Hansen tests of overidentifying restrictions which present an evaluation of exogeneity of the subset of instruments. In addition, we test for the presence of first and second order serial autocorrelation, which is inconsistent with predetermined variable regressions (Windmeijer 2006).

2.4.3 Matching Method

However, following the previous literature on this topic, we are concious of possible endogeneity problems affecting the analysis on innovation and trade. Hence, in order to properly identify the causal link connecting innovation and export performance, we make use of a difference-in-differences (DID) propensity score matching (PSM) technique in a multiple treatment approach (Lechner 2002; Leuven and Sianesi 2003). In particular, we are interested in comparing the export performance of firms before and after they start innovating with respect to non-innovators. Matching methods allow to correct the endogeneity bias thanks to the construction of valid control groups based on the observable differences between innovators and non-innovators. A range of related studies apply matching techniques to analyse the causal relationship between innovation and exports (e.g. Caldera 2010; Lo Turco and Maggioni 2015; Becker and Egger 2013; Damijan and Kostevc 2015; Boermans and Roelfsema 2015). The main difference with the previous studies is that we follow a multiple treatment approach, taking into consideration both R&D input and output measures in order to estimate the impact of innovation on export performance. In addition, we control for firms previous export performance, matching treated and control group firms with similar export behaviour in order to adjust the estimation bias related to the reverse causality issue. Finally, we analyse the impact of different R&D activities on a number of export performance variables, namely the trade margins, estimating the effect of R&D activities on the value of exports, the product mix of exporters and their foreign-market access.

As previously discussed, one of our main contributions to the existing literature is the estimation of the impact of both R&D input and output measures on firm export performance. Hence, we consider a set of multiple endogenous innovating "treatments" a which firms might perform. We consider innovation as an incremental process in which firms, conditional on an initial investment in R&D, could introduce a new product, a new process or both. The first innovation treatment considers the case in which a firm has invested in R&D activities for the first time (Rd). Even if the introduction of an innovation does not take place after the expenditure in R&D, research and development activities may still improve firm stock of knowledge or its human capital, resulting in a positive effect for the export performance.

Secondly, investment in R&D may result in two different positive outcomes. We then consider separately the case in which after an investment in R&D the firm introduces a product innovation (Pd) and the case in which instead the investment in R&D resulted in a process innovation (Pc). Finally, in the last treatment we consider the case in which after an investment in R&D the firm successfully introduced both a product and a process innovation in the same year ($PdPc$). Thus, our categorical variable a could take a value equal to 0 if a firm does not innovate and Rd, Pd, Pc or $PdPc$ if it performs one of the innovation treatments for the first time.

Each of the previous treatments consider only firms which perform one of the innovating activities for the first time, in order to isolate the effects on export performance after firms start innovating. To accurately identify the treatments, we first drop all the firms which have undertaken R&D activities since the beginning of our sample period. Then, we rescale the time periods in order to consider time $t = 0$ as the time in which a firm performs one of the treatments or as the median year for non-innovators. Based on $t = 0$ observations, we measure the growth of firms' export performance variables over the next three years, in order to assess the effect of the different types of innovating treatments on firm trade margins in the following period. We then drop the subsequent observations of treated firms after the first treatment at time $t = 0$ so that a firm cannot be matched with itself or could be erroneously included in the control group after being treated.

The aim of our analysis is to assess the average treatment effect on the treated (ATT) for each treatment, in other words to estimate the difference in export performance between firms which have implemented one of the innovative treatments and similar firms which instead have not started any R&D activity or have implemented a different treatment. In this way it is possible to compare the effect of each kind of treatment not only against untreated firms, but also with respect to other kinds of R&D activities. We define y_{it} as firm i export performance at time t and $y_{i(t+n)}$ as the export performance at n periods later. The causal effect of innovative activities on the export performance of firm i at time $t+n$ can be identified as the difference between:

$$y^{a}_{i(t+n)} - y^{0}_{i(t+n)} \tag{2.9}$$

where the subscripts denote the innovation treatments a undertaken by firm i at time t or 0 for firms who have never innovated. Thus, $y^{0}_{i(t+n)}$ represents the export performance of firm i at time $t+n$ if it had not performed any innovative treatment at time t. Since we are interested in identifying the differences in export performance after a firm starts innovating, we can express the average effect on export performance that new innovators would experience if they had not performed any R&D activity as:

$$\tau_{ATT} = E\left(y^{a}_{i(t+n)} - y^{0}_{i(t+n)} \mid S_{it} = a\right) = E\left(y^{a}_{i(t+n)} \mid S_{it} = a\right) - E\left(y^{0}_{i(t+n)} \mid S_{it} = a\right) \tag{2.10}$$

in which τ represents the expected effect on outcome y of treatment a in the post-treatment period, relative to the effect of no treatment 0 for the same firm. We are interested in assessing the average treatment effect for each of the treatments a, that is the difference in the outcome a firm would have experienced if it had not performed treatment a. The fundamental problem is that only one of the two possible outcomes in the previous equation is observable, whether the firm decides to perform or not an innovating activity, while the counter-factual for the same firm could not be observed. Since $E\left(y^{0}_{i(t+n)} \mid S_{it} = a\right)$ is not observable, we construct a control group by considering instead the effect of no treatment or of a different innovative treatment on similar firms which actually implemented the innovating activity that has to be compared or have not innovated at all, $E\left(y^0_{l(t+n)} \mid S_{lt} = 0\right)$.

In order to build a consistent control group to be compared with the treated firms we apply a matching approach as introduced by Rosenbaum and Rubin (1983) and Heckman et al. (1997). The aim of matching techniques is to select from the sample of untreated firms a control group for which the distribution of observed characteristics in the pre-innovation period is as similar as possible to the distribution of treated firms (Becker and Ichino 2002). The first step is to estimate the probability that a firm undertakes each of the innovating treatments at time t, the so called propensity score, based on a set of observable characteristics. The multinomial logit model that we use to estimate the propensity score for undertaking the different innovating treatments is given by:

$$\begin{aligned} Pr\left(Inn_{it}\right) = & \beta_0 + \beta_1 Empl_{it-1} + \beta_2 Salary_{it-1} + \beta_3 TFP_{it-1} + \beta_4 Exp_{it-1} + \\ & \beta_5 Inv_{it-1} + \beta_6 Cashflow_{it-1} + \beta_7 Group_{it} + k_j + k_t + k_r + \epsilon_{it} \end{aligned} \tag{2.11}$$

Following the previous literature, we use as explanatory variables of the probability of implementing an innovating treatment a set of firms characteristics including lagged values of total employment, average salary, total factor productivity, total investment, cash-flow and group affiliation. We also include industry (2-digit NACE rev.1 industries), year and region dummies (Becker and Egger 2013; Lo Turco and Maggioni 2015). In addition, because of possible complementarity between export and innovation, we also include firms' previous export performance to explain their propensity towards different innovating activities. Our purpose is to mitigate the problems related to reverse causality so to avoid that any potential impact of innovation on exports in the DID estimation might be driven by previous performance in international markets. This mean that our matching procedure will be able to draw from the control group firms with an export performance similar to treated firms, in order to level off the contribution of the so called "learning-by-exporting" phenomenon.

Table 2.5 presents the results of the multinomial logit used to estimate the propensity score. As expected, most of the variables have a positive and significant effect on the probability of undertaking one of the four treatments. It is interesting to note that only the probability of introducing a new process innovation behaves in a different way compared to the probabilities of undertaking one of the other treatments. In particular, TFP has a significant and positive effect only on total investment in R&D and on the joint adoption of both new product and process innovations. On the contrary, average salary and cash-flow despite been significant for the probability of the other three treatments, do not seem not to be relevant for the introduction of new processes. Moreover, previous export performance has a positive and significant impact on the probability of undertaking any of the possible treatments, highlighting the importance of previous international experience as a driver of innovation.

The next stage is to employ the propensity scores obtained from the previous model to match treated and control observations. We decided to match firms within each 2-digit NACE sector and for each year in order to create more homogeneous control groups instead of matching across the entire sample of French manufacturing firms (Girma et al. 2004; De Loecker 2007). In this way, we take into account the large variance in the probability and the effect of starting an innovating activity on export performance across different manufacturing industries, considering as well any time-variant shocks which might have affected firms across different industries. After obtaining the propensity score for a firm starting an innovating activity, we force the matching by multiplying each score by a new industry-year

Table 2.5: Multinomial logit estimation to estimate the propensity score

Treatment	(1) R&D	(2) Pd	(3) Pc	(4) PdPc
$Tot.Employment_{t-1}$	0.625***	0.628***	0.550***	0.805***
	(0.0638)	(0.0561)	(0.0790)	(0.0429)
$Av.Salary_{t-1}$	1.171***	0.939***	0.339	1.341***
	(0.238)	(0.211)	(0.297)	(0.160)
TFP_{t-1}	0.504*	0.0354	0.0895	0.443*
	(0.306)	(0.115)	(0.165)	(0.239)
$Export_{t-1}$	1.140***	1.351***	1.003***	1.459***
	(0.150)	(0.144)	(0.176)	(0.111)
$Tot.Investment_{t-1}$	0.0712**	0.139***	0.212***	0.138***
	(0.0302)	(0.0279)	(0.0413)	(0.0210)
$Cash-flow_{t-1}$	1.779***	1.631***	-0.0188	1.833***
	(0.578)	(0.552)	(0.704)	(0.411)
$ForeignGroup_t$	0.551***	0.599***	0.427**	0.506***
	(0.157)	(0.134)	(0.184)	(0.0998)
$FrenchGroup_t$	0.845***	0.742***	0.750***	0.716***
	(0.128)	(0.114)	(0.151)	(0.0843)
No. of Firms	26,479	26,479	26,479	26,479

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a multinomial logit. Unreported year, region and industry (NACE rev.1, 2-digit) dummies are included. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variables $R\&D$, Pd, Pc and $PdPc$ denotes the possible innovating treatments of investing in R&D, introducing a product innovation, a process innovation or to jointly introduce a product and a process innovation respectively and are equal to 1 if firms have been tretaed for the first time and 0 otherwise. As regressors, total employment is the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach. Export is a dummy variable equal to 1 if firm reports positive foreign sales and 0 otherwise, total investment is the log of total investment in fixed tangible assets, cash-flow is calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP, export, total investment and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variables.

identifier only if the firm belongs to that industry and if the treatment occurred in that year.[9] Following the previous literature which have used this matching procedures, in Figure A.2.1 and Figure A.2.2 in the appendix we checked whether the propensity score for the four different treatments is balanced across the two different groups of treated and control firms (Imbens 2004; Garrido et al. 2014). From Figure A.2.1 it is possible to observe that the

[9] As additional robustness check we estimated as well the ATT effect of innovating treatments on firm export performance not forcing the matching between treated and control observations to be within industry and year. The results, available on request, are robust and consistent with the analysis presented in this chapter.

probability of performing the four innovative treatments for treated firms follows the same density distribution of the firms in the untreated group. In addition, Figure A.2.2 shows how the mean propensity score is equivalent in the treatment and in the comparison group in all the cases of the four different treatments, demonstrating that the probability of being treated is evenly balanced between innovating and non-innovating firms.

After assessing the distribution of the propensity score, we then match the untreated firms which have an estimated propensity score as close as possible to that of the new innovators, imposing a common support condition by dropping the treated firms whose propensity scores are higher than the maximum or lower than the minimum of those persistent non-innovators. Different matching algorithms have been proposed in the previous literature, mainly varying in terms of how the neighbourhood of control individuals is built around the treated observations, providing different solutions to the trade-off between matching quality and variance (Caliendo and Kopeinig 2008). In our main specification, we apply a Kernel matching technique with a strict bandwidth of 0.01 to match firms that are part of the same industry and which performed the treatment in the same year and for which the distance between their propensity scores is the smallest possible. The Kernel matching estimator associates to the outcome y_{it} of treated firm i a matched outcome given by a kernel-weighted average of the outcome of comparable non-treated firm, where the weight given to non-treated firm j is in proportion to the closeness between i and j. In other words, using the Kernel technique we are able to down-weight the contribution to the outcome of non-treated individuals which are further from the treated firms within a certain range (i.e. bandwidth) of the propensity score distribution. Using a weighted smoothed matching estimator like the Kernel one presents several advantages in respect to other matching procedures, particularly in reducing the median standardized bias between treated and control groups. In addition, it permits to exploit as much information as possible in matching firms from the control group, gaining in this way in precision without losing anything in terms of matching quality (Leuven and Sianesi 2003; Caliendo and Kopeinig 2008). As a robustness check, we have also employed different matching procedures yielding very similar results. In Tables A.2.17-A.2.26 in the appendix we present the results of the nearest neighbour matching 1-to-1 without replacement as an alternative robustness check. In addition, in Tables A.2.27-A.2.29 in the appendix we present the estimation results applying a propensity score matching technique in a single treatment approach, considering the different treatments as unrelated to each other and calculating separately the propensity scores and their average treatment effect for each case.

In order to verify the consistency of the construction of the two groups, we run several balancing tests to examine the quality of our propensity score matching. To check this balancing we calculate the mean differences across the treatments and the control groups for a set of observable characteristics comparing them before and after the matching has taken place. Even if differences between the treated and the control group are expected before matching, these differences should be significantly reduced after matching. In Tables A.2.4, A.2.5, A.2.6 and A.2.7 in the appendix we present several tests assessing the comparability of the two groups for each combination of treatments, in particular testing whether the covariates used to control the probability of starting an innovative activity are not significantly different between the treated and the control group and the achieved percentage reduction in the standardised bias after the matching (Caliendo and Kopeinig 2008). According to Rosenbaum and Rubin (1985) the bias after the matching procedure between treated and untreated observations should not exceed the 25% threshold in order to deliver a consistent matching. Figure A.2.3 in the appendix shows the reduction in bias for most of the regressors following the kernel matching technique, where none of the absolute standardized bias exceed 25%. Also the variance ratios between treated over non-treated indicate a good balance for most of the covariates, with none of them being of particular concern for the quality of the matching. These results indicate that there are no systematic differences in the observables characteristics between the treated and the control groups, demonstrating that the matching procedure satisfies the balancing property and that the conditional independence assumption is not violated and assigning the appropriate controls to treated observations (Rosenbaum and Rubin 1985; Damijan and Kostevc 2015).

In this way we are able to estimate the growth of the trade margins premium for firms who started innovating for the subsequent 3 years with respect to the pre-treatment level and to compare it with the corresponding growth for non-innovators. The combination of matching techniques and difference-in-differences is likely to increase the quality of our empirical analysis on the causal effect of innovation on export performance. In particular, matching within each 2-digit industry and considering previous export performance we are able to compare closely related firms, characterized by similar productive structures and export status. Secondly, the difference-in-differences should remove the effects of common shocks and provide a robust estimation of the innovative treatment effect on the export performance differential between innovators and non innovative firms (Blundell and Dias 2009). In addition, following previous studies on the link between innovation, exports and firm size (Caldera 2010; Damijan et al. 2010; Movahedi and Gaussens 2013; Damijan and Kostevc 2015), and to be consistent with our fixed-effect model, we provide also the results of the difference-in-differences estimation dividing the population of French firms in sub-samples according to their size in terms of employees and their group affiliation. This procedure will allow us to test whether the effect of R&D activities on export performance varies according to the size and the ownership of the firm. Finally, we use bootstrapped standard errors with 500 repetitions in the Kernel matching technique in order to yield heteroskedasticity-consistent standard errors which take into account the additional source of variability introduced by the estimation of the propensity score and by the matching process (Heckman et al. 1997;

Abadie and Imbens 2011).

2.5 Results

The main contribution of this chapter to the existing literature on the role of innovation in improving the international trade performance is to decompose this effect taking into account not only total exports and the probability of being an exporter but also the extensive and intensive margins of trade. For the first time, we establish whether innovation activities improve exporters' performance creating new trade links, enriching firms' product mix and opening new export markets, or if they support the intensification of existing flows. In addition, we assess as well the effect of different forms of innovation on export performance, by simultaneously taking into account both innovation input and output measures. We are able to identify in this way the direct connection between new innovations and their commercial adoption in international markets and as well to evaluate the indirect effect of firms' R&D investment on exports performance. In the next section we analyse the effect of firms R&D activities on the standard measures of export performance, firm total exports and the probability of being an exporter. Secondly, we focus on the impact of innovations on firm trade margins, considering the role played by R&D activities in increasing the value of firm shipments, the number of product exported and of foreign markets served. Finally, using a difference-in-differences (DID) propensity score matching (PSM) technique in a multiple treatment approach we will be able to properly identify the causal link connecting innovation and export performance, comparing the export performance of firms before and after they start innovating with respect to non-innovators (the ATT effect).

2.5.1 Total Exports and Probability of Exporting

The first step is to analyse the effect of firms' innovation activities on the probability of being an exporter. All the following estimations include firm-year fixed-effects and control for a number of firm characteristics and measures of performance. Moreover, we have disaggregated the sample according to the degree of foreign ownership and firm size in terms of employees.[10] In particular, we divide firms into small, medium and large enterprises according to the European Commission definition.[11] Following the previous literature, we expect innovation activities to have a consistently different effect on firms' export performance not only across different margins, but also in respect to their size and ownership structure, due to the different possibilities firms might have to exploit economies of scale, of scope and to internalise positive externalities related to their participation to domestic or foreign business groups (Cassiman and Golovko 2007; Movahedi and Gaussens 2013; Esteve-Pérez and Rodriguez 2013; Palangkaraya 2013). Table 2.6 presents results of the impact of innovation on the probability of being an exporter using a panel logit model with fixed-effects.

Overall, we find that in general total investment in R&D has a positive and significant effect on the probability of being an exporter. However, total R&D seems to be particularly relevant for the export participation of domestic and small-medium enterprises, while it does not appear to play any role in increasing the probability of being an exporter for large and foreign firms. This evidence is consistent with recent studies on the export participation of firms which have highlighted how R&D only has a significant impact on the internationalization of SMEs (Cassiman and Golovko 2007; Palangkaraya 2013; Esteve-Pérez and Rodriguez

[10] Following the INSEE guidelines we define a firm as foreign-owned if at least 10% of the equity is controlled by a foreign company.

[11] According to the EU Recommendation 2003/361 it is possible to categorize firms according to their size in terms of employees and total revenues (micro: employees $<$ 10, turnover $\leq$ EUR 2 million; small: employees $<$ 50, turnover $\leq$ EUR 10 million; medium: employees $\leq$ 250, turnover $\leq$ EUR 50 million; large: employees $>$ 250, turnover $>$ EUR 2 million).

Table 2.6: The impact of innovation on the probability of a firm to be an exporter (EAE data).

Prob. Exporter	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.0747***	0.0929***	0.0599	0.153***	0.103***	-0.00881
	(0.0231)	(0.0281)	(0.0463)	(0.0517)	(0.0371)	(0.0448)
$ProductInn._t$	0.400**	0.400**	0.241	-0.0741	0.846***	0.381
	(0.169)	(0.199)	(0.350)	(0.294)	(0.277)	(0.397)
$ProcessInn._t$	-0.0368	-0.0533	0.359	-0.0267	-0.386	0.372
	(0.174)	(0.204)	(0.374)	(0.319)	(0.266)	(0.437)
$Tot.Employment_{t-1}$	0.630***	0.650***	0.538**	0.363***	0.815***	-0.120
	(0.0694)	(0.0739)	(0.231)	(0.101)	(0.138)	(0.406)
$Av.Salary_{t-1}$	0.0813	0.0639	0.183	0.108	-0.0574	-0.540
	(0.108)	(0.115)	(0.398)	(0.133)	(0.232)	(0.827)
TFP_{t-1}	0.184***	0.213***	0.0121	0.127*	0.225*	0.220
	(0.0606)	(0.0654)	(0.183)	(0.0753)	(0.125)	(0.316)
$Cash-flow_{t-1}$	-0.00379	-0.0185	0.230	-0.0544	0.390	0.354
	(0.201)	(0.220)	(0.554)	(0.254)	(0.401)	(0.858)
$ForeignGroup_t$	0.104			0.0785	-0.193	0.558
	(0.0998)			(0.136)	(0.177)	(0.649)
$FrenchGroup_t$	0.00172	-0.000376		0.00955	0.00845	-0.829
	(0.0473)	(0.0486)		(0.0559)	(0.104)	(0.596)
Observations	38,573	35,112	2,584	26,517	8,721	1,090
No.Firms	6,166	5,694	473	4,486	1,452	177

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a panel logit with year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable probability of being an exporter is a dummy variable equal to 1 if firm reports positive foreign sales and 0 otherwise. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

2013; Movahedi and Gaussens 2013; Altomonte et al. 2013). Turning to product innovation, it also seems to play a key role in increasing the export probability for domestic and medium-sized firms. Hence, French firms find it easier to export once they introduce new products. On the contrary, product innovation may not be particularly relevant for foreign owned companies which may already be large multi-product exporters (Cassiman and Golovko 2011). Interestingly, process innovation does not appear to have any influence on the probability of exporting. Looking at the control variables, it is possible to note that total employment has a positive and significant impact on the probability of exporting for all firms except the largest ones. Total factor productivity increases as well the likelihood of exporting in the general sample, but this phenomenon seems to be mainly driven by the effect on domestic small-medium enterprises. On the contrary, the average salary paid, firm cash-flow and the ownership structure do not seem to influence firm probability of being an exporter.

Table 2.7: The impact of innovation on firm level total exports (EAE data).

Tot. Exports (EAE)	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.0174***	0.0200***	0.0149**	0.0227**	0.0183***	0.0104*
	(0.00420)	(0.00548)	(0.00634)	(0.0111)	(0.00617)	(0.00575)
$ProductInn._t$	0.0724**	0.0636*	0.0530	-0.0362	0.109**	0.0541
	(0.0304)	(0.0385)	(0.0485)	(0.0687)	(0.0437)	(0.0455)
$ProcessInn._t$	0.0369	0.0469	0.0505	0.116	-0.0358	0.0562
	(0.0320)	(0.0406)	(0.0502)	(0.0756)	(0.0458)	(0.0464)
$Tot.Employment_{t-1}$	0.628***	0.619***	0.661***	0.387***	0.615***	0.407***
	(0.0231)	(0.0265)	(0.0500)	(0.0378)	(0.0401)	(0.0598)
$Av.Salary_{t-1}$	0.0988***	0.0887**	0.137*	0.0737	0.0270	-0.0317
	(0.0366)	(0.0412)	(0.0830)	(0.0487)	(0.0671)	(0.113)
TFP_{t-1}	0.140***	0.148***	0.107***	0.121***	0.141***	0.0312
	(0.0177)	(0.0204)	(0.0359)	(0.0244)	(0.0314)	(0.0454)
$Cash-flow_{t-1}$	0.204***	0.188***	0.292**	0.102	0.362***	0.455***
	(0.0544)	(0.0620)	(0.114)	(0.0702)	(0.107)	(0.156)
$ForeignGroup_t$	0.0950***			0.0846*	0.0174	0.110
	(0.0281)			(0.0467)	(0.0422)	(0.101)
$FrenchGroup_t$	0.0384**	0.0339*		0.0300	0.0399	-0.0182
	(0.0166)	(0.0175)		(0.0214)	(0.0293)	(0.0953)
Observations	152,681	129,350	23,331	89,106	49,324	14,251
No.Firms	29,467	26,395	5,367	19,846	10,445	2,800

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable total exports is the log of total foreign sales as reported by firms in the EAE dataset. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

In Table 2.7 we present the estimation of the impact of innovation on total exports using the EAE data. Previous investment in R&D increases total exports for all firms in the sample. In addition, we find that product innovation plays a significant role in increasing firms' total sales abroad, although this is driven mainly by domestic and medium sized firms. Process innovation remains generally insignificant. This evidence is consistent with previous findings showing how efficiency-enhancing activities such as process innovations play a key role in exploiting economies of scale, but may not be relevant in improving firms' export performance (Mayer and Ottaviano 2007; Corcos et al. 2012; Aw et al. 2011; Rubini et al. 2012). Most of the covariates seem to play a significant role in explaining total exports. In particular, total employment and the average salary have a positive and significant effect on total exports for both domestic and foreign firms. Total factor productivity as well plays a significant role in improving total export, but not for large firms, while cash-flow seems to be particularly relevant for medium and large firms. Also the affiliation to a business group increases foreign sales, in particular for small firms which are foreign-owned.

The next stage is to proceed using the richer trade data provided by the Customs Agency (CA) which allows us to calculate the firm-level trade margins. As a first step, in Table 2.8 we present the estimation of the impact of innovation on total exports using now the Customs Agency trade data as our right-hand side variable. There are a number of notable differences between Table 2.8 and Table 2.7. In particular, R&D investment has only a small positive and significant effect on total exports, playing a role just for foreign and large firms. In addition, the introduction of product innovations does not have a significant impact on total exports. Conversely, using the Customs data, process innovation appears to have a positive effect on total exports of firms in our sample. One explanation for the inconsistency in the results between the two different sources of data may be explained by the structure of the two datasets. As previously discussed, while the EAE dataset provides the value of total exports for all French manufacturing firms with more than 20 employees, the Custom Agency database instead reports just the intra-EU shipments with values greater than €100,000 or the extra-EU shipments above €1,000. For this reason, when looking at the Customs Agency variable of total exports we are considering only large exports. It could be argued that small shipments to high-income countries should have higher degree of product differentiation and a larger share of added value embedded in their production in order to be profitable for a firm to export (Head and Ries 2001; Mayer and Ottaviano 2007; Bernard et al. 2007).

Table 2.8: The impact of innovation on firm level total exports (Customs Agency data).

Tot. Exports (CA)	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.00529	0.00457	0.00711*	-0.00190	0.00488	0.00761*
	(0.00441)	(0.00597)	(0.00416)	(0.0124)	(0.00628)	(0.00423)
$ProductInn._t$	0.000576	-0.0104	0.0163	-0.0776	0.0276	0.0312
	(0.0317)	(0.0417)	(0.0388)	(0.0781)	(0.0439)	(0.0328)
$ProcessInn._t$	0.0584*	0.0597	0.0436	0.105	0.0402	0.0235
	(0.0333)	(0.0444)	(0.0400)	(0.0871)	(0.0463)	(0.0331)
$Tot.Employment_{t-1}$	0.794***	0.803***	0.788***	0.599***	0.665***	0.640***
	(0.0279)	(0.0338)	(0.0442)	(0.0506)	(0.0461)	(0.0473)
$Av.Salary_{t-1}$	0.292***	0.342***	0.00813	0.309***	0.151**	-0.0414
	(0.0446)	(0.0529)	(0.0734)	(0.0641)	(0.0765)	(0.0892)
TFP_{t-1}	0.0844***	0.0840***	0.0885***	0.0295	0.171***	0.0342
	(0.0204)	(0.0248)	(0.0307)	(0.0303)	(0.0344)	(0.0344)
$Cash-flow_{t-1}$	0.173***	0.118	0.435***	0.0123	0.425***	0.133
	(0.0650)	(0.0773)	(0.105)	(0.0893)	(0.126)	(0.114)
$ForeignGroup_t$	0.00721			0.0222	-0.00123	0.0913
	(0.0329)			(0.0594)	(0.0470)	(0.0838)
$FrenchGroup_t$	0.00438	-0.00253		-0.0329	0.0689**	0.0630
	(0.0203)	(0.0224)		(0.0280)	(0.0336)	(0.0787)
Observations	102,894	85,617	17,277	57,042	34,566	11,286
No.Firms	21,832	19,483	3,850	14,507	7,522	2,146

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of the sum of total foreign sales of a firm in a year including all the intra-EU shipments over € 100,000 and extra-EU over € 1,000 as collected by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

To investigate the source of this discrepancy between the two sources of data we present the estimated effect of innovation across different quantiles of total exports, using both EAE

Table 2.9: The impact of innovation across different quantiles for firm level total exports (EAE data).

Tot. Exports (EAE)	(1) .10	(2) .25	(3) .50	(4) .75	(5) .90
$Tot.R\&D_{t-1}$	0.834***	0.306***	0.0529***	0.0302***	0.0288***
	(0.00110)	(0.0139)	(0.00883)	(0.00507)	(0.00435)
$ProductInn._t$	1.446***	1.231***	0.579***	0.272***	0.118**
	(0.0104)	(0.132)	(0.0838)	(0.0481)	(0.0513)
$ProcessInn._t$	0.319***	0.183	0.0818	0.0708	0.0601
	(0.0109)	(0.138)	(0.0877)	(0.0503)	(0.0432)
$Tot.Employment_{t-1}$	0.212***	1.336***	1.386***	1.114***	0.975***
	(0.002)	(0.0267)	(0.0170)	(0.00976)	(0.00838)
$Av.Salary_{t-1}$	0.998***	1.182***	2.358***	1.853***	1.695***
	(0.006)	(0.0784)	(0.0499)	(0.0286)	(0.0246)
TFP_{t-1}	0.339***	0.161**	0.738***	0.873***	0.793***
	(0.005)	(0.0649)	(0.0413)	(0.0237)	(0.0203)
$Cash-flow_{t-1}$	0.195***	-0.479**	-0.982***	-1.039***	-0.840***
	(0.0176)	(0.223)	(0.142)	(0.0814)	(0.0698)
$ForeignGroup_t$	-0.952	2.856***	1.555***	1.011***	0.775***
	(0.519)	(0.0655)	(0.0417)	(0.0239)	(0.0205)
$FrenchGroup_t$	-0.294	0.113**	0.607***	0.347***	0.234***
	(0.355)	(0.0448)	(0.0285)	(0.0164)	(0.0141)
Observations	152,681	152,681	152,681	152,681	152,681
No.Firms	29,467	29,467	29,467	29,467	29,467

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a panel quantile regression with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of total foreign sales as reported by firms in the EAE dataset. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable.

and the Custom Agency data as dependent variables, in Tables 2.9 and 2.10. Our linear OLS regressions show the effect of innovation on the outcome variable based on the conditional mean function. With a quantile regression instead we can provide a richer analysis, describing the full relationship between innovation and export performance at different points in the conditional distribution of total exports and not just at the mean.

In Tables 2.9 and 2.10 we compare the effect of R&D activities on firms' total exports at different quantiles. The results are consistent with the previous results: using both sources of data we find that both the effect of R&D investment and the impact of product innovation

Table 2.10: The impact of innovation across different quantiles for firm level total exports (CA data).

Tot. Exports (CA)	(1) .10	(2) .25	(3) .50	(4) .75	(5) .90
$Tot.R\&D_{t-1}$	1.399***	0.0568**	0.0086	0.001	0.0016
	(0.00768)	(0.0256)	(0.0118)	(0.00511)	(0.00435)
$ProductInn._t$	3.770***	2.307***	0.482***	0.195***	0.0771*
	(0.0767)	(0.255)	(0.118)	(0.051)	(0.0434)
$ProcessInn._t$	0.083	-0.0471	0.0834	0.0533	0.0541
	(0.081)	(0.270)	(0.124)	(0.0539)	(0.0459)
$Tot.Employment_{t-1}$	2.456***	2.273***	1.455***	1.098***	0.933***
	(0.225)	(0.0457)	(0.0295)	(0.0114)	(0.00956)
$Av.Salary_{t-1}$	0.214***	2.531***	2.996***	1.728***	1.348***
	(0.0231)	(0.152)	(0.0981)	(0.0380)	(0.0317)
TFP_{t-1}	0.312***	0.878***	0.896***	0.770***	0.694***
	(0.0484)	(0.0755)	(0.0488)	(0.0189)	(0.0158)
$Cash-flow_{t-1}$	0.645***	0.739*	0.975***	-0.248**	-0.419***
	(0.145)	(0.390)	(0.252)	(0.0977)	(0.0816)
$ForeignGroup_t$	4.896***	6.274***	2.287***	1.163***	0.905***
	(0.497)	(0.116)	(0.0752)	(0.0291)	(0.0243)
$FrenchGroup_t$	0.239***	0.475***	1.342***	0.489***	0.313***
	(0.0562)	(0.0800)	(0.0517)	(0.0200)	(0.0167)
Observations	102,894	102,894	102,894	102,894	102,894
No.ofFirms	21,832	21,832	21,832	21,832	21,832

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel quantile regression with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of the sum of total foreign sales of a firm in a year including all the intra-EU shipments over € 100,000 and extra-EU over € 1,000 as collected by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable.

on total exports decrease in terms of magnitude and in terms of statistical significance as firms' total exports increase in volume. Especially in the case of the Customs Agency data it is possible to notice that total R&D has a positive and significant effect just in the first quartile of small exporters, which are largely under-represented in this database. Moreover, in Table 2.9 process innovations seem to be statistically significant just for exporters in the first quantile, exporting small volumes, while the positive effect disappears after the first quartile, further corroborating the hypothesis that innovation mainly affects the export performance of small exporters.

Secondly, we decided to deepen our analysis by looking at the different impact of innovation on the EAE total exports variable in the sample of firms which are matched between the EAE and the Custom Agency datasets and in the sample of firms which instead were not merged between the two datasets. From Table 2.11 and Table 2.12 it is possible to notice that the different R&D variables have a much larger positive and significant effect on the unmatched sample of firms only present in the EAE dataset rather than on the matched sample, providing a further evidence that R&D activities seem to be particularly relevant for firms exporting small shipments, i.e. those not included in the Custom Agency database.

Finally, as a further robustness check we exploit the difference in the thresholds for the inclusion of shipments in the datasets in order to compare the effect of innovation on total exports distinguishing between intra-EU shipments (included if worth more than €100,000) and extra-EU exports which instead have a much lower threshold for the inclusion into the Custom Agency data (all the shipments above €1,000). In this way we will be able to check within the same database (i.e. the Customs Agency dataset) whether smaller extra-EU shipments are more affected by innovating activities.

The immediate observation from Table 2.13 is that innovation does not have any significant effect on intra-EU exports (when only large shipments above the €100,000 threshold are considered) while we find a positive and significant effect when looking at extra-EU exports which consider everything exported above €1,000 in value. This phenomenon is even more evident when differentiating between only intra-EU exporters and pure extra-EU exporters in Table 2.14, comparing the effect on total exports.[12] Again, note that R&D activities do not play any significant role in improving export performance for pure intra-EU exporters, while

[12]In Tables A.2.8 and A.2.9 in the appendix we provide as well these estimations for the different trade margins leading to consistent results.

Table 2.11: Impact of innovation on total exports for firms which are matched between the EAE and the CA datasets.

Matched Firms Total Exports (EAE)	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.00692***	0.00761**	0.0062	0.0048	0.0051	0.00668**
	(0.0025)	(0.0033)	(0.0039)	(0.00654)	(0.0039)	(0.00339)
$ProductInn._t$	0.0041	-0.0142	0.0267	-0.0320	0.0037	0.0173
	(0.0193)	(0.0246)	(0.0306)	(0.0443)	(0.0288)	(0.027)
$ProcessInn._t$	0.0436**	0.0583**	0.02632	0.0677	0.0321	0.221
	(0.0203)	(0.0261)	(0.0315)	(0.0493)	(0.0304)	(0.0273)
$Tot.Employment_{t-1}$	0.556***	0.546***	0.587***	0.399***	0.449***	0.425***
	(0.0169)	(0.0197)	(0.0346)	(0.0285)	(0.03)	(0.0386)
$Av.Salary_{t-1}$	0.242***	0.246***	0.176***	0.194***	0.185***	0.088
	(0.0246)	(0.0280)	(0.0538)	(0.0327)	(0.0454)	(0.0696)
TFP_{t-1}	0.103***	0.104***	0.0946***	0.0641***	0.147***	0.0651**
	(0.0127)	(0.0149)	(0.025)	(0.0174)	(0.0232)	(0.030)
$Cash-flow_{t-1}$	0.160***	0.129***	0.336***	0.0519	0.307***	0.268***
	(0.0398)	(0.0456)	(0.083)	(0.0507)	(0.0833)	(0.095)
$ForeignGroup_t$	0.0339*			0.024	0.0207	0.0373
	(0.0200)			(0.0336)	(0.0308)	(0.069)
$FrenchGroup_t$	0.0237*	0.0241*		0.0106	0.0583***	0.0111
	(0.0124)	(0.0132)		(0.0158)	(0.0221)	(0.0648)
Observations	102894	85618	17277	57042	34566	11286
No.Firms	21832	19483	3850	14507	7522	2146

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of total foreign sales as reported by firms in the EAE dataset. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

they have a positive and significant effect on total exports for firms exporting only outside the EU. Taken together all these results shed a light on the puzzling differences using the EAE or the Customs Agency dataset, corroborating the previous findings in the literature according to which innovating activities mainly affect the trade performance of small firms exporting to more difficult markets (Cassiman and Golovko 2007; Palangkaraya 2013; Movahedi and Gaussens 2013).

The results found so far on the impact of innovation on exports for the manufacturing

Table 2.12: Impact of innovation on total exports for firms which are just present in the EAE dataset.

Unmatched Firms Total Exports (EAE)	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.0389***	0.0339***	0.0432**	0.0245	0.0442***	0.0183
	(0.0099)	(0.0128)	(0.0174)	(0.0241)	(0.0148)	(0.0178)
$ProductInn._t$	0.297***	0.268***	0.330**	0.01709	0.340***	0.252
	(0.0791)	(0.0972)	(0.15)	(0.16)	(0.115)	(0.160)
$ProcessInn._t$	-0.0362	-0.0937	0.0911	-0.0290	-0.1189	-0.0041
	(0.0834)	(0.0998)	(0.163)	(0.167)	(0.12)	(0.171)
$Tot.Employment_{t-1}$	0.380***	0.361***	0.431***	0.237***	0.245***	0.505***
	(0.0391)	(0.0424)	(0.111)	(0.0543)	(0.0742)	(0.162)
$Av.Salary_{t-1}$	0.0398	0.0274	0.114	0.0507	-0.122	-0.259
	(0.0511)	(0.0541)	(0.171)	(0.0602)	(0.112)	(0.247)
TFP_{t-1}	0.125***	0.120***	0.185**	0.0753*	0.120*	0.299**
	(0.0319)	(0.0348)	(0.088)	(0.0393)	(0.0638)	(0.129)
$Cash-flow_{t-1}$	0.155*	0.135	0.1789	0.128	0.365*	1.212**
	(0.0872)	(0.0949)	(0.24)	(0.102)	(0.188)	(0.492)
$ForeignGroup_t$	0.215***			0.130*	0.148*	0.408*
	(0.0480)			(0.0713)	(0.078)	(0.215)
$FrenchGroup_t$	0.0647**	0.0581**		0.0736**	0.0159	0.2429
	(0.0253)	(0.0260)		(0.0301)	(0.0518)	(0.203)
Observations	63041	56908	6133	43982	16304	2751
No.Firms	16195	15071	2012	12269	4704	773

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of total foreign sales as reported by firms in the EAE dataset. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

sector are consistent with the evidence for all the other industries reported in Tables A.2.10 and A.2.11 in the appendix. As previously explained, since the Custom Agency data takes into account just trade in goods we decided to consider just the manufacturing sectors to carry on a comprehensive analysis of the effect of innovation across the different margins of trade. However, not using the Custom Agency data it is still possible to provide an analysis of the impact of R&D activities on total exports and the probability of being an exporter for all the other industries (agriculture, mining and services) adding to our sample almost 100,000 firms more, most of them part of the service industry. Tables A.2.10 and A.2.11

Table 2.13: The impact of innovation on total exports intra-EU or extra-EU (CA data).

	Total Exports Intra-EU					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0057	0.0015	0.00613	-0.0161	0.0068	0.012
	(0.0068)	(0.00909)	(0.00952)	(0.0192)	(0.00971)	(0.00845)
$ProductInn._t$	0.0254	-0.0176	0.1019	-0.156	0.0772	0.0448
	(0.0511)	(0.0669)	(0.074)	(0.13)	(0.0718)	(0.0671)
$ProcessInn._t$	0.0242	0.00216	0.0609	0.107	-0.0560	0.0686
	(0.0538)	(0.0712)	(0.0763)	(0.145)	(0.0759)	(0.0677)
$Tot.Employment_{t-1}$	0.934***	0.957***	0.880***	0.790***	0.897***	0.544***
	(0.0508)	(0.0627)	(0.0876)	(0.104)	(0.0819)	(0.0986)
$Av.Salary_{t-1}$	0.365***	0.451***	-0.0256	0.378***	0.314**	-0.0785
	(0.0765)	(0.0922)	(0.136)	(0.122)	(0.122)	(0.179)
TFP_{t-1}	0.151***	0.168***	0.089	0.170***	0.190***	-0.0703
	(0.0366)	(0.0447)	(0.0621)	(0.0573)	(0.0607)	(0.0755)
$Cash-flow_{t-1}$	0.292**	0.226*	0.396*	0.303*	0.13	-0.0806
	(0.114)	(0.136)	(0.207)	(0.165)	(0.22)	(0.238)
$ForeignGroup_t$	0.0846			-0.0627	0.169**	0.230
	(0.0575)			(0.111)	(0.0806)	(0.179)
$FrenchGroup_t$	0.0028	-0.0062		-0.0182	0.0262	0.194
	(0.0393)	(0.0435)		(0.0589)	(0.0601)	(0.170)
Observations	102,894	85,617	17,277	57,042	34,566	11,286
No.Firms	21,832	19,483	3,850	14,507	7,522	2,146

	Total Exports Extra-EU					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0180**	0.0095	0.0334**	0.0208	0.0043	0.0290**
	(0.00864)	(0.0109)	(0.0151)	(0.0212)	(0.0136)	(0.0147)
$ProductInn._t$	0.166**	0.162**	0.108	0.019	0.214**	0.15
	(0.0649)	(0.0804)	(0.117)	(0.143)	(0.101)	(0.117)
$ProcessInn._t$	-0.0371	0.0087	-0.0709	0.0085	-0.0025	-0.138
	(0.0684)	(0.0856)	(0.121)	(0.16)	(0.106)	(0.118)
$Tot.Employment_{t-1}$	1.065***	0.964***	1.252***	0.859***	0.853***	1.354***
	(0.0645)	(0.0754)	(0.139)	(0.114)	(0.115)	(0.172)
$Av.Salary_{t-1}$	0.244**	0.305***	-0.0855	0.349***	0.138	-0.434
	(0.0972)	(0.111)	(0.216)	(0.134)	(0.171)	(0.313)
TFP_{t-1}	0.063	0.0199	0.116	0.0347	0.0621	0.0138
	(0.0465)	(0.0537)	(0.0985)	(0.0632)	(0.085)	(0.132)
$Cash-flow_{t-1}$	0.017	-0.0582	0.322	-0.171	0.274	0.315
	(0.145)	(0.163)	(0.328)	(0.181)	(0.308)	(0.415)
$ForeignGroup_t$	0.110			0.0521	0.145	0.332
	(0.0731)			(0.123)	(0.113)	(0.313)
$FrenchGroup_t$	0.0379	0.070		-0.0022	0.130	0.200
	(0.0499)	(0.0523)		(0.065)	(0.0843)	(0.296)
Observations	102,894	85,617	17,277	57,042	34,566	11,286
No.Firms	21,832	19,483	3,850	14,507	7,522	2,146

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variables total exports intra and extra-EU are the log of the sum of total foreign sales to intra or extra-EU countries of a firm in a year including alternatively all the intra-EU shipments over € 100,000 or all extra-EU exports over € 1,000 as collected by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees < 50, turnover $\leq$ EUR 10 million), medium (employees ≤ 250, turnover $\leq$ EUR 50 million) and large firms (employees > 250, turnover $>$ EUR 2 million).

Table 2.14: The impact of innovation on total exports of firms exporting just within or extra-EU (CA data).

Only Intra-EU Exports						
	Total Exports					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0177	-0.0167	0.120*	-0.0458	0.105**	-0.0918*
	(0.0240)	(0.0270)	(0.0631)	(0.0418)	(0.0457)	(0.0502)
$ProductInn._t$	0.0849	-0.0448	-0.0523	-0.151	0.402	-0.219
	(0.158)	(0.167)	(0.664)	(0.254)	(0.296)	(0.396)
$ProcessInn._t$	-0.0190	-0.114	0.769	-0.145	0.289	-0.0419
	(0.174)	(0.179)	(0.781)	(0.261)	(0.316)	(0.507)
Observations	36,388	34,015	2,373	27,354	8,184	850
No.ofFirms	10,750	10,163	893	8,523	2,679	289
Only Extra-EU Exports						
	Total Exports					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0564**	0.0463	0.0790	0.0953**	-0.0591	0.113*
	(0.0260)	(0.0301)	(0.0537)	(0.0430)	(0.0400)	(0.0599)
$ProductInn._t$	0.124	0.104	0.0711	-0.180	0.152	1.348***
	(0.161)	(0.174)	(0.458)	(0.245)	(0.260)	(0.429)
$ProcessInn._t$	0.101	0.0679	0.262	0.362	0.0537	1.776***
	(0.169)	(0.181)	(0.472)	(0.262)	(0.242)	(0.517)
Observations	36,339	34,282	2,057	27,813	7,738	788
No.ofFirms	10,843	10,327	795	8,745	2,573	272

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable total exports is the log of the sum of total foreign sales of firms in a year exporting just within or outside the EU. Total exports could alternatively include all the intra-EU shipments over € 100,000 or all the extra-EU exports over € 1,000 as collected by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As unreported control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

in the appendix supports the results discussed previously for the manufacturing industry: total investment in R&D has a positive effect on total exports even for firms in the service sectors, especially for domestic and medium-sized companies. The introduction of new product innovations seems to be particularly relevant for firms in the service industry, increasing the total value of exports for all firms across the different specifications. Process innovation instead does not have any effect on the trade performance of service firms, similarly to the previous analysis on the manufacturing sectors. When looking at the probability of being an exporter it is possible to notice that R&D investment plays a significant role in increasing firm probability of being an exporter only for medium-size companies. Moreover, neither the introduction of new products nor of new process innovations seem to play any role in improving firm probability of being an exporter. Focusing on the agriculture and mining sectors it is possible to notice that R&D activities do not improve the export performance of the small number of French firms in our sample in any way, except for a positive and significant effect of total investment in R&D on total exports of small-sized firms. These results seem to suggest a similar effect of innovation on the export performance of manufacturing and service firms, especially regarding the particularly positive impact of product innovation on total exports. However, given the limitation of the Custom Agency data just to manufacturing goods, we are not able to further analyse this relationship looking as well at the impact of innovation on the trade margins of services firms.

As a further robustness check in Table A.2.12 in the appendix we present as well the estimations of the impact of innovation on export performance including our R&D variables separately and then together. The results suggest that collinearity between the different R&D variables should not be a concern. On the contrary, each of these variables explains a different aspect of the same phenomena as suggested by previous literature (Kleinknecht et al. 2002; Mohnen and Hall 2013) and identifies a different effect of the overall R&D effort on export performance. In addition, in Table A.2.13 available in the appendix we provide a further robustness check only using the EAE dataset as a source for the R&D investment variable and sequentially dropping the possible outliers. As previously explained, when comparing the two datasets it can be noted that some firms reporting investment in R&D in a given year in the EAE dataset were not included in the R&D survey or vice-versa due to misreporting or because their investment in innovation did not reach the threshold required to be included in the R&D survey. Thus, we dropped from the sample all the observations in which firms report an investment in R&D in the EAE dataset but which were not present in the R&D survey and as well the observations included in the R&D survey which did not reported any investment in innovation in the EAE dataset. In Table A.2.13 we compare the effect of using the two different sources of data and we analyse the variations in the results when dropping from the whole sample the observations with incoherent information from the two different datasets. We find that the R&D investment variable from the EAE dataset is generally consistent with the results we find when using the R&D survey data, and it is robust across specifications sequentially pulling out from the sample the different combinations of incoherent observations.

This first set of results has stressed the importance of using a disaggregated analysis at the trade margin level in order to fully evaluate the comprehensive effect of R&D on firms' export performance otherwise unobservable at the aggregate level. In the next section we will analyse the effect of innovating activities on the intensive and extensive margins of trade at the firm-level.

2.5.2 Trade Margins

In the second stage of our analysis we disentangle the impact of innovation on the intensive and extensive margins of trade. As discussed earlier, we decompose the extensive margin into the number of products exported, the number of destinations served by each firm and the average number of products exported to each foreign market. The intensive margin is instead measured as the average value of a firm's shipments. In Table 2.15 we estimate the effect of innovation on the intensive margin.

Table 2.15 shows that R&D investment positively affects just the average value of exports (the intensive margin) for large enterprises. In addition, while product innovation does not seem to play any significant role in increasing firm intensive margin, the introduction of new process innovation has a positive and significant impact on the value of shipments exported abroad. Note that this effect is particularly important for small and large enterprises, while medium-size firms are not affected. These results stress the key role played by process innovation in increasing the average value of exports as pointed out in the previous literature (Parisi et al. 2006; Caldera 2010; Becker and Egger 2013). In particular in developed countries, new production processes might help firms to increase the value and the quality of products exported and to become more efficient reducing in this way the average cost of exports and more generally of production.

When we consider the country and the product extensive margins we use a poisson fixed-effect regression model given the count structure of the data. Results are presented in Table 2.16 for product extensive margins and Table 2.17 for country extensive margins. Innovative activities seem to have contrasting effects on the two extensive margins and across the different categories of firms. For instance, investment in R&D seems to have a negative effect on the number of products exported by domestic firms, while it increases the number of products exported by foreign and large enterprises. Table 2.17 shows that total R&D has a positive and significant impact on the number of foreign markets served, again an effect driven mainly by large and foreign-owned firms. In fact, foreign and large enterprises seem to be more likely to invest in R&D activities, firstly to introduce new products, and secondly in order to exploit the knowledge acquired from this investment in order to enter new markets.

As expected, product innovation has a significant impact on the number of products exported by firms, while process innovation significantly affects the number of products ex-

Table 2.15: The impact of innovation on firm level intensive margin of trade.

Intensive Margin	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.00256	0.00260	0.00312	-0.00243	0.00150	0.00567**
	(0.00205)	(0.00269)	(0.00311)	(0.00566)	(0.00300)	(0.00270)
$ProductInn._t$	-0.0129	-0.0180	-0.00126	-0.0659	-0.00713	-0.00336
	(0.0154)	(0.0198)	(0.0242)	(0.0482)	(0.0222)	(0.0214)
$ProcessInn._t$	0.0370**	0.0326	0.0321	0.0851**	0.00467	0.0437**
	(0.0162)	(0.0211)	(0.0249)	(0.0427)	(0.0234)	(0.0216)
$Tot.Employment_{t-1}$	0.223***	0.198***	0.295***	0.198***	0.223***	0.137***
	(0.0153)	(0.0186)	(0.0286)	(0.0305)	(0.0253)	(0.0315)
$Av.Salary_{t-1}$	0.0587**	0.0633**	0.00906	0.0921**	0.0213	0.0367
	(0.0230)	(0.0273)	(0.0445)	(0.0357)	(0.0377)	(0.0573)
TFP_{t-1}	0.0700***	0.0622***	0.0863***	0.0723***	0.0544***	0.0773***
	(0.0110)	(0.0132)	(0.0203)	(0.0168)	(0.0187)	(0.0241)
$Cash-flow_{t-1}$	0.106***	0.00762	0.424***	-0.0194	0.237***	0.0778
	(0.0344)	(0.0402)	(0.0676)	(0.0484)	(0.0679)	(0.0759)
$ForeignGroup_t$	0.00705			-0.00856	0.0171	-0.0364
	(0.0173)			(0.0327)	(0.0249)	(0.0572)
$FrenchGroup_t$	-0.0296**	-0.0292**		-0.0178	-0.0396**	-0.0286
	(0.0118)	(0.0129)		(0.0173)	(0.0186)	(0.0542)
Observations	102,894	85,617	17,277	57,042	34,566	11,286
No.Firms	21,832	19,483	3,850	14,507	7,522	2,146

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel OLS with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable intensive margin of trade is the log of the average value of firm shipments abroad including all the intra-EU shipments over € 100,000 and all the extra-EU over € 1,000 as collected by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

ported just for foreign firms, corroborating previous findings on the role played by process innovation in improving large foreign-owned firms' export performance (Huergo and Jaumandreu 2004; Parisi et al. 2006; Mairesse 2008). In terms of the number of foreign countries supplied, note that the introduction of new products does not improve access to new foreign markets, while process innovation is particularly relevant for small firms which need to become more efficient and to reduce their production costs in order to serve a larger number of foreign markets. However, Table 2.18 shows that firm R&D activities do not have any

Table 2.16: The impact of innovation on the product extensive margin.

Product Ext. Margin	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	-0.0007	-0.00384***	0.00216**	0.000369	0.000129	0.00221***
	(0.0006)	(0.000824)	(0.00101)	(0.00215)	(0.00110)	(0.000836)
$ProductInn._t$	0.0144***	0.00830	0.0155**	0.0315**	0.0138*	0.0129**
	(0.00475)	(0.00658)	(0.00722)	(0.0158)	(0.00827)	(0.00641)
$ProcessInn._t$	0.00542	0.00559	0.0213***	-0.00168	0.000174	0.00922
	(0.00487)	(0.00676)	(0.00733)	(0.0182)	(0.00869)	(0.00638)
$Tot.Employment_{t-1}$	0.333***	0.317***	0.367***	0.235***	0.285***	0.391***
	(0.00562)	(0.00697)	(0.0105)	(0.0132)	(0.0102)	(0.0101)
$Av.Salary_{t-1}$	0.134***	0.130***	0.126***	0.131***	0.160***	0.0755***
	(0.00884)	(0.0108)	(0.0170)	(0.0148)	(0.0154)	(0.0188)
TFP_{t-1}	0.00412	0.0169***	-0.0205***	0.0359***	0.00435	-0.0348***
	(0.00401)	(0.00504)	(0.00707)	(0.00719)	(0.00731)	(0.00699)
$Cash-flow_{t-1}$	0.101***	0.161***	-0.0320	0.0631**	0.127***	0.144***
	(0.0134)	(0.0168)	(0.0244)	(0.0256)	(0.0254)	(0.0221)
$ForeignGroup_t$	0.0127*			-0.00381	0.00879	0.0830***
	(0.00691)			(0.0149)	(0.0105)	(0.0184)
$FrenchGroup_t$	0.0158***	0.0111*		-0.00898	0.0149*	0.0789***
	(0.00532)	(0.00577)		(0.00835)	(0.00823)	(0.0176)
Observations	74,414	58,309	15,397	34,527	28,345	10,533
No.Firms	12,705	10,476	2,835	6,748	5,045	1,754

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel Poisson model with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable product extensive margin is a count variable reporting the number of products exported by a firm in a year taking into account all the intra-EU shipments over € 100,000 and the extra-EU exports over € 1,000 as registered by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

significant effect on the average number of products exported to the different foreign markets.

The results found so far are generally confirmed by the estimation of innovation's impact on firm export performance done using a random-effects model and a dynamic system GMM model presented in Tables A.2.14 and A.2.15 of the appendix. Focusing on the random-effects model in Table A.2.14 it is possible to notice that both R&D investment and product innovations have a positive and significant effect on firm total exports and the probability of being an exporter. Conversely, the intensive margin is not significantly affected by firm

Table 2.17: The impact of innovation on the country extensive margin.

Country Ext. Margin	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	0.00189***	0.000706	0.00321***	0.00161	0.00114	0.00293***
	(0.000627)	(0.000843)	(0.000983)	(0.00205)	(0.00103)	(0.000895)
$ProductInn._t$	0.00427	0.00637	-0.000182	-0.00821	0.00884	0.00513
	(0.00476)	(0.00643)	(0.00742)	(0.0146)	(0.00760)	(0.00696)
$ProcessInn._t$	0.00429	0.00235	0.00709	0.0363**	0.00613	0.000983
	(0.00489)	(0.00666)	(0.00751)	(0.0164)	(0.00791)	(0.00691)
$Tot.Employment_{t-1}$	0.248***	0.251***	0.228***	0.212***	0.222***	0.217***
	(0.00600)	(0.00763)	(0.0108)	(0.0141)	(0.0104)	(0.0114)
$Av.Salary_{t-1}$	0.0702***	0.0809***	0.0332*	0.0725***	0.0676***	0.0356*
	(0.00957)	(0.0120)	(0.0172)	(0.0161)	(0.0160)	(0.0208)
TFP_{t-1}	0.0221***	0.0175***	0.0342***	0.0272***	0.0233***	0.00168
	(0.00425)	(0.00537)	(0.00742)	(0.00744)	(0.00736)	(0.00809)
$Cash-flow_{t-1}$	0.0222*	0.0592***	-0.0403*	0.0253	0.0469*	0.0265
	(0.0135)	(0.0161)	(0.0243)	(0.0219)	(0.0256)	(0.0256)
$ForeignGroup_t$	0.00896			0.0168	0.00540	-0.00863
	(0.00697)			(0.0147)	(0.0101)	(0.0227)
$FrenchGroup_t$	0.0175***	0.0163***		0.00933	0.0186**	-0.0127
	(0.00547)	(0.00598)		(0.00846)	(0.00828)	(0.0217)
Observations	74,414	58,309	15,397	34,527	28,345	10,533
No.Firms	12,705	10,476	2,835	6,748	5,045	1,754

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel Poisson model with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable country extensive margin is a count variable reporting the number of foreign markets served by a firm in a year taking into account all the intra-EU shipments over € 100,000 and the extra-EU exports over € 1,000 as registered by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

R&D activities corroborating the results found applying the fixed-effects model. Innovation instead has a significant effect on the extensive margins of trade, especially with the introduction of new products which positively affects the number of countries served and the number of products exported. These results are confirmed when applying a dynamic system GMM instrumenting the possible endogenous variables - the innovation measures - with their three-periods lagged values plus the total amount of public resources used to fund their R&D activities. Again, note in Table A.2.15 that R&D investment and product innovations improve firm total exports and the probability of being an exporter. In addition

Table 2.18: The impact of innovation on the product-country extensive margin.

Prod-Cod. Ext. Margin	(1) General	(2) Domestic	(3) Foreign	(4) Small	(5) Medium	(6) Large
$Tot.R\&D_{t-1}$	-0.000519	-0.000873	-0.000196	-0.000243	-0.000467	-0.000317
	(0.000677)	(0.000880)	(0.00106)	(0.00178)	(0.00104)	(0.000980)
$ProductInn._t$	0.00526	0.00371	0.00702	0.0116	0.00252	0.00771
	(0.00486)	(0.00615)	(0.00797)	(0.0112)	(0.00726)	(0.00759)
$ProcessInn._t$	0.000783	0.00673	-0.00656	-0.00267	0.00241	-0.00291
	(0.00512)	(0.00654)	(0.00822)	(0.0125)	(0.00765)	(0.00767)
$Tot.Employment_{t-1}$	0.0965***	0.0913***	0.116***	0.0421***	0.0925***	0.156***
	(0.00429)	(0.00498)	(0.00908)	(0.00728)	(0.00762)	(0.0109)
$Av.Salary_{t-1}$	0.0553***	0.0563***	0.0334**	0.0388***	0.0644***	0.0191
	(0.00685)	(0.00780)	(0.0151)	(0.00922)	(0.0126)	(0.0207)
TFP_{t-1}	0.00321	0.00611*	-0.00229	0.00408	0.00965*	0.0179**
	(0.00314)	(0.00366)	(0.00631)	(0.00435)	(0.00569)	(0.00795)
$Cash-flow_{t-1}$	0.0241**	0.0325***	-0.00348	0.00740	0.0364*	0.0586**
	(0.00999)	(0.0114)	(0.0215)	(0.0128)	(0.0209)	(0.0265)
$ForeignGroup_t$	0.00608			0.0131	0.0100	0.0141
	(0.00505)			(0.00854)	(0.00776)	(0.0194)
$FrenchGroup_t$	0.00428	0.000676		-0.00423	0.0197***	0.0108
	(0.00312)	(0.00331)		(0.00402)	(0.00555)	(0.0182)
Observations	102,894	85,617	17,277	57,042	34,566	11,286
No.Firms	21,832	19,483	3,850	14,507	7,522	2,146

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used is a panel OLS model with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable product-country extensive margin is a continuous variable reporting the average number of products exported by a firm to each foreign markets served in a year, taking into account all the intra-EU shipments over € 100,000 and the extra-EU exports over € 1,000 as registered by the French Custom Agency. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees < 50, turnover $\leq$ EUR 10 million), medium (employees ≤ 250, turnover $\leq$ EUR 50 million) and large firms (employees > 250, turnover $>$ EUR 2 million).

product innovation plays a key role in increasing the number of products exported and the number of countries served, while we do not find any significant effect of innovation on the intensive margin of exports. To evaluate the overall goodness of fit of the GMM models we report the Hansen tests of over-identifying restrictions and we test for the presence of first and second order serial autocorrelation. We can notice that almost all our specifications passed these robustness tests except for the total export (EAE) specification in which the Hansen test rejected the null hypothesis. Nevertheless, we should not be too worried about this fact given that when samples with a very large dimension are used in estimation, the Sargan and Hansen tests for over-identifying restrictions tend to over-reject the null hypothesis of instrument validity (Blundell and Bond 2000; Bo and Jagadeesh 2010; Ding et al. 2013).

2.5.3 Difference-in-Differences Estimation

Although our results are generally consistent with the previous literature, we now examine the impact of the decision to start innovating on the different margins of trade. In fact, we are aware of the possible endogeneity problem affecting this analysis and, to properly identify the causal link connecting innovation and export performance, we make use of a difference-in-differences (DID) propensity score matching (PSM) technique in a multiple treatment approach. In this way we will be able to compare the export performance of firms before and after they start innovating with respect to non-innovators (the ATT effect). Matching methods allow to mitigate the endogeneity bias thanks to the construction of valid control groups based on the observable differences between innovators and non-innovators. In Table A.2.16 in the appendix we report some brief statistics about the scale, strategies and export performance of firms included in the different treated and control groups. It is possible to notice that most of the firms in our DID analysis (31,714) have never performed any R&D activity and will be part of our control group. Looking at the treated firms, note that a large part of them (more than 1,800) have introduced jointly a product and a process innovation as a result of their first year of R&D activity, followed by a lower number of firms which have instead just introduced a product or a process innovation or have just invested in R&D activities without any result in terms of innovative output. Finally, these statistics show that firms that have jointly introduced a product and a process innovation outperform all the other categories in terms of all the indicators of productivity, scale and export performance. On the contrary, non-innovators are characterised, as expected, by the worst performance in terms of productivity, scale of operation and export performance according to all indicators. This preliminary evidence stresses even more the relevance of a propensity score matching technique in order to select from the sample of untreated firms a control group for which the distribution of observed characteristics in the pre-innovation period is as similar as possible to the distribution of treated firms.

The difference-in-differences analysis slightly differs from the previous fixed-effect estimations mainly because of the way the treatments have been defined. In fact, to properly identify the ATT effect we considered as treated observations only those firms who have implemented one of the innovation treatments for the first time (investing in R&D, introducing a product innovation, a process innovation or jointly introducing a product and a process innovation), in other words just the innovation switchers, and we compared them against a control group of untreated companies, excluding in this way from our analysis the persistent innovators. On the contrary, in the fixed-effect estimations we have included all the firms part of our sample, estimating the effect of R&D activities on the export performance for innovating switchers, persistent innovators and non-innovating firms. In addition, while in the fixed-effect analysis we took into account the magnitude of firm investment in R&D activities, in the DID estimation we observe just the effect of starting to invest in R&D, not considering the overall value of the investment though. These methodological differences might lead to slightly different results between the fixed-effect and the DID estimations.

Table 2.19 presents the ATT effects of the four possible treatments on the export performance after the first time a firm started innovating and for the following 2 years. In particular in this table we focus on firms total exports and on the probability of starting to export as reported in the EAE dataset. Differently from the fixed-effect estimation, in the DID analysis we consider the difference in firm exporting status before and after the implementation of the innovative treatment, thus estimating firm probability of starting to export abroad. The number of treated and untreated observations for each treatment case and in the different sub-samples depends on the number of treated firms in the remaining cases, on the persistence of firms in our sample over the years and as well on the persistence of observations in the common support based on the matching technique used, resulting in a sample size decreasing as t increases. Consistent bootstrapped standard errors are reported below the ATT estimates.

Table 2.19: Impact of innovation on firm's export performance - ATT effects with Kernel matching.

	Total Exports (EAE)			**Prob. Exporting (EAE)**		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.309***	0.285***	0.474***	0.0428***	0.0510***	0.0520***
b.s.e.	(0.0824)	(0.0941)	(0.126)	(0.0117)	(0.0136)	(0.0178)
Treated	497	472	352	497	472	352
Untreated	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator					
ATT	0.262***	0.249***	0.477***	0.0420***	0.0494***	0.0713***
b.s.e.	(0.0671)	(0.0825)	(0.0978)	(0.0111)	(0.0130)	(0.0152)
Treated	665	663	544	665	663	544
Untreated	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator					
ATT	0.203**	0.142	0.284**	0.0326**	0.0300*	0.0199
b.s.e.	(0.0933)	(0.110)	(0.144)	(0.0147)	(0.0166)	(0.0217)
Treated	338	314	236	338	314	236
Untreated	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator					
ATT	0.231***	0.241***	0.405***	0.0382***	0.0388***	0.0539***
b.s.e.	(0.0638)	(0.0750)	(0.0915)	(0.0111)	(0.0127)	(0.0155)
Treated	1572	1489	1196	1572	1489	1196
Untreated	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (*Pd*), a process innovation (*Pc*) or to jointly introduce a product and a process innovation (*PdPc*) against not having innovated at all for the following three years after the treatment.

First, we find that after starting to invest in R&D firms experience a steady growth in total exports in the following 3 years relative to similar firms in the same industry which did not invest in R&D, accounting on average for 30% increase in total export in 3 years. We find a comparable effect for firms who have introduced for the first time a product innovation, while the effect of introducing a process innovation seems to be smaller both in terms of growth and of statistical significance. Similarly, firms have an higher probability of starting to export in the next 3 years once they start innovating, on average 5% more than other competitors in the same industry. These effects seem to be robust across all the different form of innovation, both for innovative input and output, confirming the causal link between R&D and trade performance and the key role played by innovation both in increasing firms' propensity to export and their intensity of total sales registered in foreign markets.

Table 2.20: Impact of innovation on firm's total exports (CA) and intensive margin - ATT effects with Kernel matching.

	Total Exports (CA)			**Intensive Margin**		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.177*	0.469***	0.801***	0.162*	0.374***	0.787***
b.s.e.	(0.0967)	(0.119)	(0.152)	(0.0870)	(0.106)	(0.136)
Treated	392	373	275	392	373	275
Untreated	16907	16907	14462	16907	16907	14462
	Product Innovation vs Non-innovator					
ATT	0.132	0.450***	0.777***	0.149*	0.375***	0.668***
b.s.e.	(0.0917)	(0.113)	(0.140)	(0.0833)	(0.100)	(0.124)
Treated	554	530	443	554	530	443
Untreated	16907	16907	14462	16907	16907	14462
	Process Innovation vs Non-Innovator					
ATT	0.126	0.163	0.562***	0.154	0.214	0.499***
b.s.e.	(0.132)	(0.165)	(0.178)	(0.123)	(0.147)	(0.153)
Treated	258	236	179	258	236	179
Untreated	16907	16907	14462	16907	16907	14462
	Product & Process Innovation vs Non-Innovator					
ATT	0.147	0.347***	0.620***	0.109	0.276**	0.462***
b.s.e.	(0.101)	(0.125)	(0.166)	(0.0934)	(0.114)	(0.150)
Treated	1267	1214	985	1267	1214	985
Untreated	16907	16907	14462	16907	16907	14462

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the intensive margin of trade have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

In Table 2.20 we focus our attention on the treatment effect on the intensive margin and on total exports using the Custom Agency data. It is interesting to note that as in the previous case firms who start investing in R&D activities are also able to improve the average value of their shipments, with an average growth rate of more than 40% in the following three years. We find a similar, but smaller, impact when analysing the effect of introducing a new product innovation which could be used by exporters to increase the value of future exports. Process innovation instead seems to bring a positive and statistically significant contribution to exports value just 3 years after the introduction of a new process, probably due to the time needed by firms to introduce and adapt new productive processes and the costs connected with this.

Similarly, using the Custom Agency data on total exports we find a positive and statistically significant impact of newly introduced product innovation and R&D investment on foreign sales, similar in magnitude to the effect estimated previously when using the EAE data, in particular a few years after the beginning of the innovative activity. As some theoretical literature has anticipated, the introduction of new innovations could result in a disruptive process of transformation for a manufacturing firm, especially regarding the introduction of new products and processes. Following the Schumpeterian idea of "creative destruction" (Schumpeter 1942) a recent study suggests that the creation and development of new technologies might initially reduce the value of domestic and foreign sales, mainly due to the costs of adaptation and production shift (Conley et al. 2012). Hence, firms would still find it profitable to innovate and introduce new varieties, since rational customers would prefer the new products rather than the old version. This phenomenon is particularly relevant in the initial periods after the introduction of innovations, explaining why in most of the cases we identify an insignificant effect of R&D activities at time $t = 0$ on export performance, turning instead to a positive and significant effect just in a later stage.

Finally, in Table 2.21 we present the treatment effect of starting innovative activities on the extensive margins of trade. Looking at the extensive margins note that the growth in total exports related to R&D activity seems to be mainly driven by a growth in the number of products exported and of foreign markets served. Firms increase the number of products exported and the destinations once they start investing in R&D. Investing in R&D and introducing new products in fact help firms in improving their international performance, mainly through the penetration of new markets and by introducing especially designed tailor-made goods, exploiting the innovative knowledge to enter potentially difficult markets. In addition, R&D activities increase as well the average number of products exported to the different foreign markets served by French firms.

Table 2.21: Impact of innovation on firm's extensive margins - ATT effects with Kernel matching.

	Country Ext. Margin			**Product Ext. Margin**			**Prod-Cod. Ext. Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator								
ATT	0.379*	0.724**	1.983***	0.502	1.959***	2.820***	0.0191	0.0510***	0.114***
b.s.e.	(0.207)	(0.308)	(0.438)	(0.416)	(0.543)	(0.7830)	(0.0149)	(0.0179)	(0.0248)
Treated	392	373	275	392	373	275	392	373	275
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Product Innovation vs Non-innovator								
ATT	0.543**	1.412***	1.858***	0.749**	0.750***	0.508***	-0.0126	0.0306*	0.0485**
b.s.e.	(0.223)	(0.307)	(0.409)	(0.347)	(0.140)	(0.111)	(0.0126)	(0.0157)	(0.0197)
Treated	554	530	443	554	530	443	554	530	443
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Process Innovation vs Non-Innovator								
ATT	0.242	0.459	1.731***	-1.269**	-1.647**	-0.0960	-0.0198	-0.0397	0.00955
b.s.e.	(0.240)	(0.384)	(0.562)	(0.476)	(0.666)	(0.923)	(0.0165)	(0.0198)	(0.0240)
Treated	258	236	179	258	236	179	258	236	179
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Product & Process Innovation vs Non-Innovator								
ATT	0.393**	0.618***	1.792***	-0.228	0.741	0.581	0.0215	0.0543***	0.0773***
b.s.e.	(0.170)	(0.230)	(0.320)	(0.388)	(0.446)	(0.589)	(0.0133)	(0.0161)	(0.0209)
Treated	1267	1214	985	1267	1214	985	1267	1214	985
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables country, product and product-country extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

After 3 years, firms investing in R&D activities seem to export on average to 2 countries more than comparable non-innovating companies and they are able to improve as well their product-mix by exporting on average 3 more products with an overal positive and significant effect on the average number of products exportde to different foreign markets. Introducing new innovative products has a similar impact on both the number of countries served and the number of products exported, particularly large in the case of foreign markets served, with a significantly larger impact on the extensive margins of trade in particular at time $t = 0$. This result is related to the previous evidence about the need of time in order to exploit commercially an innovative activity such as R&D investment and process innovations. On the contrary, the introduction of new innovative products might have a quicker positive impact on firm export performance thanks to the immediate commercial exploitation of this type of innovation also in foreign markets.

Surprisingly, the introduction of new innovative process seems to have a significant and negative impact on the number of products exported. As previously shown, a low-cost business policy might negatively affect the value of goods and their attractiveness on the foreign markets. At the same time, an efficiency-seeking strategy could push firms towards a rationalization of supply, reducing the number of varieties offered and focusing just on the most added-value intensive products in which firms hold a comparative advantage. On the contrary, the joint introduction of product and process innovations seem to have an increasing effect over time but just on the country extensive margin of trade. We find that three years after the introduction of both new product and process innovations firms penetrate on average almost two new foreign markets more than non-innovators.

Overall, we find that investment in R&D and the introduction of new products positively affect firms' international trade performance, mainly exporting new products to new foreign markets and marginally improving the average value of exports. Thus, the positive effect of

R&D on a firm export performance appears to be mainly driven by an improvement in the extensive margins of trade, both in terms of products exported and countries served.

We further developed our analysis by looking at the treatment effect of the introduction of R&D activities on the export performance of French firms differentiating between their size and according to their ownership. From Tables 2.22 and 2.23 note that it is only medium-sized new innovators who experience an increase of their total exports or a higher probability of becoming an exporter after the introduction of new innovation. In addition, we find evidence of a similar phenomenon just for domestic firms, while multinational enterprises based in France do not seem to improve their export performance after the beginning of R&D activities. These results are in line with our previous findings from the fixed-effect model in which we estimated a positive and significant effect of innovation in particular for domestic-owned and SMEs. On the one side firms might need a certain size, in terms of internal resources, in order to exploit the economies of scale related to R&D activities. For this reason, small firms might find it difficult in the first place to start innovating and secondly to exploit commercially the results of their innovative efforts due to their size constraints. On the other side, French firms that are part of a foreign multinational group might be unaffected by their innovative output given that MNEs are usually larger in size, multi-product manufacturers and already exporting to different foreign markets. For these reasons, a new innovative activity might not have any significant effect in improving their total export or the probability of becoming an exporter given that most of them already sell their products abroad.

We find slightly different evidence when estimating the effect of innovation on the trade margins of firms across different size and ownership categories. First, from Table 2.24 we see that the introduction of product or of jointly product and process innovations have a

Table 2.22: Impact of innovation on firm's export performance - ATT effects with Kernel matching for small, medium and large firms.

	Small Firms						Medium Firms						Large Firms					
	Total Exports (EAE)			Prob. Exporting (EAE)			Total Exports (EAE)			Prob. Exporting (EAE)			Total Exports (EAE)			Prob. Exporting (EAE)		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator																	
ATT	0.008	-0.050	0.152	0.003	0.006	0.012	0.199	0.254**	0.268**	0.025	0.035*	0.039***	0.216	0.269	0.482	0.007	0.007	0.010
b.s.e.	(0.089)	(0.120)	(0.120)	(0.011)	(0.016)	(0.014)	(0.141)	(0.109)	(0.109)	(0.016)	(0.018)	(0.015)	(0.211)	(0.266)	(0.388)	(0.022)	(0.027)	(0.037)
Treated	158	113	73	158	113	73	271	227	177	271	227	177	126	119	83	126	119	83
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator																	
ATT	-0.060	-0.010	0.165	2E-3	0.006	0.021	0.299***	0.314**	0.295*	0.038***	0.050***	0.067***	0.101	0.071	0.469**	-0.007	-0.016	0.0246
b.s.e.	(0.081)	(0.116)	(0.136)	(0.008)	(0.010)	(0.013)	(0.094)	(0.135)	(0.159)	(0.011)	(0.015)	(0.021)	(0.144)	(0.174)	(0.235)	(0.011)	(0.018)	(0.023)
Treated	176	136	104	176	136	104	404	327	271	404	327	271	201	170	145	201	170	145
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator																	
ATT	-0.014	-0.031	0.126	-0.004	-0.024	-0.035	0.202	0.230	0.357	0.012	0.016	0.001	0.254	0.375	0.203	0.001	0.063	0.041*
b.s.e.	(0.111)	(0.165)	(0.237)	(0.017)	(0.032)	(0.026)	(0.185)	(0.209)	(0.231)	(0.026)	(0.027)	(0.039)	(0.253)	(0.374)	(0.389)	(0.023)	(0.340)	(0.023)
Treated	84	54	38	84	54	38	200	156	121	200	156	121	87	76	66	87	76	66
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator																	
ATT	-0.001	0.199	0.176	0.001	0.020	0.123	0.167**	0.280***	0.408***	0.022**	0.039***	0.053***	0.050	0.004	0.529***	-0.001	0.001	0.029
b.s.e.	(0.052)	(0.066)	(0.085)	(0.005)	(0.007)	(0.011)	(0.076)	(0.097)	(0.126)	(0.010)	(0.012)	(0.016)	(0.113)	(0.144)	(0.194)	(0.011)	(0.013)	(0.019)
Treated	362	285	213	362	285	213	788	649	524	788	649	524	571	485	407	571	485	407
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. ATT effects are reported for the export performance of firms in three different sub-samples: small (employees < 50, turnover $\leq$ EUR 10 million), medium (employees ≤ 250, turnover $\leq$ EUR 50 million) and large firms (employees > 250, turnover $>$ EUR 2 million).

Table 2.23: Impact of innovation on firm's export performance - ATT effects with Kernel matching for domestic and foreign firms.

	Domestic Firms						**Foreign Firms**					
	Total Exports (EAE)			**Prob. Exporting (EAE)**			**Total Exports (EAE)**			**Prob. Exporting (EAE)**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator											
ATT	0.421***	0.365***	0.579***	0.053***	0.065***	0.078***	0.021	0.117	0.186	-0.001	0.003	-0.004
b.s.e.	(0.102)	(0.113)	(0.163)	(0.013)	(0.015)	(0.019)	(0.225)	(0.211)	(0.318)	(0.027)	(0.024)	(0.034)
Treated	435	344	249	435	344	249	150	128	103	150	128	103
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator											
ATT	0.315***	0.275***	0.603***	0.051***	0.058***	0.088***	0.310**	0.440**	0.357**	0.045**	0.033**	0.023
b.s.e.	(0.087)	(0.098)	(0.123)	(0.013)	(0.014)	(0.017)	(0.138)	(0.203)	(0.160)	(0.019)	(0.016)	(0.017)
Treated	566	456	370	566	456	370	257	212	176	257	212	176
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator											
ATT	0.242*	0.185	0.458*	0.035*	0.024	0.032	-0.128	-0.131	-0.174	-0.005	0.005	0.0008
b.s.e.	(0.123)	(0.146)	(0.185)	(0.018)	(0.019)	(0.026)	(0.227)	(0.231)	(0.354)	(0.026)	(0.029)	(0.039)
Treated	298	222	168	298	222	168	107	92	69	107	92	69
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator											
ATT	0.321***	0.321***	0.433***	0.045***	0.044***	0.069***	0.008	0.167	0.019	0.005	0.012	-0.008
b.s.e.	(0.064)	(0.078)	(0.103)	(0.007)	(0.009)	(0.012)	(0.094)	(0.143)	(0.187)	(0.012)	(0.013)	(0.015)
Treated	1215	990	782	1215	990	782	599	503	419	599	503	419
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. ATT effects are reported for the export performance of firms in two different sub-samples: domestic firms and enterprises affiliated to foreign business groups.

positive effect on the trade margins of small firms as well as medium sized firms. In particular, introducing both a product and a process innovation helps small firms to increase not only the average value of their exports, but also to export more products (2 more on average in respect to non-innovating firms) and to a larger number of countries (one foreign market more) at a later stage, with an average positive effect of almost 50% growth in total exports in the following 3 years. Secondly, from Tables 2.25 and 2.27 it is possible to notice that medium and domestic firms profit the most from investment in R&D activities and from the introduction of innovative products, in particular improving the average value of their shipments and increasing the overall number of countries served, with an export performance improvement in the following 3 years similar in magnitude to the previously discussed general sample. Finally, Tables 2.26 and 2.28 confirm the previous results not finding any significant effect of new R&D activities on the trade margins of large and foreign-owned firm. This evidence seems to corroborate the hypothesis that R&D activities could play an essential role in improving the export performance of medium-sized and domestic-owned firms, in particular increasing the likelihood of their participation to international markets and by increasing the number of products exported and of foreign markets served in respect to non-innovators. On the contrary, small firms might not have the sufficient resources required in order to exploit in the international markets the positive externalities related to R&D activities, while large and foreign-owned companies might not depend on innovation in order to boost their export performance, given their possibility to exploit economies of scale and the positive spillovers of being part of multinational business groups.

As previously discussed in the methodological section, we have performed a series of robustness checks in order to verify the goodness of our difference-in-differences approach. In particular, in Tables A.2.27-A.2.29 in the appendix we have firstly estimated the previous model but considering separately the four different treatments as individual activities which

Table 2.24: Impact of innovation on firm's trade margins - ATT effects with Kernel matching for small firms.

	Small Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.164	0.192	0.554**	0.184	0.2260	0.496**	0.417	0.381	1.399*	0.477	-0.048	0.472	0.00609	0.0538	0.0170
b.s.e.	(0.252)	(0.270)	(0.276)	(0.215)	(0.236)	(0.234)	(0.366)	(0.455)	(0.703)	(0.634)	(0.968)	(1.262)	(0.0233)	(0.0377)	(0.0350)
Treated	157	112	73	157	112	73	157	112	73	157	112	73	157	112	73
Untreated	11196	11196	9353	11196	11196	9353	11196	11196	9353	11196	11196	9353	11196	11196	9353
	Product Innovation vs Non-innovator														
ATT	0.168	0.367	1.002***	0.175	0.259	0.765***	-0.057	0.783	1.993***	0.329	0.987	1.828**	0.00744	0.00445	0.00728
b.s.e.	(0.217)	(0.249)	(0.316)	(0.191)	(0.212)	(0.291)	(0.398)	(0.530)	(0.731)	(0.535)	(0.679)	(0.848)	(0.0289)	(0.0324)	(0.0413)
Treated	176	136	104	176	136	104	176	136	104	176	136	104	176	136	104
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353
	Process Innovation vs Non-Innovator														
ATT	0.151	0.014	0.114	0.145	0.014	0.024	0.289	0.926	2.025*	0.353	0.445	0.065	0.0136	0.0316	0.0113
b.s.e.	(0.281)	(0.416)	(0.359)	(0.239)	(0.345)	(0.295)	(0.501)	(0.631)	(1.051)	(0.516)	(0.764)	(1.211)	(0.0279)	(0.0318)	(0.0426)
Treated	84	54	38	84	54	38	84	54	38	84	54	38	84	54	38
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353
	Product & Process Innovation vs Non-Innovator														
ATT	0.356**	0.544***	0.792***	0.375**	0.486***	0.607***	-0.058	0.010	1.080**	-0.184	0.77*	2.198***	-0.00376	-0.00678	0.00166
b.s.e.	(0.157)	(0.160)	(0.234)	(0.145)	(0.150)	(0.221)	(0.274)	(0.393)	(0.526)	(0.349)	(0.473)	(0.778)	(0.0273)	(0.0348)	(0.0394)
Treated	362	285	213	362	285	213	362	285	213	362	285	213	362	285	213
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (*Pd*), a process innovation (*Pc*) or to jointly introduce a product and a process innovation (*PdPc*) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of small firms (employees < 50, turnover $\leq$ EUR 10 million).

Table 2.25: Impact of innovation on firm's trade margins - ATT effects with Kernel matching for medium firms.

	Medium Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.042	0.384*	0.573*	-0.002	0.292	0.426	0.251	-0.008	0.645	0.937	1.892**	1.672***	0.0341*	0.0679***	0.112***
b.s.e.	(0.130)	(0.227)	(0.338)	(0.119)	(0.200)	(0.259)	(0.411)	(0.563)	(0.794)	(0.703)	(0.917)	(0.211)	(0.0189)	(0.0238)	(0.0291)
Treated	220	180	134	220	180	134	220	180	134	220	180	134	220	180	134
Untreated	4867	4867	4368	4867	4867	4368	4867	4867	4368	4867	4867	4368	4867	4867	4368
	Product Innovation vs Non-innovator														
ATT	0.237*	0.585**	0.914***	0.189*	0.444**	0.676***	0.855**	2.07***	2.747***	0.825	1.133	1.634*	0.00639	0.0625**	0.0738*
b.s.e.	(0.141)	(0.218)	(0.274)	(0.106)	(0.175)	(0.234)	(0.409)	(0.629)	(0.771)	(0.556)	(0.772)	(0.909)	(0.0223)	(0.0282)	(0.0402)
Treated	323	255	215	323	255	215	323	255	215	323	255	215	323	255	215
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368
	Process Innovation vs Non-Innovator														
ATT	-0.064	-0.122	0.371	-0.049	-0.065	0.293	0.378	0.592	1.262	-0.700	-1.546	-1.020	-0.000362	0.0453*	0.0892***
b.s.e.	(0.277)	(0.318)	(0.331)	(0.256)	(0.286)	(0.259)	(0.463)	(0.635)	(0.930)	(0.849)	(0.996)	(1.422)	(0.0187)	(0.0249)	(0.0291)
Treated	159	122	90	159	122	90	159	122	90	159	122	90	159	122	90
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368
	Product & Process Innovation vs Non-Innovator														
ATT	0.084	0.521***	0.824***	0.095	0.467***	0.686***	0.437*	0.87**	1.752***	0.043	0.131	1.523*	-0.0114	-0.0678	-0.0123
b.s.e.	(0.110)	(0.200)	(0.261)	(0.090)	(0.170)	(0.222)	(0.254)	(0.421)	(0.609)	(0.452)	(0.573)	(0.813)	(0.0285)	(0.0431)	(0.0401)
Treated	632	518	425	632	518	425	632	518	425	632	518	425	632	518	425
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of medium firms (employees ≤ 250, turnover $\leq$ EUR 50 million).

Table 2.26: Impact of innovation on firm's trade margins - ATT effects with Kernel matching for large firms.

	Large Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	-0.140	0.203	1.119	-0.0429	0.180	0.821	0.031	1.870	5.920**	-2.259	3.750	6.886	-0.0745	-0.0415	0.0169**
b.s.e.	(0.190)	(0.384)	(0.826)	(0.154)	(0.303)	(0.634)	(0.829)	(1.419)	(2.517)	(2.757)	(5.188)	(8.617)	(0.0481)	(0.0556)	(0.0652)
Treated	90	81	68	90	81	68	90	81	68	90	81	68	90	81	68
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Product Innovation vs Non-innovator														
ATT	-0.320	-0.236	-0.2989	-0.115	-0.115	-0.074	-0.810	-0.139	0.182	-2.744	-2.182	-3.665	-0.0454	-0.0366	-0.0801
b.s.e.	(0.288)	(0.417)	(0.281)	(0.249)	(0.335)	(0.206)	(0.851)	(1.137)	(1.372)	(1.852)	(2.421)	(3.424)	(0.0330)	(0.0390)	(0.0474)
Treated	168	139	124	168	139	124	168	139	124	168	139	124	168	139	124
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Process Innovation vs Non-Innovator														
ATT	0.048	0.313	0.834	0.124	0.512	0.902	1.229	0.442	1.93	-2.76	-1.207	-0.4919	-0.0920**	-0.102**	-0.0229
b.s.e.	(0.170)	(0.416)	(0.842)	(0.160)	(0.404)	(0.764)	(1.098)	(1.625)	(1.845)	(2.667)	(3.085)	(3.969)	(0.0360)	(0.0484)	(0.0626)
Treated	71	51	59	71	51	59	71	51	59	71	51	59	71	51	59
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Product & Process Innovation vs Non-Innovator														
ATT	-0.161	-0.007	0.285	-0.100	0.0210	0.304	-0.118	0.105	1.708	-0.218	0.756	-0.850	-0.0361	0.00331	0.00953
b.s.e.	(0.116)	(0.230)	(0.365)	(0.103)	(0.185)	(0.270)	(0.582)	(0.776)	(1.088)	(1.201)	(1.551)	(1.850)	(0.0286)	(0.0325)	(0.0396)
Treated	491	419	357	491	419	357	491	419	357	491	419	357	491	419	357
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of large firms (employees > 250, turnover > EUR 2 million).

Table 2.27: Impact of innovation on firm's trade margins - ATT effects with Kernel matching for domestic firms.

	Domestic Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.161	0.397**	0.876***	0.138	0.310**	0.693***	0.381	0.725**	1.717**	0.806	2.041*	2.461**	0.0177	0.0491**	0.0838***
b.s.e.	(0.120)	(0.158)	(0.247)	(0.109)	(0.139)	(0.192)	(0.274)	(0.357)	(0.703)	(0.584)	(1.205)	(1.063)	(0.0175)	(0.0213)	(0.0292)
Treated	361	280	199	361	280	199	361	280	199	361	280	199	361	280	199
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Product Innovation vs Non-innovator														
ATT	0.112	0.264*	0.64***	0.153*	0.263**	0.535***	0.605**	1.19***	2.335***	-0.45	0.217	0.653	0.0177	0.0491**	0.0838***
b.s.e.	(0.954)	(0.155)	(0.208)	(0.091)	(0.128)	(0.183)	(0.291)	(0.409)	(0.665)	(0.484)	(0.647)	(0.791)	(0.0175)	(0.0213)	(0.0292)
Treated	462	362	301	462	362	301	462	362	301	462	362	301	462	362	301
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Process Innovation vs Non-Innovator														
ATT	0.227	0.234	0.529**	0.224	0.263	0.409*	0.352	0.703*	1.847***	-0.558	-1.588	-0.815	-0.0159	-0.00151	0.0434*
b.s.e.	(0.174)	(0.237)	(0.236)	(0.158)	(0.200)	(0.232)	(0.321)	(0.425)	(0.682)	(0.609)	(0.924)	(1.329)	(0.0162)	(0.0191)	(0.0243)
Treated	221	159	124	221	159	124	221	159	124	221	159	124	221	159	124
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Product & Process Innovation vs Non-Innovator														
ATT	0.184**	0.353***	0.636***	0.147*	0.297***	0.479***	0.187	0.311	1.469***	0.608	1.077**	2.096***	0.00708	-0.0329	0.0126
b.s.e.	(0.085)	(0.110)	(0.175)	(0.077)	(0.092)	(0.150)	(0.217)	(0.353)	(0.456)	(0.426)	(0.564)	(0.731)	(0.0210)	(0.0249)	(0.0292)
Treated	990	804	639	990	804	639	990	804	639	990	804	639	990	804	639
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (*Pd*), a process innovation (*Pc*) or to jointly introduce a product and a process innovation (*PdPc*) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of domestic firms not affiliated to foreign-owned groups.

Table 2.28: Impact of innovation on firm's trade margins - ATT effects with Kernel matching for foreign firms.

	Foreign Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.102	0.624*	0.888*	0.056	0.500*	0.605	-0.287	0.325	1.405	1.417	2.874**	6.095**	0.0320**	0.0458**	0.0718***
b.s.e.	(0.152)	(0.339)	(0.499)	(0.126)	(0.272)	(0.386)	(0.622)	(1.090)	(1.457)	(1.187)	(1.348)	(3.037)	(0.0141)	(0.0171)	(0.0213)
Treated	106	94	76	106	94	76	106	94	76	106	94	76	106	94	76
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Product Innovation vs Non-innovator														
ATT	0.157	0.358	0.505	0.151	0.230	0.405	0.405	1.062	1.008	-0.230	0.97	0.148	0.0414	0.100**	0.204***
b.s.e.	(0.191)	(0.267)	(0.310)	(0.151)	(0.199)	(0.251)	(0.597)	(0.839)	(1.152)	(1.080)	(1.342)	(1.990)	(0.0341)	(0.0399)	(0.0586)
Treated	205	168	142	205	168	142	205	168	142	205	168	142	205	168	142
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Process Innovation vs Non-Innovator														
ATT	-0.348	-0.387	0.368	-0.219	-0.23	0.321	0.142	0.518	2.396	-2.012	-1.355	0.916	-0.0119	0.0500	0.0392
b.s.e.	(0.215)	(0.276)	(0.448)	(0.198)	(0.237)	(0.306)	(0.766)	(1.137)	(1.665)	(1.453)	(1.482)	(3.017)	(0.0224)	(0.0315)	(0.0369)
Treated	93	77	55	93	77	55	93	77	55	93	77	55	93	77	55
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Product & Process Innovation vs Non-Innovator														
ATT	-0.032	0.188	0.165	-0.012	0.141	0.164	0.230	0.085	1.108	-0.348	1.018	-0.690	0.0798**	0.104**	0.0144
b.s.e.	(0.122)	(0.207)	(0.282)	(0.095)	(0.157)	(0.204)	(0.446)	(0.653)	(0.802)	(0.873)	(1.050)	(1.469)	(0.0326)	(0.0405)	(0.0521)
Treated	495	417	356	495	417	356	495	417	356	495	417	356	495	417	356
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (*Pd*), a process innovation (*Pc*) or to jointly introduce a product and a process innovation (*PdPc*) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of firms affiliated to a foreign-owned group.

are not correlated with each other and estimating a single separate propensity score for each of the four treatments. Secondly, we have replicated our results applying different matching algorithms, among which one-to-one with and without replacement, nearest-neighbour, caliper and radius using as well different measures of matching bandwidth. In Tables A.2.17-A.2.26 in the appendix we present these results using a nearest-neighbour matching technique with a conservative matching range of 5 nearest observations. Finally, we have re-estimated our model not forcing the matching between treated and control observations to be within industry and year cohorts, but just based on the basic propensity score estimated with the multinomial logit as explained above. Our main results are consistent with all the specifications previously used, once again confirming the robustness of our analysis in terms of the goodness of methodologies applied and of the accuracy of findings.[13]

2.6 Conclusions

In this chapter we have exploited four unique and detailed datasets to investigate the impact of the innovating activities of French firms on their trade margins for the period 1999-2007. Our main contribution to the existing literature is the decomposition of this effect on the extensive and intensive margins of trade. For the first time, we established at the firm level whether innovation activities improve exporters' performance creating new trade links, enriching firms' product mix and opening new export markets, or if they support the intensification of existing flows. In addition, we assessed the effect of different forms of innovation on export performance, by simultaneously taking into account both innovation input and output measures. Controlling for firm characteristics across different industries, the general result is that R&D has a positive and significant effect on export performance.

[13] The results of these additional robustness checks are available upon request.

First, we found a positive and significant effect of past investment in R&D on exports that is particularly robust and consistent across all different measures of trade performance and the different estimation techniques. Using a difference-in-differences (DID) propensity score matching (PSM) technique in a multiple treatment approach we have been able to compare the export performance of firms before and after they start innovating with respect to non-innovators, providing estimations robust to possible endogenity concerns, and finding a particularly relevant dynamic effect on export performance in the years following the innovative activity.

First, innovation increases by 5% on average the probability of French firms to participate in the international markets, helping them to face the pressure of foreign competitors and experiencing a steady growth of more than 30% in total exports in the following years in respect to similar firms which do not innovate. Overall, we found that both investment in R&D and the introduction of new products positively affect firms' international trade performance, while process innovation seems to play a marginal role in improving firm exports.

Most importantly, we disentangled the effect of innovating activities on the different margins of trade in order to identify the role played by specific R&D activities across the different components of firms' export performance. Generally, we found that R&D activities positively affect firms' international trade performance, mainly exporting new products to new foreign markets and marginally improving the average value of exports. Thus, dissecting the impact on the trade margins we found that the growth in total exports related to R&D activity seems to be mainly driven by a growth in the number of products exported and of foreign markets served. Investing in R&D and introducing new products in fact help French firms to export on average to 2 more new markets and by introducing 3 more products on average than non-innovators, using especially designed varieties and exploiting the innovative knowledge to enter potentially difficult markets.

We further exploited our data by analysing the treatment effect of the introduction of R&D activities on export performance of French firms differentiating between their size and according to their ownership. Our results corroborate the hypothesis that R&D activities play an essential role in improving the export performance of medium-sized and domestic-owned firms, in particular increasing the likelihood of their participation to international markets and by increasing the number of products exported and of foreign markets served in respect to non-innovators. In fact, small firms might not have the sufficient resources required in order to exploit in the international markets the positive externalities related to R&D activities, while large and foreign-owned companies might not depend solely on innovation in order to boost their export performance, given their possibility to exploit economies of scale and the positive spillovers of being part of multinational business groups.

Overall, innovation plays a key role in developed and mature economies as France, preparing firms to face international competition, upgrading their knowledge of foreign markets and introducing tailor-made goods designed to penetrate distant and difficult countries. However, we also found some evidence that innovation is a dynamic, time-consuming and resources-intensive process, with a "creative destruction" effect of new innovations on firm performance, leading to an initial insignificant or even negative impact of R&D on exports due to the costs of adaptation, production shift and the time needed in order to commercially exploit new technologies especially in foreign markets. Nevertheless, although a negative or zero impact in the short-run, returns to R&D investment seem to pay back in the long-run with a twofold impact on economic growth, both as a mean of developing new technologies but also boosting export performance with potential welfare gains in terms of production and employment.

To conclude, our analysis has identified for the first time at the firm-level the precise impact of several innovating activities on export performance, dissecting this impact across the different margins of trade. It helped as well to identify the main channels linking R&D activities and exports, establishing through which trade margins innovation drives firm export performance. We deem this investigation on the dynamic effect of R&D activities across the different trade margins particularly relevant in order to elaborate the appropriate policies to be used to support and foster this relationship, and in turn to boost economic recovery encouraging international trade, R&D investment and employment.

Appendix A2

Table A.2.1: Variables Summary Statistics

Variable	Mean	Std.Dev.	Min.	Max.	Observations	Firms
Tot. Employment	137.34	1047.32	20	115,968	192,697	35,583
Av. Salary	25,444	9,534	500	760,458	192,697	35,583
log(TFP)	4.446	0.617	-1.840	8.901	192,697	35,583
Tot. Sales	3,676,280	3,781,990	1	44,500,000	192,697	35,583
Cash-flow	0.0414	0.1160	-6.243	11.616	192,697	35,583
Tot. Investment	1,050,059	1,550,118	-2,146,786	30,372,891	192,697	35,583
Foreign Group	0.15	0.36	0	1	192,697	35,583
French Group	0.43	0.49	0	1	192,697	35,583
Foreign Ownership	0.14	0.34	0	1	192,697	35,583
Tot. R&D	710,668	14,128	0	1,628,152	192,697	35,583
R&D Intensity	0.005	0.16	0	5.42	192,697	35,583
Product Inn.	0.0643	0.2454	0	1	192,697	35,583
Process Inn.	0.0526	0.2232	0	1	192,697	35,583
R&D Public Funds	1,078	14,192	0	474,383	192,697	35,583
Tot. Exports (EAE)	1,109,188	1,926,680	0	27,100,000	192,697	35,583
Export Intensity	0.16	0.23	0	1	192,697	35,583
Pr. Exporter	0.72	0.44	0	1	192,697	35,583
Tot. Exports (CA)	1,390,000	1,300,000	3	15,100,000	102,924	18,421
Intensive Margin	200,304	901,215	3	77,700,000	102,924	18,421
Country Ext. Margin	14.90	18.10	1	174	102,924	18,421
Product Ext. Margin	16.40	30.77	1	840	102,924	18,421
Prod-Country Ext. Mar.	2.85	3.55	1	152	102,924	18,421

Note: Statistics based on EAE dataset, Custom Agency and R&D survey data, average from year 1999 to 2007. Employment calculated as average number of full-time employees (EAE data). Average salary represents average annual salary of full-time employees in Euro (EAE data). Total sales calculated as average total sales (domestic+foreign) (EAE data). Total investment calculated as average of firm total investment in fixed tangible assets (EAE data). Productivity calculated as log of total factor productivity following the De Loecker (2007) approach (EAE data). Cash-flow calculated as the ratio between firm net income and total sales (EAE data). Export intensity calculated as the ratio of firm total exports over total sales (EAE data). Foreign and French group are dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise (EAE data). Foreign ownership represents the share of participation in the company capital by foreign firms (EAE data). Total R&D investment includes all positive investment of firm in R&D activities (R&D Survey data). R&D intensity calculated as average ratio of firms total investment in R&D over total sales (R&D Survey data). R&D public funding calculated as the average funds received by French, foreign and international public authorities to stimulate private firms innovative activities (R&D Survey data). Product and Process Innovation reports the average frequency of the introduction of new product or process innovations in French firms during the period of interest (R&D Survey data). Total exports (EAE) equal to firms foreign sales in each year as reported in the EAE dataset. Total exports (CA) includes data on all intra-EU shipments over € 100,000 and extra-EU over € 1,000 collected by the French Custom Agency. Intensive Margin calculated as average value of firms shipments abroad (CA data). Product extensive margin calculated as average number of products exported by French firms each year (CA data). Country extensive margin calculated as average number of foreign markets served by French firms each year (CA data). All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

Table A.2.2: Definition of Variables

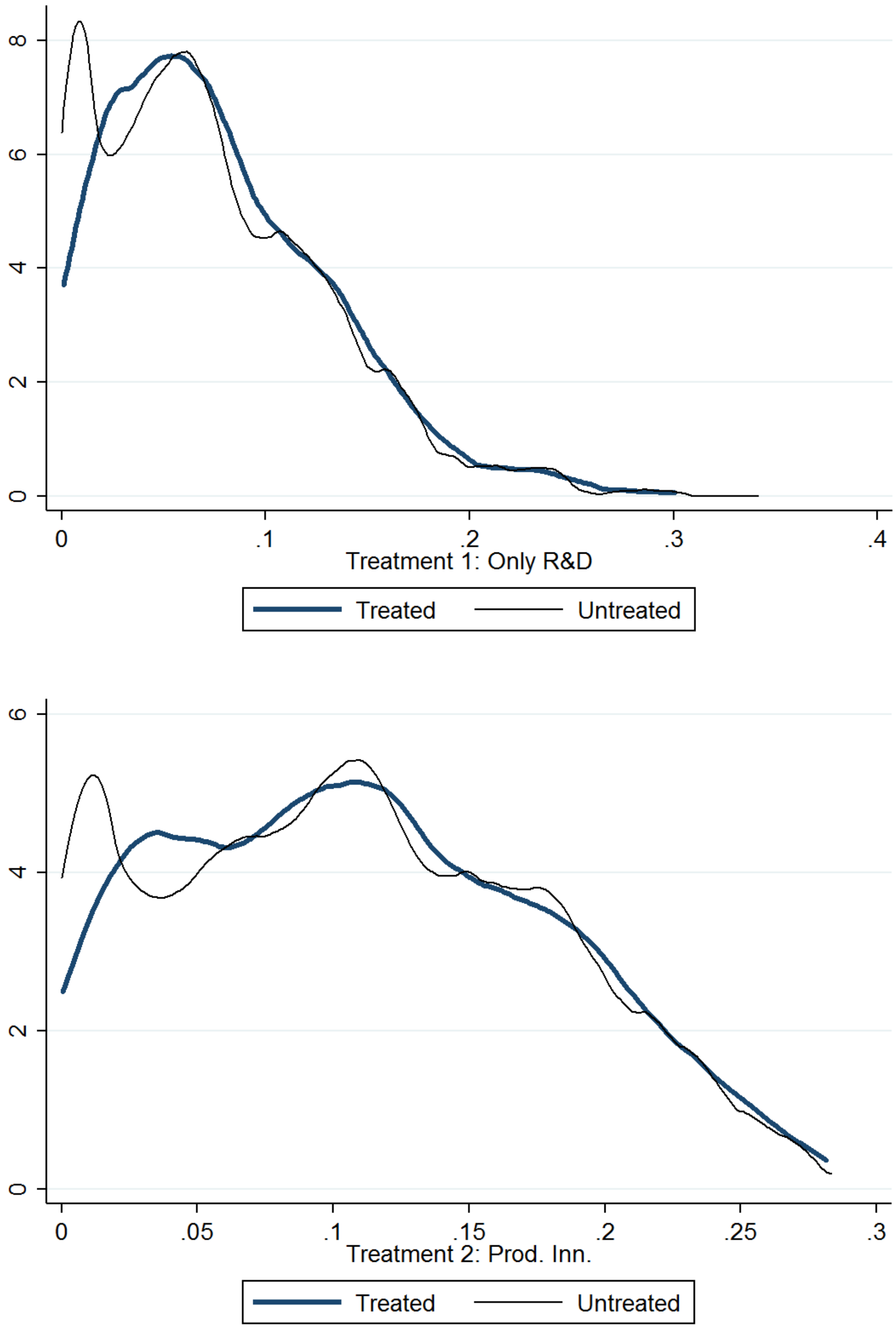
Variable	**Definition**
Pr. Exporter	Dummy variable for export status equals to 1 if firm i at time t has positive export sales and 0 otherwise (EAE Data).
Tot. Exports (EAE)	Firm i total export sales at time t according to the EAE dataset.
Export Intensity	Ratio of firm i total exports over total sales at time t according to the EAE dataset.
Tot. Exports (CA)	Firm i exports about intra-EU shipments over € 100,000 and extra-EU over € 1,000 according to the French Custom Agency data.
Intensive Margin	Average value of firm i shipments abroad (Custom Data).
Product Extensive Margin	Count variable for the number of products exported by each firm (Custom Data).
Country Extensive Margin	Count variable for the number of foreign markets served by each firm (Custom Data).
Product-Country Extensive Margin	Average number of products exported to each foreign market by each firm (Custom Data).
Tot. Employment	Size of firm i measured as the log of total employees (EAE Data).
Av. Salary	The log of wage per employee calculated as the ratio of total labour payments over total labour (EAE Data).
Total Sales	The log of of firm i total sales (domestic+foreign) at time t (EAE data).
Total Investment	The log of of firm i total investment in fixed tangible assets at time t (EAE data).
Cash-flow	The ratio between firm i net income and total sales (EAE Data).
TFP	The log of total factor productivity calculated following the De Loecker (2007) approach. We have used value added as a proxy for output, including in the estimation total wages as measure for labour, export dummy, the total costs of intermediate input as costs of production and total investment in tangible and intangible assets (EAE Data).
Foreign Group	Dummy variable equals to 1 if firm i is part of a foreign-owned group or 0 otherwise (LiFi Data).
French Group	Dummy variable equals to 1 if firm i is part of a French group or 0 otherwise (LiFi Data).
Foreign Ownership	Variable measuring the share of ownership of firm i by individuals and companies which are not based in France (LiFi Data).
Tot. R&D	The log of firm i total investment in R&D activities at time $t-1$ both internally and externally (R&D Data).
R&D Intensity	Ratio of firm i total investment in R&D activities over total sales at time t according to the EAE dataset and the R&D Survey.
Product Innovation	Dummy variable equals to 1 if firm i has introduced a new product innovation thanks to its R&D activity and 0 otherwise (R&D Data).
Process Innovation	Dummy variable equals to 1 if firm i has introduced a new process innovation thanks to its R&D activity and 0 otherwise (R&D Data).
R&D Public Funds	The log of total funds received by firm i from public authorities to support firm's R&D activities (R&D Data).
Rd	Dummy variable equals to 1 if firm i has started investing in R&D activities for the first time and 0 otherwise (R&D Data).
Pd	Dummy variable equals to 1 if firm i has introduced a new product innovation for the first time and 0 otherwise (R&D Data).
Pc	Dummy variable equals to 1 if firm i has introduced a new process innovation for the first time and 0 otherwise (R&D Data).
PdPc	Dummy variable equals to 1 if firm i has introduced both a new process and a new product innovation for the first time and 0 otherwise (R&D Data).
Ind	Industrial sector at the NACE 2-digit-level of disaggregation (EAE Data).
Year	Year fixed effect (EAE Data).
Domestic	Dummy variable equals to 1 if firm i is owned for less than 10% by a foreign company and 0 otherwise following the INSEE guidelines (LiFi Data).
SmallEC	Dummy variable equals to 1 if the total labour force of firm i at time t is smaller than 50 employees following the European Commission guidelines (EAE Data).
MediumEC	Dummy variable equals to 1 if the total labour force of firm i at time t is larger than 50 and smaller than 250 employees following the European Commission guidelines (EAE Data).
LargeEC	Dummy variable equals to 1 if the total labour force of firm i at time t is larger than 250 employees following the European Commission guidelines (EAE Data).

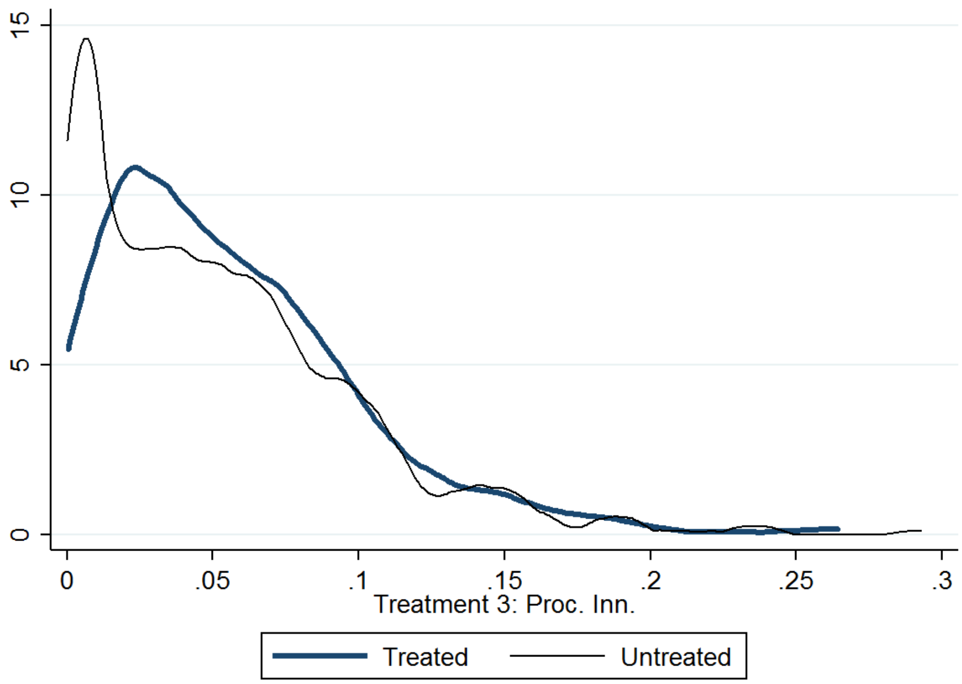
Table A.2.3: Correlation Table

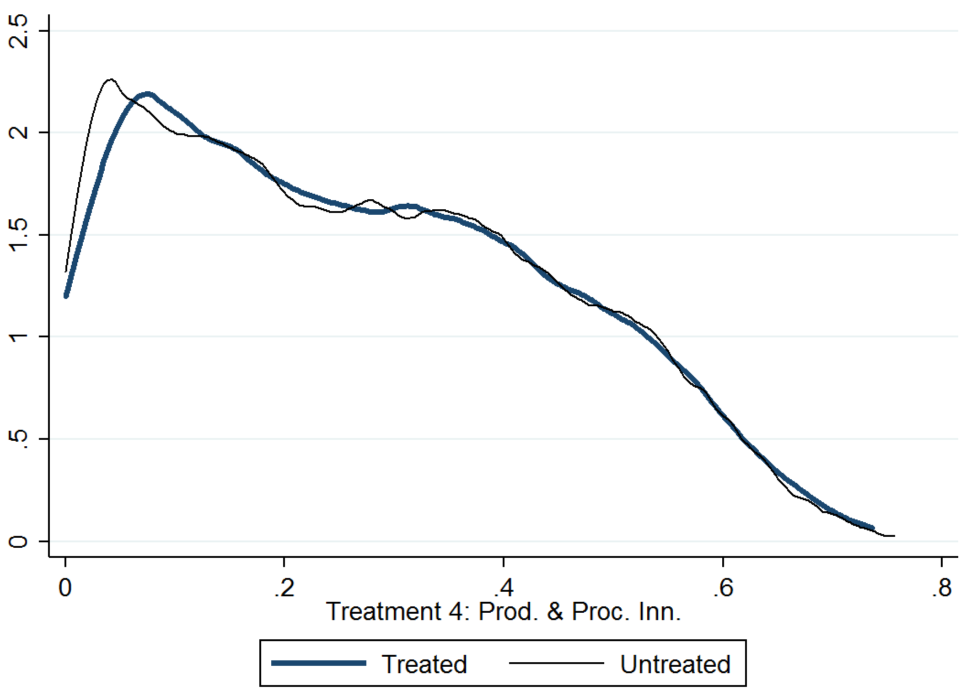
	Cash-flow	R&D Public Funds	Tot. Exports (CA)	Tot. Employment	Av. Salary	TFP	Unit Value	Foreign Group	French Group
Cash-flow	1								
R&D Public Funds	0.0137	1							
Tot. Exports (CA)	0.0125	0.1839	1						
Tot. Employment	0.0285	0.2546	0.5640	1					
Av. Salary	0.0710	0.1517	0.2730	0.1477	1				
TFP	0.4627	0.1186	0.3743	0.4361	0.3003	1			
Unit Value	0.0650	0.1885	0.1801	0.1444	0.2234	0.0899	1		
Foreign Group	-0.0308	0.0003	0.3449	0.3285	0.2147	0.2049	0.0402	1	
French Group	0.0363	0.0782	0.0108	0.0943	-0.0383	0.0703	0.0112	-0.4722	1
Foreign Ownership	-0.0188	0.0294	0.3656	0.3615	0.2344	0.2346	0.0522	0.9537	-0.4411
Tot. R&D	0.0405	0.4884	0.4044	0.4930	0.254	0.2822	0.2369	0.1857	0.0497
Product Inn.	0.0436	0.3622	0.3063	0.3416	0.1762	0.2044	0.1760	0.1346	0.0453
Process Inn.	0.0399	0.3601	0.2835	0.3236	0.1605	0.1953	0.1769	0.1186	0.0429
Tot. Exports (EAE)	0.0250	0.1840	0.8151	0.5212	0.2883	0.3497	0.1819	0.3161	0.0005
Pr. Exporter	0.0106	0.0423	0.3627	0.0985	0.0641	0.0628	0.0697	0.0776	-0.0134
Intensive Mar.	0.0033	0.1247	0.8222	0.4395	0.183	0.3133	0.0259	0.3094	-0.0245
Country Ext. Mar.	0.0359	0.2111	0.6700	0.5260	0.2898	0.3180	0.2186	0.2384	0.0420
Product Ext. Mar.	0.0145	0.2335	0.4765	0.4461	0.2111	0.2406	0.2229	0.1373	0.0473
Prod-Cod. Ext. Mar.	0.0026	0.0865	0.3937	0.4096	0.1370	0.1669	-0.0060	0.0555	0.0019

	Foreign Ownership	Tot. R&D	Product Inn.	Process Inn.	Tot. Exports	Pr. Exporter	Intensive Mar.	Country Ext. Mar.	Product Ext. Mar.	Prod-Cod. Ext. Mar.
Foreign Ownership	1									
Tot. R&D	0.2393	1								
Product Inn.	0.1806	0.7897	1							
Process Inn.	0.1588	0.7161	0.7715	1						
Tot. Exports	0.3362	0.3821	0.2886	0.2665	1					
Pr. Exporter	0.0807	0.0922	0.0787	0.0666	0.6704	1				
Intensive Mar.	0.3216	0.2731	0.1879	0.1899	0.6301	0.2321	1			
Country Ext. Mar.	0.2690	0.4633	0.3603	0.3211	0.6084	0.1943	0.2994	1		
Product Ext. Mar.	0.159	0.3558	0.2454	0.2250	0.4204	0.1174	0.1439	0.6006	1	
Prod-Cod. Ext. Mar.	0.0603	0.3511	0.0367	0.0248	0.4248	0.0693	-0.0077	0.3923	0.8202	1

Figure A.2.1: Density distribution of propensity scores for firms in the treated and control groups for each different treatment.

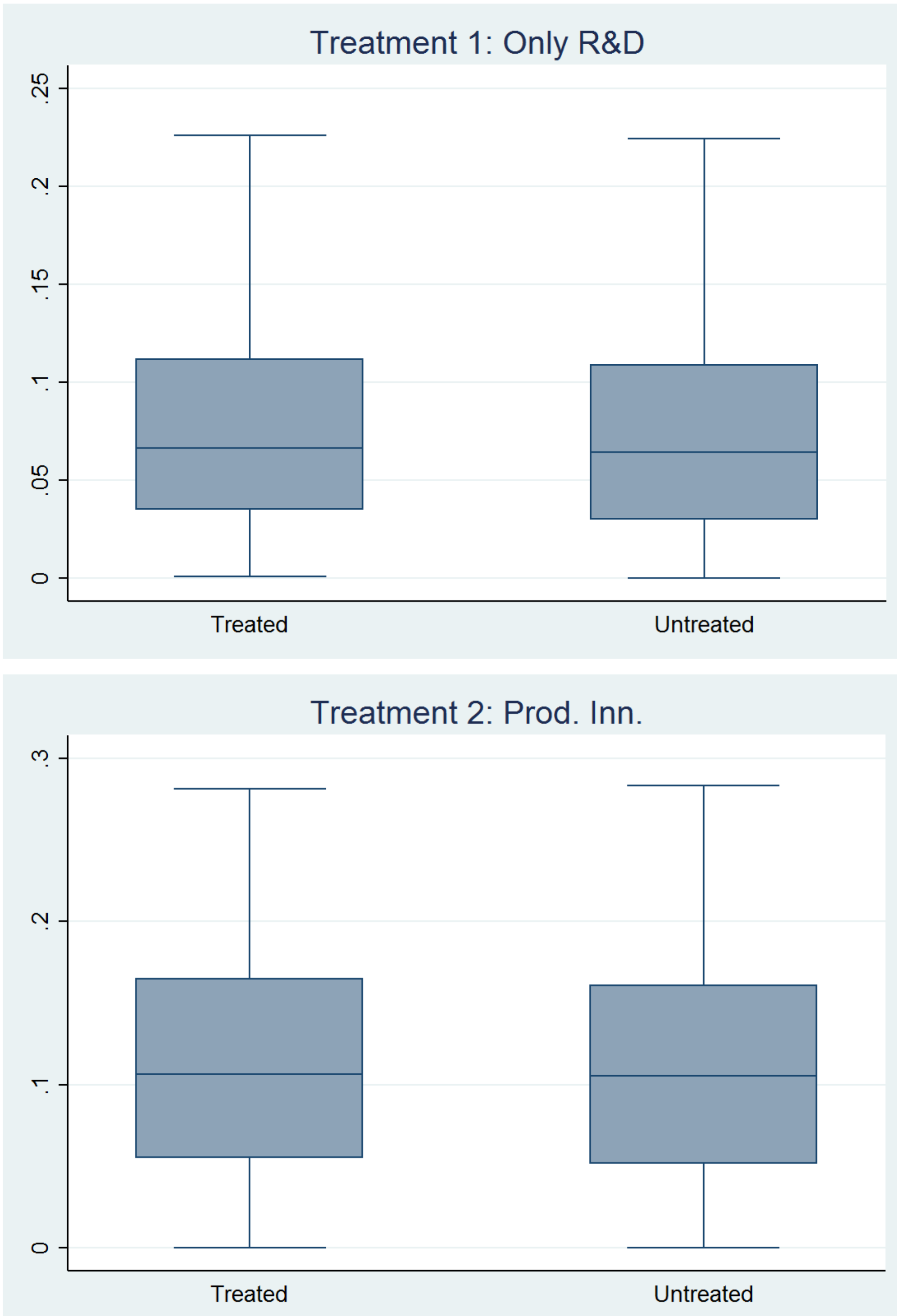


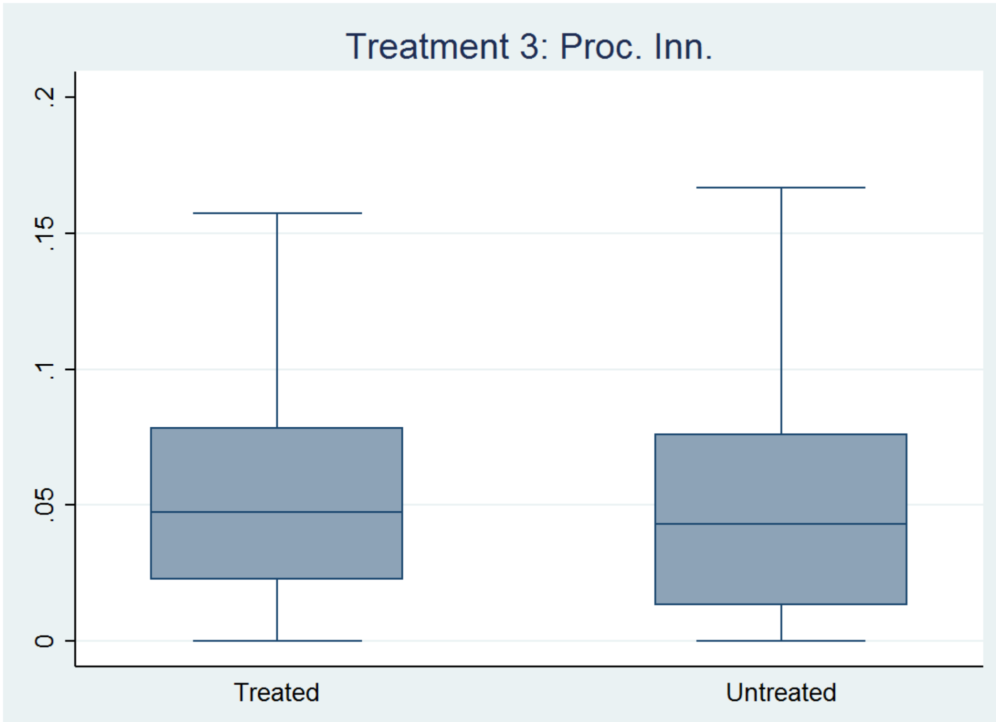


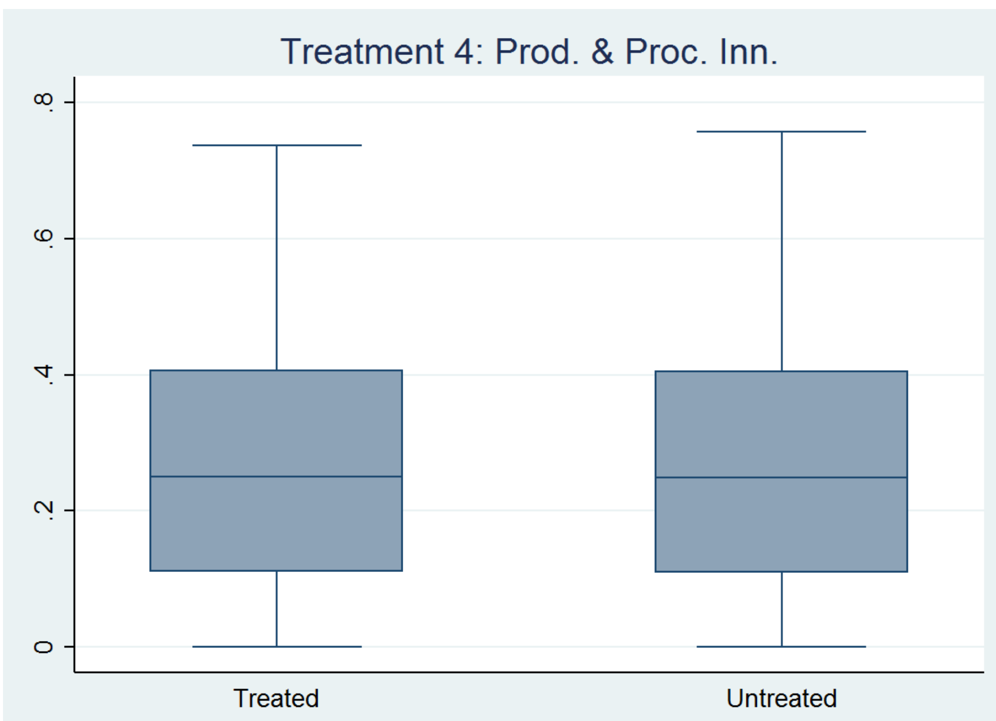


Note: Propensity scores for the 4 treatments (investing in R&D, introducing a product innovation, introducing a process innovation, introducing jointly a product and a process innovations) estimated using a multinomial logit.

Figure A.2.2: Median, 25th and 75th percentile and confidence interval of the propensity scores for firms in the treated and control groups for the 4 different treatments.







Note: Propensity scores for the 4 treatments (investing in R&D, introducing a product innovation, introducing a process innovation, introducing jointly a product and a process innovations) estimated using a multinomial logit.

Table A.2.4: Matching propensity average balancing test for *Rd* propensity score

		Mean		Bias		Equality of Means		Ratio of
Variable	Sample	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|	variance residuals
Tot. Employment	Unmatched	4.661	3.805	88.5		24.6	0.000	1.04
	Matched	4.657	4.465	19.89	77.59	2.96	0.850	0.85
Av. Salary	Unmatched	3.277	3.189	30.8		7.32	0.000	0.97
	Matched	3.277	3.262	5.3	82.8	0.9	0.365	0.98
TFP	Unmatched	4.695	4.3369	57.7		14.62	0.000	1.23
	Matched	4.695	4.640	8.9	84.6	1.39	0.166	0.89
Export	Unmatched	0.916	0.662	65.59		12.96	0.000	0.45**
	Matched	0.9165	0.846	17.89	72.59	3.7	0.729	0.64*
Tot. Investment	Unmatched	5.693	4.276	71.59		17.64	0.000	0.86
	Matched	5.6892	5.277	20.8	71	3.41	0.480	0.87
Cash-flow	Unmatched	5.194	2.570	25.9		5.45	0.000	0.55*
	Matched	5.188	3.653	15.2	41.5	2.79	0.005	0.72*
Foreign Group	Unmatched	0.255	0.115	36.70		10.46	0.000	1.90*
	Matched	0.256	0.227	7.6	79.2	1.17	0.242	1.05
French Group	Unmatched	0.588	0.401	38.1		9.16	0.000	1.22
	Matched	0.588	0.592	-0.8	97.9	-0.140	0.890	1
Sample Stat.		R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	B	R
	Unmatched	0.124	727.49	0.000	42.2	37.4	120.8*	0.77
	Matched	0.22	35.94	0.000	10.19	8.30	25.2	0.76

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the multinomial logit estimation before and after and the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, while the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index.

Table A.2.5: Matching propensity average balancing test for Pd propensity score

		Mean		Bias		Equality of Means		Ratio of
Variable	Sample	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|	variance residuals
Tot. Employment	Unmatched	4.797	3.805	104.1		33.65	0.000	0.9
	Matched	4.793	4.676	12.3	88.1	2.11	0.350	0.78
Av. Salary	Unmatched	3.322	3.189	49.3		13.1	0.000	0.76*
	Matched	3.321	3.313	2.9	94.1	0.59	0.558	0.71*
TFP	Unmatched	4.7923	4.3369	72.5		21.89	0.000	1.22
	Matched	4.788	4.789	-0.2	99.7	-0.04	0.970	0.75*
Export	Unmatched	0.938	0.662	73.5		16.7	0.000	0.37**
	Matched	0.937	0.885	13.9	81.09	3.74	0.010	0.68*
Tot. Investment	Unmatched	6.018	4.276	92.5		25.69	0.000	0.69*
	Matched	6.011	5.752	13.8	85.1	2.62	0.089	0.75*
Cash-flow	Unmatched	4.837	2.570	21		5.56	0.000	0.73*
	Matched	4.803	3.534	11.8	44	2.57	0.010	0.88
Foreign Group	Unmatched	0.311	0.115	49.2		17.14	0.000	2.14**
	Matched	0.310	0.314	-1	98	-0.17	0.862	0.99
French Group	Unmatched	0.545	0.401	29.1		8.33	0.000	1.17
	Matched	0.547	0.530	3.3	88.7	0.66	0.509	1
Sample Stat.		R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	B	R
	Unmatched	0.169	1300.14	0.000	50.2	49.3	138.9*	0.74
	Matched	0.170	37.72	0.000	6.7	4.5	30.3*	0.8

Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the multinomial logit estimation before and after and the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, while the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index.

Table A.2.6: Matching propensity average balancing test for Pc propensity score

		Mean		Bias		Equality of Means		Ratio of
Variable	Sample	Treated	Control	Std. Bias	Reduct Bias	t	p>|t|	variance residuals
Tot. Employment	Unmatched	4.713	3.805	94.2		21.85	0.000	1.04
	Matched	4.712	4.464	25.7	72.7	3.23	0.343	0.99
Av. Salary	Unmatched	3.290	3.189	36.5		6.97	0.000	0.83
	Matched	3.289	3.254	12.5	65.7	1.86	0.063	0.94
TFP	Unmatched	4.632	4.3369	45.8		10.03	0.000	1.39*
	Matched	4.6311	4.536	14.7	67.90	1.94	0.052	1.02
Export	Unmatched	0.916	0.662	65.59		10.82	0.000	0.44**
	Matched	0.916	0.825	23.5	64.09	3.9	0.008	0.74*
Tot. Investment	Unmatched	5.956	4.276	88.1		17.51	0.000	0.75*
	Matched	5.955	5.372	27.6	65.3	4.17	0.075	0.87
Cash-flow	Unmatched	4.411	2.570	15.7		3.18	0.001	1.06
	Matched	4.435	3.746	5.9	62.6	0.88	0.378	1.25*
Foreign Group	Unmatched	0.267	0.115	39.4		9.49	0.000	1.89*
	Matched	0.266	0.232	8.6	78.3	1.09	0.276	1.10
French Group	Unmatched	0.572	0.401	34.70		6.99	0.000	1.18
	Matched	0.573	0.545	5.9	83.1	0.83	0.407	1.01
Sample Stat.		R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	B	R
	Unmatched	0.134	584.17	0.000	45.3	37.9	128.5*	0.8
	Matched	0.290	32.47	0.000	12.9	10.5	40.1*	0.63

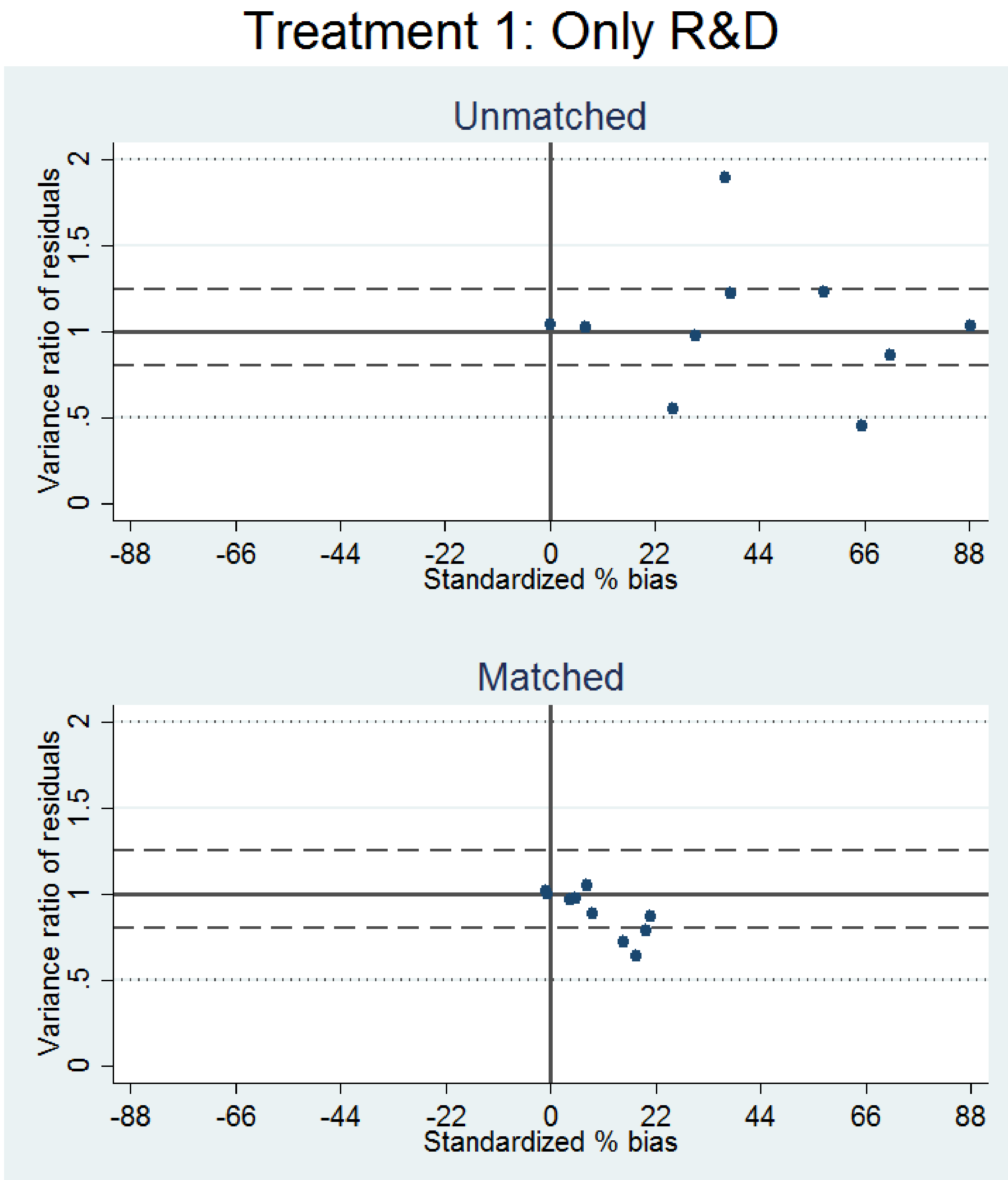
Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the multinomial logit estimation before and after and the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, while the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index.

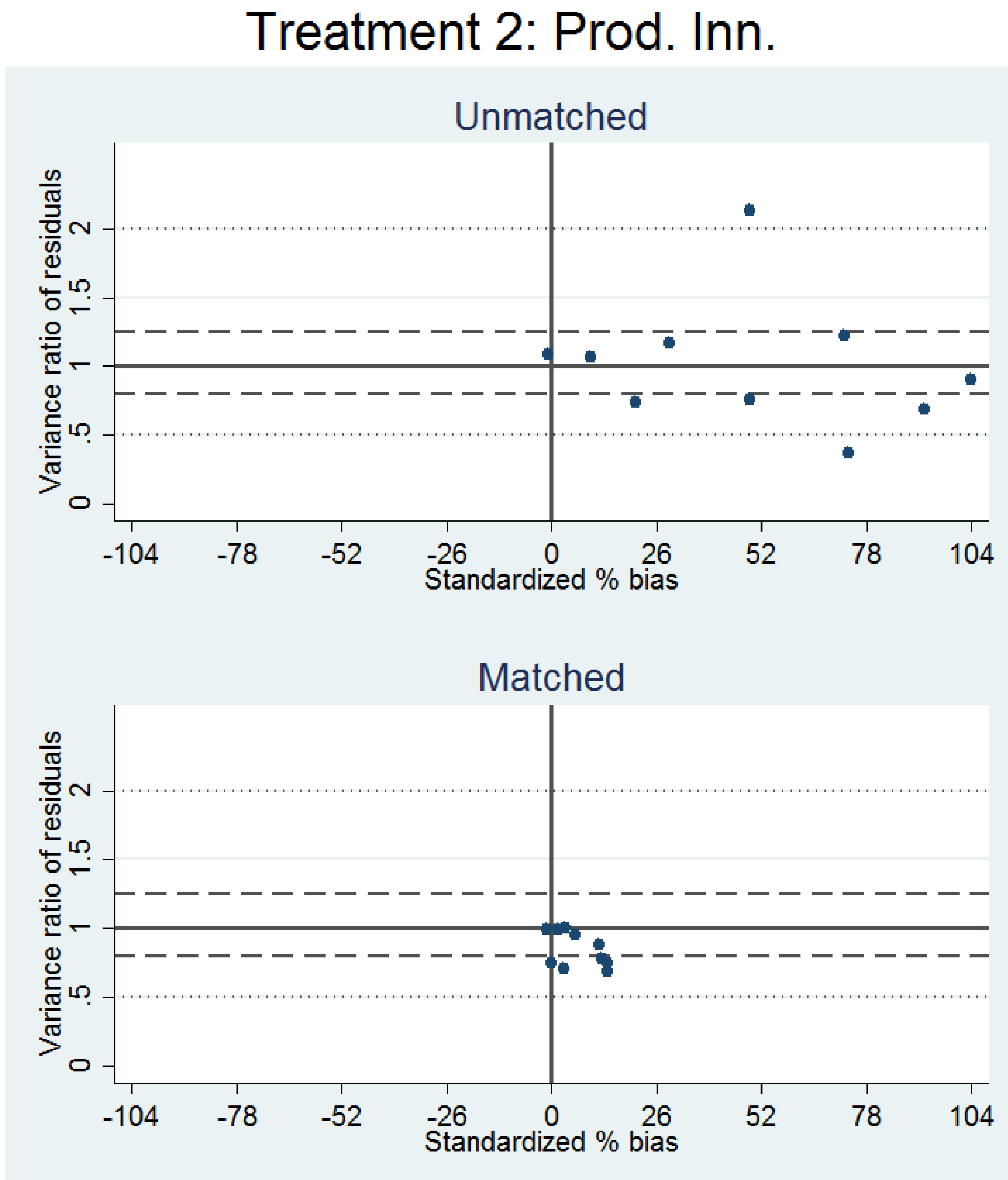
Table A.2.7: Matching propensity average balancing test for $PdPc$ propensity score

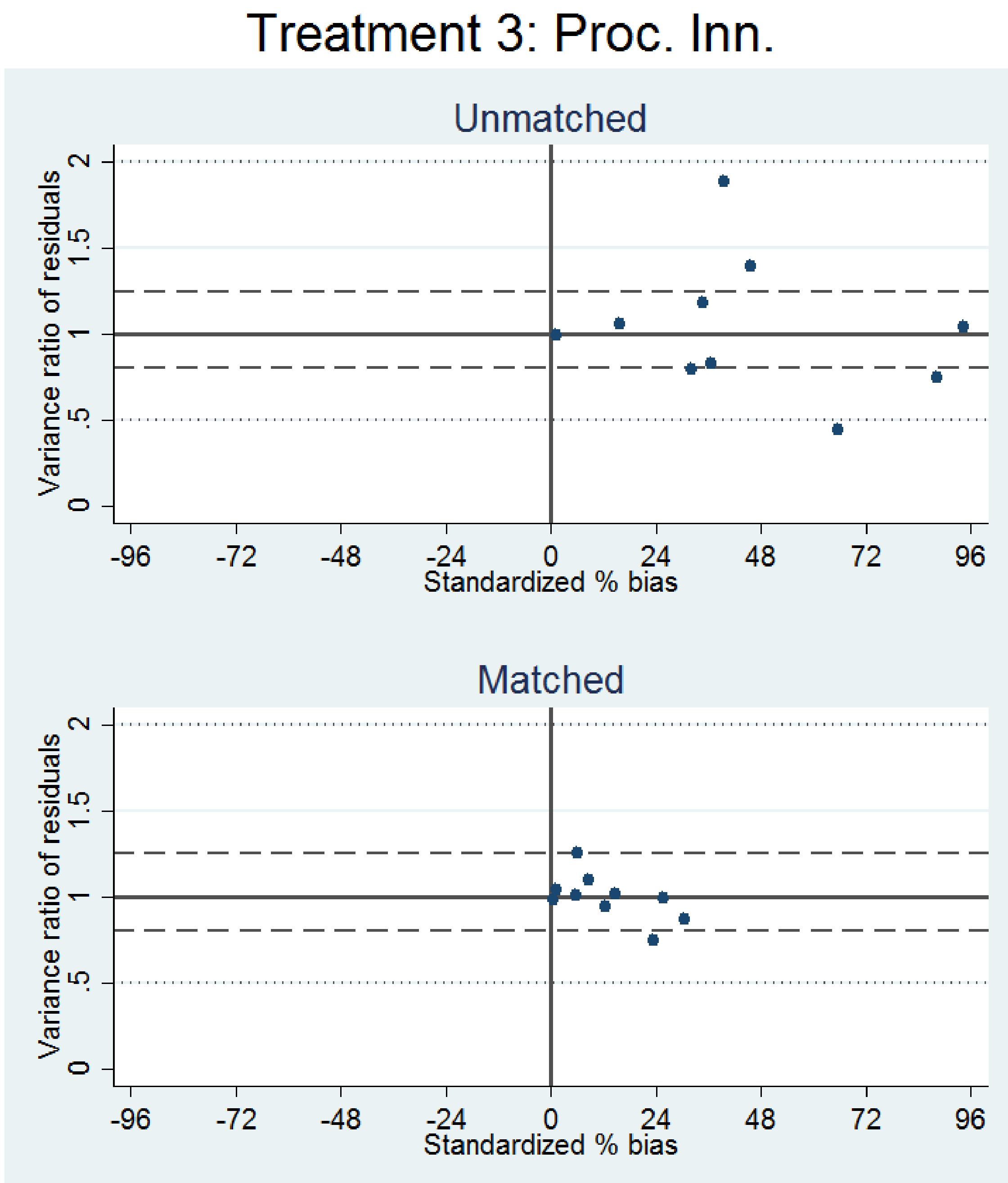
Variable	Sample	Mean		Bias		Equality of Means		Ratio of
		Treated	Control	Std. Bias	Reduct Bias	t	p>|t|	variance residuals
Tot. Employment	Unmatched	5.005	3.805	113.8		58.08	0.000	1.01
	Matched	4.999	5.022	-2.20	98.1	-0.54	0.587	0.84
Av. Salary	Unmatched	3.346	3.189	56.8		22.63	0.000	0.83
	Matched	3.345	3.348	-1.00	98.2	-0.3	0.766	0.81
TFP	Unmatched	4.790	4.336	70.40		31.67	0.000	1.37*
	Matched	4.790	4.797	-1.10	98.5	-0.280	0.777	0.83
Export	Unmatched	0.952	0.662	79		25.97	0.000	0.31**
	Matched	0.951	0.907	12.1	84.6	5.26	0.010	0.84
Tot. Investment	Unmatched	6.270	4.276	99.9		42.78	0.000	0.74*
	Matched	6.260	6.043	10.8	89.1	2.98	0.003	0.83
Cash-flow	Unmatched	5.235	2.570	24.7		9.59	0.000	0.75*
	Matched	5.258	3.851	13.1	47.2	4.08	0.000	0.78*
Foreign Group	Unmatched	0.330	0.115	53.4		27.00	0.000	2.15**
	Matched	0.330	0.341	-2.8	94.7	-0.72	0.470	0.97
French Group	Unmatched	0.540	0.401	28.1		11.74	0.000	1.14
	Matched	0.540	0.520	4.00	85.80	1.19	0.234	0.98
Sample Stat.		R_2	$LRchi_2$	$p > chi_2$	Mean Bias	Med.Bias	B	R
	Unmatched	0.241	3422.42	0.000	56.3	55.1	151.8*	0.92
	Matched	0.149	77.48	0.000	5.5	3.9	25.1	0.73

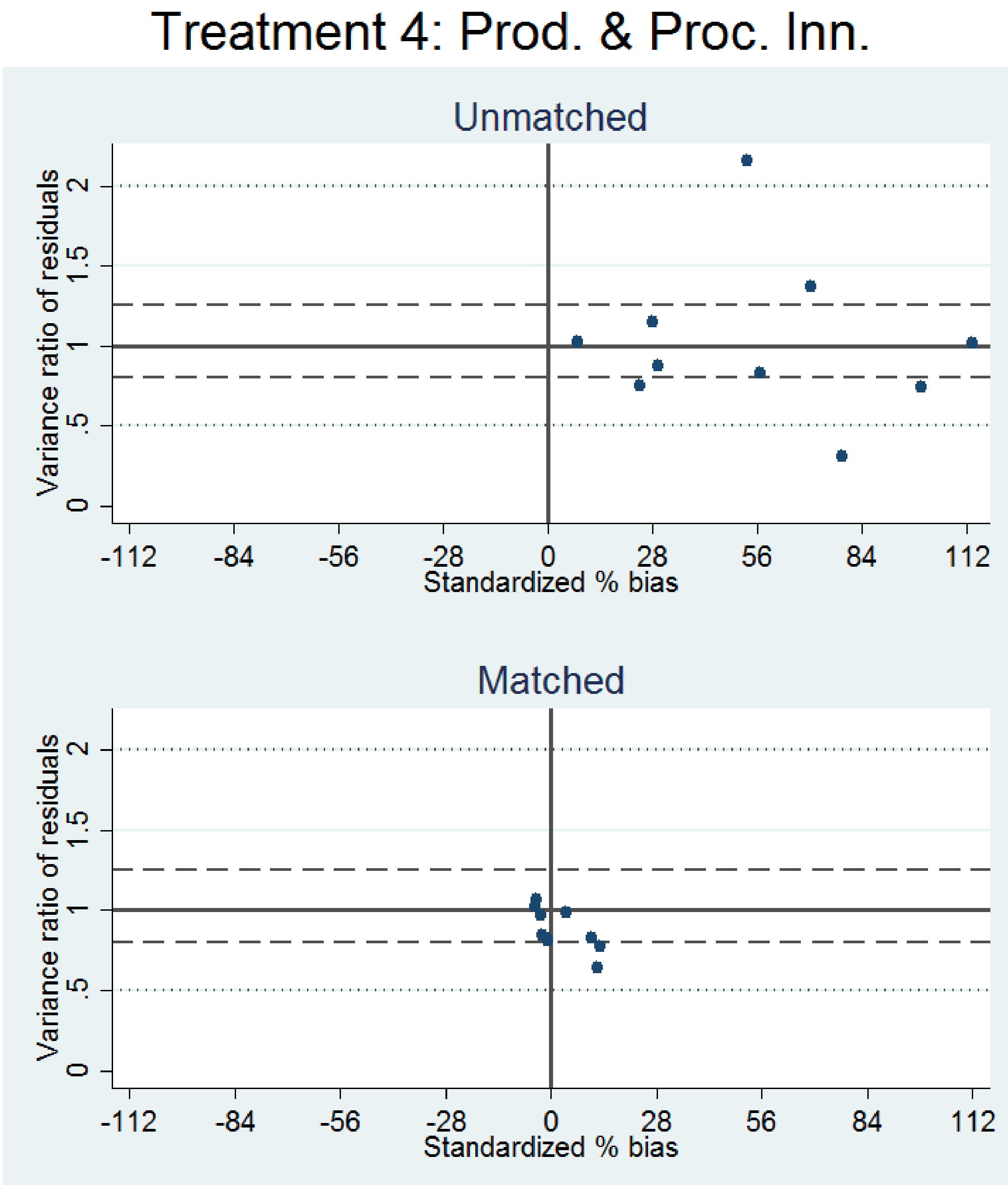
Note: in the second column we differentiate between the sample before and after the implementation of the matching technique. Columns 3 and 4 present the mean value of each control variable for firms in the treated and control groups before and after the implementation of the matching technique. In columns 5 and 6 we display the median standard bias across all the covariates included in the multinomial logit estimation before and after and the percentage reduction in the bias after the application of the matching procedure. Columns 7 and 8 report the t-tests for the equality of the mean values of firms in the matched sample compared to those in unmatched sample. Columns 9 and 10 show the ratio of variance of residuals orthogonal to linear index of the propensity score in treated group over non-treated group. Finally, in the bottom two rows we present a summary of statistics regarding the whole sample. First, we include the pseudo R^2 from the probit estimation of the treatment on covariates on raw or matched samples and the corresponding χ^2 statistic and p-value of likelihood-ratio test of joint significance of covariates. In addition, we present the mean and median bias as summary indicators of the distribution of bias across the samples. Finally, the Rubin's B shows the absolute standardized difference of means of linear index of propensity score in treated and matched non-treated groups, while the Rubin's R is the ratio of treated to matched non-treated variances of the propensity score index.

Figure A.2.3: Propensity scores regressors bias between firms in the treated and control groups before and after the application of the kernel matching technique.




Treatment 2: Prod. Inn.
Unmatched
Variance ratio of residuals
0
.5
1
1.5
2
-104
-78
-52
-26
0
26
52
78
104
Standardized % bias
Matched
Variance ratio of residuals
0
.5
1
1.5
2
-104
-78
-52
-26
0
26
52
78
104
Standardized % bias


Treatment 3: Proc. Inn.
Unmatched
Variance ratio of residuals
0
.5
1
1.5
2
-96
-72
-48
-24
0
24
48
72
96
Standardized % bias
Matched
Variance ratio of residuals
0
.5
1
1.5
2
-96
-72
-48
-24
0
24
48
72
96
Standardized % bias



Note: Propensity scores for the 4 treatments (investing in R&D, introducing a product innovation, introducing a process innovation, introducing jointly product and process innovations) estimated using a multinomial logit. Kernel matching technique applied with a 0.01 bandwidth and imposing a common support condition, matching firms part of the same industry and which performed the treatment in the same year. Treated firms are in the common support if their propensity score is lower than the maximum and higher than the minimum score of the control units.

Table A.2.8: The impact of innovation on trade margins of firms exporting just within the EU (CA data).

Only Intra-EU Exports						
	Intensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0411*	0.0567**	-0.0290	-0.00651	0.0611	0.110*
	(0.0240)	(0.0265)	(0.0656)	(0.0422)	(0.0382)	(0.0605)
$ProductInn._t$	0.115	0.133	0.357	0.0616	0.225	-0.0902
	(0.151)	(0.165)	(0.445)	(0.255)	(0.244)	(0.383)
$ProcessInn._t$	0.0155	0.0623	-0.669	-0.254	0.146	0.463
	(0.178)	(0.189)	(0.614)	(0.280)	(0.281)	(0.538)
$Observations$	7,594	6,686	908	5,016	2,277	301
$No.ofFirms$	2,593	2,332	346	1,775	857	114
	Country Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	-0.00810	-0.00978	0.00236	0.00610	-0.00877	-0.0514
	(0.0169)	(0.0187)	(0.0465)	(0.0326)	(0.0249)	(0.0394)
$ProductInn._t$	-0.0244	-0.0407	-0.0395	0.0380	-0.00126	-0.192
	(0.107)	(0.117)	(0.329)	(0.191)	(0.163)	(0.253)
$ProcessInn._t$	-0.0463	-0.0394	-0.0729	-0.0692	-0.0755	-0.0402
	(0.122)	(0.129)	(0.419)	(0.202)	(0.184)	(0.339)
$Observations$	6,701	5,852	771	4,360	1,946	260
$No.ofFirms$	1,700	1,498	209	1,119	526	73
	Product Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	-0.0150	-0.0137	0.0162	-0.0400	-0.0158	0.00429
	(0.0128)	(0.0137)	(0.0446)	(0.0271)	(0.0179)	(0.0314)
$ProductInn._t$	0.183*	0.170*	0.571*	-0.203	-0.255	-0.0287
	(0.0937)	(0.100)	(0.304)	(0.169)	(0.174)	(0.174)
$ProcessInn._t$	0.0951	0.0752	0.470	0.0836	0.0840	0.0854
	(0.115)	(0.122)	(0.371)	(0.187)	(0.198)	(0.256)
$Observations$	6,701	5,852	771	4,360	1,946	260
$No.ofFirms$	1,700	1,498	209	1,119	526	73
	Product-Country Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.00159	-0.00421	0.0107	0.0122***	0.00460	-0.00227
	(0.00273)	(0.00294)	(0.0100)	(0.00458)	(0.00512)	(0.00598)
$ProductInn._t$	-0.0194	-0.0318	-0.0867	-0.0450	-0.00676	-0.0296
	(0.0190)	(0.0194)	(0.107)	(0.0316)	(0.0350)	(0.0473)
$ProcessInn._t$	0.0242	0.0188	0.150	0.0355	0.0192	0.0530
	(0.0210)	(0.0209)	(0.126)	(0.0322)	(0.0373)	(0.0605)
$Observations$	6,701	5,852	771	4,360	1,946	260
$No.ofFirms$	1,700	1,498	209	1,119	526	73

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used for the intensive margin and product-country extensive margin of trade is a panel OLS with firm and year fixed-effects, while for country and product extensive margins is a Poisson model with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As unreported control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees < 50, turnover $\leq$ EUR 10 million), medium (employees ≤ 250, turnover $\leq$ EUR 50 million) and large firms (employees > 250, turnover $>$ EUR 2 million).

Table A.2.9: The impact of innovation on trade margins of firms exporting just outside the EU (CA data).

	Only Extra-EU Exports					
	Intensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
Tot.R&D$_{t-1}$	0.0635**	0.0405	0.166***	0.0639*	0.0319	-0.00644
	(0.0256)	(0.0289)	(0.0623)	(0.0357)	(0.0465)	(0.0994)
ProductInn.$_t$	0.0227	-0.00595	0.247	-0.0387	-0.137	0.597
	(0.144)	(0.156)	(0.405)	(0.193)	(0.285)	(0.566)
ProcessInn.$_t$	0.196	0.103	0.936**	0.239	0.418	-1.005
	(0.155)	(0.169)	(0.423)	(0.219)	(0.257)	(0.651)
Observations	7,439	6,843	596	5,365	1,831	243
No.ofFirms	2,829	2,637	247	2,122	740	101
	Country Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
Tot.R&D$_{t-1}$	0.0460***	0.0009	0.0910***	-0.00452	-0.00952	0.0103
	(0.0154)	(0.0200)	(0.0295)	(0.0258)	(0.0297)	(0.0341)
ProductInn.$_t$	0.154	0.190*	-0.139	0.246*	0.00755	-0.190
	(0.0946)	(0.106)	(0.214)	(0.129)	(0.170)	(0.415)
ProcessInn.$_t$	-0.00405	-0.0303	0.112	0.112	-0.199	-0.365
	(0.101)	(0.112)	(0.244)	(0.149)	(0.160)	(0.431)
Observations	6,329	5,792	487	4,487	1,529	197
No.ofFirms	1,719	1,586	138	1,244	438	55
	Product Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
Tot.R&D$_{t-1}$	0.00994	-0.0184	0.0703***	-0.0196	-0.00545	0.00681
	(0.0129)	(0.0161)	(0.0252)	(0.0212)	(0.0200)	(0.0430)
ProductInn.$_t$	0.217***	0.236***	-0.182	0.393***	0.0098	-0.344
	(0.0765)	(0.0866)	(0.180)	(0.110)	(0.130)	(0.335)
ProcessInn.$_t$	0.0511	0.0446	0.161	0.311**	-0.160	-0.122
	(0.0774)	(0.0914)	(0.155)	(0.128)	(0.107)	(0.353)
Observations	6,329	5,792	487	4,487	1,529	197
No.ofFirms	1,719	1,586	138	1,244	438	55
	Product-Country Extensive Margin					
	General	Domestic	Foreign	Small	Medium	Large
Tot.R&D$_{t-1}$	0.00296	0.000818	0.00768	0.00447	-0.000331	0.00712
	(0.00315)	(0.00361)	(0.00717)	(0.00497)	(0.00536)	(0.00737)
ProductInn.$_t$	0.00507	-0.00178	-0.0524	0.0816***	0.0640*	0.0760
	(0.0210)	(0.0225)	(0.0645)	(0.0316)	(0.0370)	(0.0542)
ProcessInn.$_t$	0.00119	0.00119	0.0148	0.0484	-0.0465	-0.0808
	(0.0220)	(0.0235)	(0.0665)	(0.0339)	(0.0343)	(0.0654)
Observations	6,329	5,792	487	4,487	1,529	197
No.ofFirms	1,719	1,586	138	1,244	438	55

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The estimator used for the intensive margin and product-country extensive margin of trade is a panel OLS with firm and year fixed-effects, while for country and product extensive margins is a Poisson model with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As unreported control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The first column includes all firms in our sample. In the second column we estimate the effect just for firms which are not part of a foreign business group. Column 3 includes firms that are part of a foreign business group only. Columns 4, 5 and 6 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

Table A.2.10: The impact of innovation on total exports (EAE) and the probability of being an exporter (EAE) for firms in the agriculture and mining industries.

	Agriculture and Mining											
	Total Exports (EAE)						Prob. Exporter (EAE)					
	General	Domestic	Foreign	Small	Medium	Large	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0521	0.0569	0.0258	0.136*	-0.00169	0.00371	-0.0582	-0.0551	-0.0746	-0.0429	-0.117	-0.324
	(0.0414)	(0.0473)	(0.0894)	(0.0732)	(0.0666)	(0.0625)	(0.0814)	(0.0877)	(0.268)	(0.198)	(0.0905)	(0.8945)
$ProductInn._t$	0.0561	0.107	-0.0529	1.019	-1.497	0.202	0.0452	0.0225	0.154	0.0827	0.0294	-0.252
	(0.406)	(0.524)	(0.591)	(0.692)	(1.260)	(0.371)	(0.0785)	(0.0849)	(2.098)	(0.202)	(0.0871)	(0.832)
$ProcessInn._t$	-0.123	-0.179	-0.276	-0.677	0.132	-0.00388	0.0422	0.0436	1.637	-0.0822	0.0697	1.054
	(0.317)	(0.429)	(0.452)	(0.605)	(0.864)	(0.262)	(0.0771)	(0.0832)	(2.224)	(0.215)	(0.0856)	(0.650)
$Tot.Employment_{t-1}$	0.440***	0.247	1.497***	0.130	0.756**	0.0711	0.633	0.367	3.778**	0.462	0.881	-0.342
	(0.143)	(0.158)	(0.313)	(0.192)	(0.310)	(0.854)	(0.641)	(0.700)	(1.895)	(0.995)	(1.343)	(0.916)
$Av.Salary_{t-1}$	0.0739	0.0491	0.00792	-0.0359	0.532	-1.843	-1.350	-1.712	3.244	-2.286	0.269	-0.647
	(0.214)	(0.227)	(0.676)	(0.228)	(0.660)	(1.836)	(1.186)	(1.207)	(5.412)	(1.420)	(2.729)	(1.961)
TFP_{t-1}	0.0924	0.0515	-0.0268	0.0589	0.0642	-1.228**	0.0280	0.0947	0.972	0.0549	-0.0690	-1.091
	(0.104)	(0.115)	(0.241)	(0.112)	(0.368)	(0.551)	(0.564)	(0.577)	(0.830)	(0.660)	(1.546)	(1.369)
$Cash-flow_{t-1}$	0.540*	0.332	0.766	0.634	0.409	2.450	1.044	0.347	0.867*	1.073	-2.111	2.542
	(0.308)	(0.384)	(0.484)	(0.406)	(0.539)	(2.267)	(1.441)	(1.558)	(0.934)	(1.558)	(5.038)	(4.186)
$ForeignGroup_t$	0.410**			0.802***	-0.311	0.0345	1.284			3.204**	-4.109	0.894
	(0.196)			(0.242)	(0.415)	(0.643)	(1.193)			(1.615)	(3.045)	(0.624)
$FrenchGroup_t$	0.155	0.168		0.194*	-0.285	0.163	1.850*	2.599**		3.120**	1.437	0.213
	(0.108)	(0.113)		(0.112)	(0.383)	(0.224)	(0.992)	(1.263)		(1.321)	(1.324)	(1.912)
Observations	2,516	2,233	283	1,970	462	84	451	406	264	332	100	63
No.Firms	484	438	73	404	96	16	71	65	69	56	18	12

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. Agriculture and mining industry includes all sectors with NACE rev.1.1 2-digit code from 01 to 14. The dependent variable in columns 1-6 is total exports (EAE) calculated the log of total foreign sales as reported by firms in the EAE dataset. The estimator used in these columns is a panel OLS with firm and year fixed-effects. The dependent variable in columns 7-12 is the probability of being an exporter, a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The estimator used in these columns is a panel logit with firm and year fixed-effects. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The columns 1 and 7 include all firms in our sample. In the second and eighth columns we estimate the effect just for firms which are not part of a foreign business group. Columns 3 and 9 include firms that are part of a foreign business group only. Columns 4-6 and 10-12 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

Table A.2.11: The impact of innovation on total exports (EAE) and the probability of being an exporter (EAE) for firms in the service industry.

	Services											
	Total Exports (EAE)						Prob. Exporter (EAE)					
	General	Domestic	Foreign	Small	Medium	Large	General	Domestic	Foreign	Small	Medium	Large
$Tot.R\&D_{t-1}$	0.0319***	0.0328***	0.0417	0.0204	0.0373***	0.0143	0.0138	0.00554	0.0390	-0.0415	0.0693**	-0.0275
	(0.00777)	(0.00806)	(0.0385)	(0.0144)	(0.0124)	(0.0217)	(0.0187)	(0.0205)	(0.0547)	(0.0338)	(0.0296)	(0.0521)
$ProductInn._t$	0.271***	0.183**	0.963***	0.434***	0.232**	0.718***	0.121	0.0721	0.632	0.131	-0.172	0.721
	(0.0744)	(0.0770)	(0.366)	(0.129)	(0.116)	(0.229)	(0.182)	(0.199)	(0.581)	(0.320)	(0.297)	(0.586)
$ProcessInn._t$	-0.0195	0.0239	-0.532	-0.189	0.0482	-0.210	-0.196	-0.110	-1.190	-0.491	-0.000378	-0.548
	(0.0729)	(0.0744)	(0.392)	(0.128)	(0.111)	(0.221)	(0.180)	(0.195)	(0.585)	(0.318)	(0.283)	(0.569)
$Tot.Employment_{t-1}$	0.0530***	0.0429***	0.267***	-0.00977	0.113***	0.213***	-0.109***	-0.123***	0.100	-0.302***	0.330***	0.653***
	(0.00849)	(0.00839)	(0.0683)	(0.0106)	(0.0203)	(0.0571)	(0.0210)	(0.0218)	(0.100)	(0.0289)	(0.0535)	(0.139)
$Av.Salary_{t-1}$	0.0472***	0.0461***	-0.0257	0.0194	0.00117	0.107	0.0211	0.0259	-0.203	-0.0113	-0.0820	0.0362
	(0.0107)	(0.0105)	(0.104)	(0.0119)	(0.0284)	(0.0931)	(0.0259)	(0.0265)	(0.148)	(0.0311)	(0.0742)	(0.240)
TFP_{t-1}	0.0631***	0.0553***	0.157*	0.0464***	0.0568**	0.0499	0.0763***	0.0709***	0.112	0.0821***	-0.0462	-0.175
	(0.0103)	(0.0102)	(0.0898)	(0.0111)	(0.0275)	(0.111)	(0.0251)	(0.0259)	(0.133)	(0.0297)	(0.0669)	(0.267)
$Cash-flow_{t-1}$	0.000396	4.18e-05	0.00715	-0.000210	0.0179***	0.00434	-0.000870	-0.0398**	0.0192	-0.0124	0.00496	0.245
	(0.000911)	(0.000900)	(0.00651)	(0.00106)	(0.00598)	(0.0163)	(0.00775)	(0.0176)	(0.0256)	(0.0167)	(0.0115)	(0.349)
$ForeignGroup_t$	0.0884***			0.0670	0.145**	-0.176	-0.221***			-0.0716	-0.400***	-0.903**
	(0.0342)			(0.0477)	(0.0615)	(0.153)	(0.0846)			(0.128)	(0.151)	(0.385)
$FrenchGroup_t$	0.0142	0.0140		-0.0187	0.0320	-0.0956	-0.311***	-0.329***		-0.343***	-0.413***	-0.864***
	(0.0188)	(0.0187)		(0.0234)	(0.0362)	(0.120)	(0.0488)	(0.0510)		(0.0669)	(0.0932)	(0.312)
Observations	259,617	249,377	10,240	172,760	75,335	11,204	70,432	65,996	3,119	43,872	15,811	2,403
No.Firms	99,109	97,196	3,578	75,437	32,826	4,050	18,766	17,932	743	13,054	4,447	512

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. Service industry instead includes all sectors with NACE rev.1.1 2-digit code from 40 to 99. The dependent variable in columns 1-6 is total exports (EAE) calculated the log of total foreign sales as reported by firms in the EAE dataset. The estimator used in these columns is a panel OLS with firm and year fixed-effects. The dependent variable in columns 7-12 is the probability of being an exporter, a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The estimator used in these columns is a panel logit with firm and year fixed-effects. Robust standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The main regressors are the one-year lags of total R&D investment, and of two dummy variables equal to 1 if firm has introduced product or process innovation or 0 otherwise as reported in the R&D survey. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. The columns 1 and 7 include all firms in our sample. In the second and eighth columns we estimate the effect just for firms which are not part of a foreign business group. Columns 3 and 9 include firms that are part of a foreign business group only. Columns 4-6 and 10-12 report the results of the estimation for small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

Table A.2.12: Sensitivity analysis on the choice of R&D variables and their effect on export performance (EAE data).

	Only Tot. R&D		Only Product Inn.		Only Process Inn.		Only R&D Output		All R&D Variables	
	Tot. Exp.	Prob. Exp.	Tot. Exp.	Prob. Exp.	Tot. Exp.	Prob. Exp.	Tot. Exp.	Prob. Exp.	Tot. Exp.	Prob. Exp.
$Tot.R\&D_{t-1}$	0.0134***	0.0673***							0.0174***	0.0747***
	(0.00406)	(0.0250)							(0.00420)	(0.0231)
$ProductInn._t$			0.0659***	0.361**			0.0553*	0.429**	0.0724**	0.400**
			(0.0242)	(0.151)			(0.0310)	(0.196)	(0.0304)	(0.169)
$ProcessInn._t$					0.0533**	0.167	0.0175	-0.110	0.0369	-0.0368
					(0.0250)	(0.154)	(0.0320)	(0.199)	(0.0320)	(0.174)
$Tot.Employment_{t-1}$	0.331***	0.342***	0.332***	0.345***	0.333***	0.346***	0.332***	0.345***	0.628***	0.630***
	(0.0244)	(0.0782)	(0.0243)	(0.0782)	(0.0243)	(0.0781)	(0.0243)	(0.0782)	(0.0231)	(0.0694)
$Av.Salary_{t-1}$	0.0731**	0.139	0.0730**	0.137	0.0726**	0.137	0.0730**	0.136	0.0988***	0.0813
	(0.0344)	(0.105)	(0.0344)	(0.104)	(0.0344)	(0.104)	(0.0344)	(0.105)	(0.0366)	(0.108)
TFP_{t-1}	0.0897***	0.0627	0.0904***	0.0657	0.0904***	0.0651	0.0904***	0.0657	0.140***	0.184***
	(0.0191)	(0.0707)	(0.0191)	(0.0707)	(0.0191)	(0.0707)	(0.0191)	(0.0707)	(0.0177)	(0.0606)
$Cash-flow_{t-1}$	0.106**	-0.0910	0.104**	-0.0914	0.105**	-0.0944	0.104**	-0.0899	0.204***	-0.00379
	(0.0521)	(0.223)	(0.0521)	(0.223)	(0.0521)	(0.223)	(0.0521)	(0.223)	(0.0544)	(0.201)
$ForeignGroup_t$	0.107***	0.191*	0.105***	0.184*	0.105***	0.188*	0.105***	0.184*	0.0950***	0.104
	(0.0287)	(0.111)	(0.0287)	(0.111)	(0.0287)	(0.111)	(0.0287)	(0.111)	(0.0281)	(0.0998)
$FrenchGroup_t$	0.0415**	0.0113	0.0410**	0.0110	0.0412**	0.0116	0.0410**	0.0113	0.0384**	0.00172
	(0.0171)	(0.0524)	(0.0171)	(0.0524)	(0.0171)	(0.0524)	(0.0171)	(0.0524)	(0.0166)	(0.0473)
Observations	152,681	38,573	152,681	38,573	152,681	38,573	152,681	38,573	152,681	38,573
No.Firms	29,467	6,166	29,467	6,166	29,467	6,166	29,467	6,166	29,467	6,166

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The dependent variable for total exports (EAE) is calculated as the log of total foreign sales as reported by firms in the EAE dataset. The estimator used for this dependent variable is a panel OLS with firm and year fixed-effects. The dependent variable for the probability of being an exporter is a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The estimator used for this dependent variable is a panel logit with firm and year fixed-effects. Robust standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. As regressors we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. In columns 1 and 2 we include only an input measure of innovation such as total investment in R&D activities. all firms in our sample. In columns 3-4 and 5-6 we included alternatively only a measure of innovation output, first product and then process innovation. In columns 7-8 we include together both measures of innovation output (product and process innovation) while in the last two columns we report the results of the main estimation, including all measures of innovation input and output.

Table A.2.13: Robustness Checks on R&D variables

	ALL		Drop R&D Outliers		Drop EAE Outliers		Drop All Outliers	
	Tot. Exp.	Prob. Exp.	Tot. Exp.	Prob. Exp	Tot. Exp.	Prob. Exp	Tot. Exp.	Prob. Exp
$Tot.R\&D(EAE)_{t-1}$	0.00823*	0.0200	0.0111**	0.0246	0.0129	0.0392	0.0606***	0.107
	(0.00442)	(0.0161)	(0.00510)	(0.0166)	(0.0101)	(0.0662)	(0.0212)	(0.0878)
$Tot.Employment_{t-1}$	0.620***	0.573***	0.600***	0.542***	0.614***	0.616***	0.592***	0.586***
	(0.0228)	(0.0676)	(0.0248)	(0.0690)	(0.0250)	(0.0757)	(0.0276)	(0.0776)
$Av.Salary_{t-1}$	0.217***	0.148	0.193***	0.123	0.191***	0.153	0.161***	0.128
	(0.0325)	(0.0910)	(0.0348)	(0.0923)	(0.0355)	(0.101)	(0.0384)	(0.103)
TFP_{t-1}	0.185***	0.193***	0.175***	0.196***	0.175***	0.155**	0.167***	0.154**
	(0.0180)	(0.0589)	(0.0204)	(0.0608)	(0.0197)	(0.0687)	(0.0231)	(0.0712)
$Cash-flow_{t-1}$	0.181***	0.0868	0.280***	0.148	0.121**	-0.0922	0.220***	0.0197
	(0.0488)	(0.157)	(0.0627)	(0.163)	(0.0539)	(0.215)	(0.0752)	(0.222)
$ForeignGroup_t$	0.110***	0.153	0.113***	0.156	0.111***	0.155	0.119***	0.158
	(0.0271)	(0.0985)	(0.0302)	(0.102)	(0.0297)	(0.107)	(0.0337)	(0.111)
$FrenchGroup_t$	0.0492***	0.0199	0.0404**	0.00689	0.0464***	0.0131	0.0361*	0.000122
	(0.0163)	(0.0466)	(0.0173)	(0.0473)	(0.0177)	(0.0508)	(0.0189)	(0.0516)
Observations	172,521	42,582	156,739	38,573	157,228	39,036	152,681	38,573
No.Firms	31,636	6,751	30,435	6,166	30,736	6,614	29,467	6,166

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. The dependent variable for total exports (EAE) is calculated as the log of total foreign sales as reported by firms in the EAE dataset. The estimator used for this dependent variable is a panel OLS with firm and year fixed-effects. The dependent variable for the probability of being an exporter is a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The estimator used for this dependent variable is a panel logit with firm and year fixed-effects. Robust standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The main regressor is total R&D investment as reported by firms in the EAE dataset and is lagged one year. As control variables we included total employment as the log of the numbers of employees, average salary is the log of wage per employee calculated as the ratio of total labour cost over total number of employees, TFP is the log of the total factor productivity calculated following the De Loecker (2007) approach, cash-flow calculated as the ratio between firm net income and total sales, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, TFP and cash-flow are lagged one year while foreign and French group dummies refer to time t like the dependent variable. In columns 1 and 2 we report the results for all the firms included in our initial sample. In columns 3-4 instead we drop the *R&D outliers* defined as observations included in the R&D survey but reporting zero investment in R&D in the EAE dataset. Column 5-6 report the results of the estimation excluding the *EAE outliers* defined as firms reporting positive investment in innovative activities in the EAE dataset but not included in the R&D survey. Finally, in columns 7-8 we exclude all the previously defined outliers, presenting the results of the estimation of the effect of R&D investment on the export performance of our final sample but using as main regressor total R&D investment as reported by firms in the EAE dataset.

Table A.2.14: Impact of innovation on firms' export performance - Random-effects estimations.

	(1) Tot.Exports (EAE)	(2) Prob.Exporter	(3) Tot.Exports (CA)	(4) Intensive Margin	(5) Country Ext.	(6) Product Ext.	(7) Prod-Cod. Ext.
$Tot.R\&D_{t-1}$	0.0468***	0.103***	0.0169***	-0.00611	0.0039***	0.0004	0.00315***
	(0.00481)	(0.0101)	(0.004)	(0.004)	(0.0006)	(0.0006)	(0.000639)
$ProductInn._t$	0.176***	0.505***	0.0442	0.0415	0.0013***	0.023***	0.0171***
	(0.0374)	(0.0819)	(0.0375)	(0.0325)	(0.004)	(0.004)	(0.00488)
$ProcessInn._t$	0.0702*	0.0702	0.0640	-0.0214	0.0041	0.0046	0.0033
	(0.0395)	(0.0863)	(0.0395)	(0.0339)	(0.0048)	(0.0046)	(0.00515)
$Tot.Employment_{t-1}$	0.1417***	0.743***	1.644***	-0.00412	0.328***	0.400***	0.178***
	(0.0198)	(0.0208)	(0.0311)	(0.0034)	(0.004)	(0.004)	(0.00307)
$Av.Salary_{t-1}$	1.083***	0.851***	1.100***	0.156***	0.181***	0.221***	0.143***
	(0.0399)	(0.0445)	(0.0526)	(0.0255)	(0.009)	(0.008)	(0.00647)
TFP_{t-1}	0.298***	0.238***	0.203***	0.0630***	0.0329***	0.0134***	0.0144***
	(0.0228)	(0.0307)	(0.0262)	(0.0195)	(0.004)	(0.003)	(0.0031)
$Cash-flow_{t-1}$	0.134*	-0.0675	0.195**	0.275***	0.0205	0.102***	0.0337***
	(0.0694)	(0.103)	(0.0826)	(0.0675)	(0.0134)	(0.0133)	(0.00997)
$ForeignGroup_t$	0.532***	0.538***	0.279***	-0.0325*	0.0494***	0.0456***	0.0448***
	(0.0333)	(0.0427)	(0.0407)	(0.0188)	(0.0067)	(0.0066)	(0.0048)
$FrenchGroup_t$	0.153***	0.0954***	0.122***	0.0137	0.0421***	0.0376***	0.0194***
	(0.0210)	(0.0234)	(0.0271)	(0.0140)	(0.005)	(0.005)	(0.00301)
Observations	152,681	152,681	102,894	102,894	102,894	102,894	102,894
No.Firms	29,467	29,467	21,832	21,832	21,832	21,832	21,832

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The dependent variable for total exports (EAE) is calculated as the log of total foreign sales as reported by firms in the EAE dataset. The dependent variable for the probability of being an exporter is a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The dependent variables total exports (CA), intensive margin, country, product and product-country extensive margins have been built as previously described using the Custom Agency data. Panel tobit model with random-effects used for total exports, the intensive and the product-country extensive margin of trade in columns 1, 3, 4 and 7. Panel probit model with random-effects used for the probability of being an exporter in column 2. Panel Poisson estimator with random-effects used for country and product extensive margins in columns 5 and 6. Unreported year and industry (NACE rev.1, 2-digit) dummies are included. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.15: Impact of innovation on firms' export performance - GMM estimations.

	(1) Tot.Exports (EAE)	(2) Prob.Exporter	(3) Tot.Exports (CA)	(4) Intensive Margin	(5) Country Ext.	(6) Product Ext.	(7) Prod-Cod. Ext.
$TotalR\&D_{t-1}$	0.0118***	0.00117***	0.0142***	0.00138	0.00721***	-0.00175	0.0002
	(0.00348)	(0.000360)	(0.00382)	(0.00166)	(0.00260)	(0.0294)	(0.0006)
$ProductInnovation_t$	0.0661**	0.0129***	0.167***	0.00227	0.105	0.701**	0.0100**
	(0.0294)	(0.00327)	(0.0340)	(0.0156)	(0.164)	(0.305)	(0.00478)
$ProcessInnovation_t$	0.0694**	-0.000799	0.0649**	0.0210	-0.237	-0.0402	0.00920**
	(0.0312)	(0.00350)	(0.0327)	(0.0155)	(0.174)	(0.298)	(0.00467)
$Tot.Employment_{t-1}$	1.382***	0.0685***	2.012***	0.470***	7.395***	9.907***	0.0367***
	(0.0198)	(0.00226)	(0.0373)	(0.0116)	(0.209)	(0.405)	(0.00152)
$Av.Salary_{t-1}$	2.128***	0.158***	4.065***	0.493***	11.96***	13.64***	0.0655***
	(0.0535)	(0.00678)	(0.116)	(0.0351)	(0.470)	(0.799)	(0.0053)
TFP_{t-1}	0.617***	0.0333***	1.388***	0.400***	1.801***	1.354***	0.00604*
	(0.0319)	(0.00378)	(0.0633)	(0.0217)	(0.237)	(0.415)	(0.00312)
$Cashflow_{t-1}$	-0.200**	-0.00963	-0.210	-0.375***	2.870***	2.411	0.0318**
	(0.0801)	(0.00968)	(0.157)	(0.0784)	(1.044)	(1.529)	(0.0125)
$ForeignGroup_t$	1.159***	0.0745***	1.891***	0.569***	1.228***	-0.234	0.0182***
	(0.0455)	(0.00540)	(0.0925)	(0.0286)	(0.344)	(0.549)	(0.0029)
$FrenchGroup_t$	0.252***	0.0238***	0.719***	0.0773***	0.975***	0.900***	0.0102***
	(0.0284)	(0.00410)	(0.0698)	(0.0196)	(0.182)	(0.281)	(0.00208)
$Observations$	152,681	152,681	102,894	102,894	102,894	102,894	102,894
$NumberofFirms$	29,467	29,467	21,832	21,832	21,832	21,832	21,832
$AR(2)$	0.20	0.10	0.25	0.03	-	-	0.68
$Hansen$	0.027	0.183	0.263	0.472	0.265	0.102	0.753

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. The dependent variable for total exports (EAE) is calculated as the log of total foreign sales as reported by firms in the EAE dataset. The dependent variable for the probability of being an exporter is a dummy variable equal to 1 if firm reports positive foreign sales in the EAE dataset and 0 otherwise. The dependent variables total exports (CA), intensive margin, country, product and product-country extensive margins have been built as previously described using the Custom Agency data. Panel system GMM estimation used in all the specifications instrumenting the possible endogenous variables (total R&D, product innovation and process innovation) with their three-periods lagged values plus the total amount of public resources received to support R&D activities. We consider the variables measuring innovation as predetermined and therefore not correlated with the error term but expected to influence firm's export performance. AR(2) and Hansen test reported to evaluate the overall goodness of fit of the GMM model except for the GMM poisson model (columns 5 and 6) in which the AR(2) is not provided by the statistical software. Unreported year and industry (NACE rev.1, 2-digit) dummies are included. Robust standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.16: Summary statistics for firms in different treatment groups.

	Only R&D Investment (No. Firms: 586)		**Product Innovation** (No. Firms: 825)		**Process Innovation** (No. Firms: 407)		**Prod. and Proc. Inn.** (No. Firms: 1,817)		**Non-Innovators** (No. Firms: 31,714)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Tot. Employment	224.56	638.00	225.02	339.46	218.35	361.40	369.99	914.54	79.47	544.54
Av. Salary	26,819	12,257	27,644	7,825	26,757	7,406	28,629	14,336	24,415	10,466
log(TFP)	4.696	0.656	4.792	0.666	4.632	0.697	4.790	0.698	4.336	0.587
Tot. Sales (EUR th.)	67,039	243,151	62,340	145,456	60,525	157,702	117,202	825,420	19,377	298,042
Cash-flow	0.051	0.083	0.048	0.098	0.044	0.118	0.052	0.098	0.025	0.116
Tot. Investment (EUR th.)	1,898	8,413	1,748	6,727	1,883	4,689	3,749	26,153	586	14,829
R&D Intensity	3.12%	7.33	3.34%	5.13	3.49%	11.51	4.51%	9.74	0.00%	0.00
Export Intensity	27.69%	26.76	29.22%	26.53	28.66%	28.10	32.75%	27.14	12.93%	21.39
Tot. Exports (EUR th.)	16,700	56,600	17,600	69,200	25,900	95,400	43,900	374,000	6,318	72,700
Intensive Margin	246,362	725,635	208,271	558,665	482,406	216,250	264,797	522,694	163,785	805,564
Country Ext. Margin	20.01	18.80	23.16	19.54	18.57	18.53	27.18	23.51	10.39	13.00
Product Ext. Margin	20.52	25.98	22.31	28.93	18.85	35.80	29.09	41.74	11.62	20.50
Product-Country Ext. Margin	3.17	3.20	3.23	3.84	2.75	3.18	3.40	3.23	2.63	3.08
Sh. Exporters	91.63%	27.70	93.81%	24.09	91.64%	27.70	95.21%	21.35	66.22%	47.29
Sh. French Group	58.87%	49.24	54.54%	49.82	57.24%	49.53%	54.04%	49.84	40.14%	49.02%
Sh. Foreign Group	25.59%	43.67	31.15%	46.33	26.78%	44.33	33.02%	47.04	11.55%	31.96

Note: statistics based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. Mean and standard deviation reported for each variable. The different categories denote firms that for the first time have invested in R&D, or introduced a product innovation, a process innovation, have jointly introduced a product and a process innovation or have never performed any R&D activity. Employment is the average number of full-time employees (EAE data). Average salary annual salary of full-time employees in Euro (EAE data). Total sales calculated as average total sales (domestic+foreign) in thousand of Euro (EAE data). Total investment calculated as average of firm total investment in fixed tangible assets in thousand of Euro (EAE data). Productivity calculated as log of total factor productivity following the De Loecker (2007) approach (EAE data). Cash-flow calculated as the ratio between firm net income and total sales (EAE data). Export intensity calculated as the ratio of firm total exports over total sales (EAE data). Foreign and French group are dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise (EAE data). R&D intensity calculated as average ratio of firms total investment in R&D over total sales (R&D Survey data). Total exports (CA) includes data on all intra-EU shipments over € 100,000 and extra-EU over € 1,000 collected by the French Custom Agency in thousand of Euro. Intensive Margin calculated as average value of firms shipments abroad (CA data). Product extensive margin calculated as average number of products exported by French firms each year (CA data). Country extensive margin calculated as average number of foreign markets served by French firms each year (CA data). Product-Country extensive margin is the average number of products exported to each foreign market by French firms each year (CA data). All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline.

Table A.2.17: Impact of innovation on firm's export performance - ATT effects with nearest-neighbour matching.

	Total Exports (EAE)			**Prob. Exporting**		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.229***	0.263***	0.560***	0.0455***	0.0513***	0.0642***
b.s.e.	(0.0771)	(0.0968)	(0.126)	(0.0112)	(0.0131)	(0.0159)
Treated	585	472	352	585	472	352
Untreated	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator					
ATT	0.243***	0.270***	0.548***	0.0376***	0.0442***	0.0745***
b.s.e.	(0.0617)	(0.0799)	(0.0930)	(0.00925)	(0.0112)	(0.0123)
Treated	819	665	545	819	665	545
Untreated	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator					
ATT	0.171*	0.176	0.258*	0.0379***	0.0381**	0.0119
b.s.e.	(0.0917)	(0.119)	(0.151)	(0.0138)	(0.0173)	(0.0216)
Treated	406	315	236	406	315	236
Untreated	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator					
ATT	0.220***	0.222***	0.310***	0.0367***	0.0318***	0.0392***
b.s.e.	(0.0541)	(0.0638)	(0.0767)	(0.00816)	(0.00899)	(0.0107)
Treated	1811	1492	1200	1811	1492	1200
Untreated	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Table A.2.18: Impact of innovation on firm's total exports (CA) and intensive margin - ATT effects with nearest-neighbour matching.

	Total Exports (CA)			**Intensive Margin**		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.239**	0.508***	0.750***	0.235***	0.442***	0.601***
b.s.e.	(0.0957)	(0.111)	(0.140)	(0.0843)	(0.0972)	(0.123)
Treated	468	374	275	468	374	275
Untreated	16907	16907	14462	16907	16907	14462
	Product Innovation vs Non-innovator					
ATT	0.0790	0.310***	0.574***	0.134*	0.265***	0.450***
b.s.e.	(0.0790)	(0.101)	(0.122)	(0.0699)	(0.0863)	(0.104)
Treated	668	530	443	668	530	443
Untreated	16907	16907	14462	16907	16907	14462
	Process Innovation vs Non-Innovator					
ATT	0.0448	0.0439	0.523***	0.105	0.101	0.442***
b.s.e.	(0.123)	(0.168)	(0.185)	(0.112)	(0.148)	(0.156)
Treated	314	236	178	314	236	178
Untreated	16907	16907	14462	16907	16907	14462
	Product & Process Innovation vs Non-Innovator					
ATT	0.0541	0.223**	0.507***	0.0840	0.223***	0.434***
b.s.e.	(0.0720)	(0.0893)	(0.124)	(0.0651)	(0.0801)	(0.110)
Treated	1485	1221	995	1485	1221	995
Untreated	16907	16907	14462	16907	16907	14462

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the intensive margin of trade have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Table A.2.19: Impact of innovation on firm's extensive margins - ATT effects with nearest-neighbour matching.

	Country Ext. Margin			Product Ext. Margin			Prod-Cod. Ext. Margin		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator								
ATT	-0.0799	0.184	0.987**	-0.232	0.965	0.644	0.0135	0.0412**	0.0583**
b.s.e.	(0.204)	(0.325)	(0.472)	(0.422)	(0.597)	(0.909)	(0.0158)	(0.0186)	(0.0258)
Treated	468	374	275	468	374	275	468	374	275
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Product Innovation vs Non-innovator								
ATT	0.0126	0.989***	1.849***	0.0956	1.127***	2.159***	-0.00830	0.0366**	0.0625***
b.s.e.	(0.230)	(0.328)	(0.440)	(0.362)	(0.446)	(0.590)	(0.0136)	(0.0160)	(0.0194)
Treated	668	530	443	668	530	443	668	530	443
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Process Innovation vs Non-Innovator								
ATT	0.0318	0.459	1.735***	-0.864*	-1.058	0.142	-0.0127	-0.0331	0.00266
b.s.e.	(0.242)	(0.407)	(0.597)	(0.461)	(0.697)	(0.889)	(0.0172)	(0.0214)	(0.0272)
Treated	314	236	178	314	236	178	314	236	178
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462
	Product & Process Innovation vs Non-Innovator								
ATT	0.0403**	0.268	1.265***	-0.284	0.588	0.260	0.00570	0.0458***	0.0563***
b.s.e.	(0.172)	(0.240)	(0.351)	(0.401)	(0.514)	(0.722)	(0.0116)	(0.0124)	(0.0156)
Treated	1485	1221	995	1485	1221	995	1485	1221	995
Untreated	16907	16907	14462	16907	16907	14462	16907	16907	14462

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables country and product extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Table A.2.20: Impact of innovation on firm's export performance - ATT effects with nearest-neighbour matching for small, medium and large firms.

	Small Firms						Medium Firms						Large Firms					
	Total Exports (EAE)			Prob. Exporting			Total Exports (EAE)			Prob. Exporting			Total Exports (EAE)			Prob. Exporting		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator																	
ATT	0.0531	-0.0782	0.0636	0.0165	0.0265	0.0384**	0.107	0.257*	0.367**	0.0229	0.0441**	0.0384*	0.139	-0.0217	0.0548	0.00159	-0.00734	-0.0193
b.s.e.	(0.0942)	(0.135)	(0.145)	(0.0125)	(0.0164)	(0.0161)	(0.115)	(0.135)	(0.177)	(0.0163)	(0.0170)	(0.0225)	(0.170)	(0.195)	(0.289)	(0.0186)	(0.0194)	(0.0298)
Treated	158	113	73	158	113	73	271	227	177	271	227	177	126	119	83	126	119	83
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator																	
ATT	-0.00301	0.0306	0.182	0.0148	0.00882	0.0327**	0.238***	0.282**	0.304**	0.0312**	0.0587***	0.0701***	0.0393	0.0114	0.316*	-0.00498	-0.0247	-0.0152
b.s.e.	(0.0838)	(0.119)	(0.142)	(0.00930)	(0.0118)	(0.0157)	(0.0907)	(0.116)	(0.136)	(0.0129)	(0.0154)	(0.0175)	(0.0888)	(0.118)	(0.177)	(0.0108)	(0.0161)	(0.0184)
Treated	176	136	104	176	136	104	404	327	271	404	327	271	201	170	145	201	170	145
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator																	
ATT	0.0431	0.106	0.246	0.0238	-0.00370	0.00526	0.135	0.143	0.285	0.0180	0.0128	-0.00826	0.114	0.0453	0.0750	0.00460	0.0158	0.00303
b.s.e.	(0.132)	(0.180)	(0.254)	(0.0197)	(0.0342)	(0.0308)	(0.148)	(0.181)	(0.235)	(0.0229)	(0.0248)	(0.0373)	(0.124)	(0.179)	(0.218)	(0.0130)	(0.0224)	(0.0237)
Treated	84	54	38	84	54	38	200	156	121	200	156	121	87	76	66	87	76	66
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator																	
ATT	0.0185	0.205**	0.0749	0.0149**	0.0344***	0.0310***	0.147*	0.242***	0.350***	0.0203*	0.0354***	0.0492***	-0.0188	-0.157	-0.0224	-0.00841	-0.0260	-0.0236
b.s.e.	(0.0595)	(0.0717)	(0.0925)	(0.00643)	(0.00891)	(0.0112)	(0.0741)	(0.0857)	(0.106)	(0.0109)	(0.0118)	(0.0143)	(0.0981)	(0.125)	(0.165)	(0.0124)	(0.0153)	(0.0194)
Treated	362	285	213	362	285	213	788	649	524	788	649	524	571	485	407	571	485	407
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. ATT effects are reported for the export performance of firms in three different sub-samples: small (employees $<$ 50, turnover $\leq$ EUR 10 million), medium (employees $\leq$ 250, turnover $\leq$ EUR 50 million) and large firms (employees $>$ 250, turnover $>$ EUR 2 million).

Table A.2.21: Impact of innovation on firm's export performance - ATT effects with nearest-neighbour matching for domestic and foreign firms.

	Domestic Firms						**Foreign Firms**					
	Total Exports (EAE)			**Prob. Exporting**			**Total Exports (EAE)**			**Prob. Exporting**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator											
ATT	0.307***	0.306***	0.596***	0.0510***	0.0645***	0.0859***	0.0320	0.135	0.259	-0.00267	-0.00156	-0.00777
b.s.e.	(0.0932)	(0.113)	(0.143)	(0.0147)	(0.0166)	(0.0204)	(0.183)	(0.204)	(0.277)	(0.0207)	(0.0201)	(0.0289)
Treated	435	344	249	435	344	249	150	128	103	150	128	103
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product Innovation vs Non-innovator											
ATT	0.298***	0.323***	0.706***	0.0544***	0.0627***	0.0995***	0.150	0.292**	0.240	0.0218	0.0358**	0.0205
b.s.e.	(0.0830)	(0.0953)	(0.108)	(0.0131)	(0.0141)	(0.0153)	(0.112)	(0.147)	(0.176)	(0.0147)	(0.0158)	(0.0177)
Treated	566	456	370	566	456	370	257	212	176	257	212	176
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Process Innovation vs Non-Innovator											
ATT	0.305**	0.319**	0.584***	0.0517***	0.0369*	0.0548**	-0.0771	-0.129	-0.270	-0.00374	0.0109	-0.0203
b.s.e.	(0.118)	(0.149)	(0.184)	(0.0183)	(0.0221)	(0.0277)	(0.180)	(0.173)	(0.265)	(0.0231)	(0.0202)	(0.0309)
Treated	298	222	168	298	222	168	107	92	69	107	92	69
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999
	Product & Process Innovation vs Non-Innovator											
ATT	0.300***	0.369***	0.530***	0.0509***	0.0580***	0.0834***	-0.00868	0.100	0.0244	0.00100	0.00596	-0.00382
b.s.e.	(0.0689)	(0.0721)	(0.0866)	(0.0108)	(0.0104)	(0.0125)	(0.0931)	(0.109)	(0.138)	(0.0115)	(0.0128)	(0.0158)
Treated	1215	990	782	1215	990	782	599	503	419	599	503	419
Untreated	22849	22849	19999	22849	22849	19999	22849	22849	19999	22849	22849	19999

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. ATT effects are reported for the export performance of firms in two different sub-samples: domestic firms and enterprises affiliated to foreign business groups.

Table A.2.22: Impact of innovation on firm's trade margins - ATT effects with nearest-neighbour matching for small firms.

	Small Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.431**	0.388	0.513**	0.460**	0.374*	0.403*	0.0930	0.441	1.247*	0.287	0.100	0.611	-0.00522	0.0343*	0.0479**
b.s.e.	(0.202)	(0.250)	(0.247)	(0.178)	(0.222)	(0.220)	(0.315)	(0.398)	(0.671)	(0.525)	(0.780)	(1.180)	(0.0152)	(0.0183)	(0.0231)
Treated	157	112	73	157	112	73	157	112	73	157	112	73	157	112	73
Untreated	11196	11196	9353	11196	11196	9353	11196	11196	9353	11196	11196	9353	11196	11196	9353
	Product Innovation vs Non-innovator														
ATT	0.179	0.333	0.918***	0.251	0.263	0.766***	-0.460	0.600	1.692***	0.166	0.709	0.940	0.0383	0.0333	0.0415
b.s.e.	(0.181)	(0.207)	(0.248)	(0.163)	(0.183)	(0.226)	(0.309)	(0.456)	(0.615)	(0.496)	(0.600)	(0.669)	(0.0284)	(0.0345)	(0.0411)
Treated	176	136	104	176	136	104	176	136	104	176	136	104	176	136	104
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353
	Process Innovation vs Non-Innovator														
ATT	0.401*	0.449	0.440	0.414*	0.429	0.316	-0.0548	1.011	2.384**	0.488	0.374	0.521	0.0106	0.0165	0.0717*
b.s.e.	(0.231)	(0.392)	(0.377)	(0.214)	(0.362)	(0.329)	(0.424)	(0.712)	(1.161)	(0.424)	(0.836)	(1.152)	(0.0267)	(0.0311)	(0.0408)
Treated	84	54	38	84	54	38	84	54	38	84	54	38	84	54	38
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353
	Product & Process Innovation vs Non-Innovator														
ATT	0.363***	0.604***	0.702***	0.378***	0.530***	0.492***	0.0569	0.347	1.434***	-0.00939	0.734*	2.156***	0.0518*	0.0428	0.0588
b.s.e.	(0.116)	(0.129)	(0.184)	(0.106)	(0.120)	(0.165)	(0.222)	(0.313)	(0.455)	(0.289)	(0.442)	(0.653)	(0.0290)	(0.0381)	(0.0469)
Treated	362	285	213	362	285	213	362	285	213	362	285	213	362	285	213
Untreated	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353	11,196	11,196	9,353

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of small firms (employees < 50, turnover $\leq$ EUR 10 million).

Table A.2.23: Impact of innovation on firm's trade margins - ATT effects with nearest-neighbour matching for medium firms.

	Medium Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.105	0.469***	0.634***	0.0711	0.349**	0.466**	0.294	0.609	1.015*	0.945	1.941***	1.470**	0.0272	0.0712***	0.107***
b.s.e.	(0.125)	(0.159)	(0.203)	(0.112)	(0.141)	(0.180)	(0.325)	(0.475)	(0.606)	(0.592)	(0.740)	(0.643)	(0.0178)	(0.0223)	(0.0270)
Treated	220	180	134	220	180	134	220	180	134	220	180	134	220	180	134
Untreated	4867	4867	4368	4867	4867	4368	4867	4867	4368	4867	4867	4368	4867	4867	4368
	Product Innovation vs Non-innovator														
ATT	0.197*	0.593***	0.859***	0.188*	0.490***	0.644***	0.354	1.560***	2.296***	0.655	0.930	1.774**	0.0117	0.0573**	0.0644*
b.s.e.	(0.115)	(0.158)	(0.196)	(0.102)	(0.132)	(0.162)	(0.352)	(0.495)	(0.654)	(0.473)	(0.604)	(0.807)	(0.0207)	(0.0268)	(0.0393)
Treated	323	255	215	323	255	215	323	255	215	323	255	215	323	255	215
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368
	Process Innovation vs Non-Innovator														
ATT	0.0676	-0.0397	0.541*	0.106	0.0210	0.463*	-0.0667	0.349	1.293	-0.928	-1.748	-0.884	0.00599	0.0506**	0.0984***
b.s.e.	(0.202)	(0.256)	(0.311)	(0.185)	(0.220)	(0.259)	(0.356)	(0.555)	(0.834)	(0.699)	(0.997)	(1.236)	(0.0172)	(0.0240)	(0.0281)
Treated	159	122	90	159	122	90	159	122	90	159	122	90	159	122	90
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368
	Product & Process Innovation vs Non-Innovator														
ATT	0.0924	0.480***	0.565***	0.0886	0.396***	0.425***	0.179	0.688**	1.378***	0.367	0.474	1.482**	-0.000145	-0.0647	-0.00535
b.s.e.	(0.091)	(0.121)	(0.156)	(0.080)	(0.107)	(0.135)	(0.239)	(0.322)	(0.440)	(0.412)	(0.515)	(0.674)	(0.0251)	(0.0415)	(0.0377)
Treated	632	518	425	632	518	425	632	518	425	632	518	425	632	518	425
Untreated	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368	4,867	4,867	4,368

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of medium firms (employees ≤ 250, turnover $\leq$ EUR 50 million).

Table A.2.24: Impact of innovation on firm's trade margins - ATT effects with nearest-neighbour matching for large firms.

	Large Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	-0.490	-0.0221	0.308	-0.364	-0.00967	0.176	-0.104	1.244	2.797**	-2.253	0.242	1.665	-0.0554	-0.0549	0.0194
b.s.e.	(0.321)	(0.242)	(0.313)	(0.286)	(0.183)	(0.246)	(0.531)	(1.025)	(1.314)	(1.347)	(2.198)	(2.903)	(0.0339)	(0.0390)	(0.0480)
Treated	90	81	68	90	81	68	90	81	68	90	81	68	90	81	68
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Product Innovation vs Non-innovator														
ATT	-0.399	-0.183	-0.0979	-0.263	-0.113	0.0284	-0.130	0.996	0.252	-1.967	-1.545	-3.631	0.0973***	0.0675**	0.0749**
b.s.e.	(0.334)	(0.182)	(0.193)	(0.217)	(0.155)	(0.160)	(0.564)	(0.753)	(0.931)	(1.303)	(1.533)	(2.057)	(0.0254)	(0.0283)	(0.0352)
Treated	168	139	124	168	139	124	168	139	124	168	139	124	168	139	124
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Process Innovation vs Non-Innovator														
ATT	-0.0812	0.0789	0.0850	-0.0471	0.212	0.125	0.749	0.393	1.698	-1.349	-2.400	-1.063	-0.0340	-0.0599	-0.0484
b.s.e.	(0.106)	(0.156)	(0.213)	(0.098)	(0.142)	(0.196)	(0.608)	(0.991)	(1.210)	(1.382)	(2.215)	(2.594)	(0.0244)	(0.0330)	(0.0440)
Treated	71	51	59	71	51	59	71	51	59	71	51	59	71	51	59
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741
	Product & Process Innovation vs Non-Innovator														
ATT	-0.270	-0.114	-0.122	-0.217	-0.0647	-0.0934	0.360	0.641	1.620**	1.039	1.427	0.172	0.0415**	0.0259	-0.0219
b.s.e.	(0.203)	(0.138)	(0.188)	(0.187)	(0.117)	(0.156)	(0.414)	(0.571)	(0.759)	(1.033)	(1.445)	(1.886)	(0.0194)	(0.0235)	(0.0305)
Treated	491	419	357	491	419	357	491	419	357	491	419	357	491	419	357
Untreated	844	844	741	844	844	741	844	844	741	844	844	741	844	844	741

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of large firms (employees > 250, turnover > EUR 2 million).

Table A.2.25: Impact of innovation on firm's trade margins - ATT effects with nearest-neighbour matching for domestic firms.

	Domestic Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.119	0.427***	0.761***	0.139	0.374***	0.608***	0.255	0.661**	1.206***	0.231	0.509	0.713	0.0259*	0.0448***	0.0892***
b.s.e.	(0.134)	(0.145)	(0.176)	(0.120)	(0.129)	(0.159)	(0.223)	(0.301)	(0.451)	(0.442)	(0.697)	(1.018)	(0.0135)	(0.0148)	(0.0176)
Treated	361	280	199	361	280	199	361	280	199	361	280	199	361	280	199
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Product Innovation vs Non-innovator														
ATT	0.0391	0.340***	0.897***	0.123	0.311***	0.754***	0.329	1.206***	2.236***	-0.400	0.167	0.369	0.0278	0.0804**	0.120**
b.s.e.	(0.109)	(0.127)	(0.151)	(0.096)	(0.110)	(0.131)	(0.265)	(0.374)	(0.494)	(0.454)	(0.519)	(0.630)	(0.0273)	(0.0361)	(0.0516)
Treated	462	362	301	462	362	301	462	362	301	462	362	301	462	362	301
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Process Innovation vs Non-Innovator														
ATT	0.324**	0.371*	0.744***	0.358**	0.382*	0.575***	0.193	0.771*	2.224***	-0.729	-1.361	-0.245	0.000205	0.0450	0.0242
b.s.e.	(0.162)	(0.228)	(0.236)	(0.149)	(0.202)	(0.204)	(0.276)	(0.426)	(0.650)	(0.551)	(0.889)	(1.195)	(0.0193)	(0.0288)	(0.0334)
Treated	221	159	124	221	159	124	221	159	124	221	159	124	221	159	124
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689
	Product & Process Innovation vs Non-Innovator														
ATT	0.173*	0.412***	0.665***	0.163**	0.349***	0.480***	0.175	0.752***	1.539***	0.572	1.339***	1.754***	0.0771***	0.0962***	0.0709
b.s.e.	(0.089)	(0.096)	(0.122)	(0.080)	(0.086)	(0.108)	(0.185)	(0.245)	(0.336)	(0.395)	(0.507)	(0.638)	(0.0231)	(0.0308)	(0.0412)
Treated	990	804	639	990	804	639	990	804	639	990	804	639	990	804	639
Untreated	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689	14900	14900	12689

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of domestic firms not affiliated to foreign-owned groups.

Table A.2.26: Impact of innovation on firm's trade margins - ATT effects with nearest-neighbour matching for foreign firms.

	Foreign Firms														
	Total Exports (CA)			**Intensive Margin**			**Country Extensive Margin**			**Product Extensive Margin**			**Prod-Cod. Extensive Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator														
ATT	0.113	0.453**	0.612**	0.0836	0.309*	0.406**	0.145	0.866	1.634	1.166	3.334***	4.724***	0.0147	0.0352	0.0641**
b.s.e.	(0.119)	(0.205)	(0.243)	(0.103)	(0.159)	(0.188)	(0.484)	(0.931)	(1.191)	(0.899)	(1.119)	(1.761)	(0.0183)	(0.0221)	(0.0285)
Treated	106	94	76	106	94	76	106	94	76	106	94	76	106	94	76
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Product Innovation vs Non-innovator														
ATT	0.119	0.347**	0.434**	0.135	0.222	0.333**	-0.0322	1.462**	0.999	-0.0478	1.132	-0.351	0.0147	0.0352	0.0641**
b.s.e.	(0.128)	(0.167)	(0.196)	(0.110)	(0.137)	(0.159)	(0.454)	(0.641)	(0.813)	(0.853)	(1.091)	(1.558)	(0.0183)	(0.0221)	(0.0285)
Treated	205	168	142	205	168	142	205	168	142	205	168	142	205	168	142
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Process Innovation vs Non-Innovator														
ATT	-0.252	-0.153	0.127	-0.158	-0.00219	0.190	0.462	0.730	1.996	-1.445	-0.943	1.593	-0.0245	0.0161	0.0694***
b.s.e.	(0.191)	(0.167)	(0.237)	(0.174)	(0.129)	(0.172)	(0.492)	(0.899)	(1.288)	(0.984)	(1.263)	(2.088)	(0.0169)	(0.0186)	(0.0229)
Treated	93	77	55	93	77	55	93	77	55	93	77	55	93	77	55
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773
	Product & Process Innovation vs Non-Innovator														
ATT	0.0310	0.231**	0.291**	0.0424	0.206**	0.250**	0.398	0.423	0.956	0.624	1.024	1.357	0.0175	-0.00613	0.0434
b.s.e.	(0.088)	(0.103)	(0.144)	(0.078)	(0.088)	(0.121)	(0.332)	(0.474)	(0.622)	(0.642)	(0.878)	(1.212)	(0.0219)	(0.0263)	(0.0313)
Treated	495	417	356	495	417	356	495	417	356	495	417	356	495	417	356
Untreated	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773	2007	2007	1773

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score applying a nearest neighbour matching 1-to-1 procedure without replacement. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables total exports (CA), intensive and extensive margins have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible treatments of investing in R&D (*R&D*), introducing a product innovation (*Pd*), a process innovation (*Pc*) or to jointly introduce a product and a process innovation (*PdPc*) against not having innovated at all for the following three years after the treatment. The ATT effects reported in this table just refer to the export performance of firms affiliated to a foreign-owned group.

Table A.2.27: Impact of innovation on firm's export performance (EAE) - single treatment ATT effects with Kernel matching.

	Total Exports (EAE)			Prob. Exporting (EAE)		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.133**	0.105	0.334***	0.0238**	0.0307**	0.0330*
b.s.e.	(0.0648)	(0.0781)	(0.107)	(0.0111)	(0.0127)	(0.0175)
Treated	1282	1211	942	1282	1211	942
Untreated	24726	24726	21692	24726	24726	21692
	Product Innovation vs Non-innovator					
ATT	0.247***	0.263***	0.382***	0.0416***	0.0418***	0.0484***
b.s.e.	(0.0547)	(0.0663)	(0.0782)	(0.00914)	(0.0107)	(0.0120)
Treated	1127	1082	887	1127	1082	887
Untreated	25060	25060	22000	25060	25060	22000
	Process Innovation vs Non-innovator					
ATT	0.157**	0.174*	0.210*	0.0324**	0.0354**	0.0166
b.s.e.	(0.0755)	(0.0899)	(0.113)	(0.0119)	(0.0138)	(0.0167)
Treated	527	485	378	527	485	378
Untreated	25734	25734	22639	25734	25734	22639
	Product & Process Innovation vs Non-Innovator					
ATT	0.223***	0.281***	0.383***	0.0355***	0.0356***	0.0478***
b.s.e.	(0.0571)	(0.0671)	(0.0792)	(0.00965)	(0.0110)	(0.0130)
Treated	1572	1489	1197	1572	1489	1197
Untreated	24198	24198	21205	24198	24198	21205

Note: estimation based on EAE dataset and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure in a single treatment framework. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the probability of starting to export have been built as previously described using the EAE dataset. We report the ATT effects of the four possible single treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Table A.2.28: Impact of innovation on firm's total exports (CA) and intensive margin - single treatment ATT effects with Kernel matching.

	Total Exports (CA)			**Intensive Margin**		
	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator					
ATT	0.0211	0.228*	0.981***	0.0581	0.201*	0.852***
b.s.e.	(0.107)	(0.130)	(0.181)	(0.0983)	(0.117)	(0.163)
Treated	1008	963	748	1008	963	748
Untreated	18395	18395	15831	18395	18395	15831
	Product Innovation vs Non-innovator					
ATT	0.0267	0.215**	0.754***	0.0657	0.191**	0.605***
b.s.e.	(0.0773)	(0.0944)	(0.110)	(0.0707)	(0.0848)	(0.0983)
Treated	914	882	736	914	882	736
Untreated	18641	18641	16065	18641	18641	16065
	Process Innovation vs Non-innovator					
ATT	0.0313	0.159	0.504***	0.104	0.225*	0.448***
b.s.e.	(0.104)	(0.137)	(0.154)	(0.0962)	(0.121)	(0.133)
Treated	415	380	299	415	380	299
Untreated	19214	19214	16602	19214	19214	16602
	Product & Process Innovation vs Non-Innovator					
ATT	0.153*	0.362***	0.631***	0.114	0.276**	0.449***
b.s.e.	(0.0857)	(0.105)	(0.138)	(0.0790)	(0.0960)	(0.124)
Treated	1269	1216	987	1269	1216	987
Untreated	17910	17910	15374	17910	17910	15374

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure in a single treatment framework. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The number of firms included in the treated and control groups is reported. The dependent variables total exports and the intensive margin of trade have been built as previously described using the Custom Agency data. We report the ATT effects of the four possible single treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Table A.2.29: Impact of innovation on firm's extensive margins - single treatment ATT effects with Kernel matching.

	Country Ext. Margin			**Product Ext. Margin**			**Prod-Cod. Ext. Margin**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
	Only R&D vs Non-innovator								
ATT	-0.177	-0.0998	0.872**	-1.530***	-0.568	-0.571	-0.0230	0.0221	0.0637***
b.s.e.	(0.198)	(0.280)	(0.414)	(0.413)	(0.579)	(0.833)	(0.0143)	(0.0171)	(0.0240)
Treated	1008	963	748	1008	963	748	1008	963	748
Untreated	18395	18395	15831	18395	18395	15831	18395	18395	15831
	Product Innovation vs Non-innovator								
ATT	0.279	0.808***	1.354***	-0.353	0.134***	0.634***	-0.0169	0.00688	0.0511***
b.s.e.	(0.188)	(0.252)	(0.340)	(0.339)	(0.027)	(0.236)	(0.0103)	(0.0128)	(0.0154)
Treated	914	882	736	914	882	736	914	882	736
Untreated	18641	18641	16065	18641	18641	16065	18641	18641	16065
	Process Innovation vs Non-innovator								
ATT	-0.630**	-0.539	0.483	-1.368**	-1.506**	-0.855	-0.0188	-0.0220	0.0305
b.s.e.	(0.236)	(0.337)	(0.457)	(0.505)	(0.683)	(0.788)	(0.0140)	(0.0176)	(0.0205)
Treated	415	380	299	415	380	299	415	380	299
Untreated	19214	19214	16602	19214	19214	16602	19214	19214	16602
	Product & Process Innovation vs Non-Innovator								
ATT	0.493***	0.925***	1.731***	0.848**	1.249***	1.865***	0.0201*	0.0470***	0.0792***
b.s.e.	(0.165)	(0.225)	(0.306)	(0.341)	(0.443)	(0.574)	(0.0116)	(0.0140)	(0.0178)
Treated	1269	1216	987	1269	1216	987	1269	1216	987
Untreated	17910	17910	15374	17910	17910	15374	17910	17910	15374

Note: estimation based on EAE dataset, Custom Agency and R&D survey data between 1999 and 2007. ATT effect estimated using a difference-in-differences technique with propensity score Kernel matching procedure in a single treatment framework. Bootstrapped standard errors (b.s.e.) with 500 repetitions reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of firms included in the treated and control groups is reported. The dependent variables extensive margins of trade have been built as previously described using the Custom Agency data. We report the ATT effects of the four single possible treatments of investing in R&D ($R\&D$), introducing a product innovation (Pd), a process innovation (Pc) or to jointly introduce a product and a process innovation ($PdPc$) against not having innovated at all for the following three years after the treatment.

Chapter 3

Outsourced R&D and export performance: resource optimization or market-seeking?

Abstract

Globalization and the fragmentation of production have contributed to the creation of internationally integrated innovation networks. The rapid rate of technological adoption combined with an increased competition in international markets have made external R&D activities a core corporate strategy in order to foster firm productivity and internationalisation. In this chapter we estimate the impact of outsourced R&D activities on firms' export performance. We take into account several measures of firms' external R&D activities, outsourced both domestically or internationally and within or outside group boundaries. After controlling for self-selection we find that outsourcing R&D if combined with internal capabilities tend to have a significant impact on export performance. Specifically, we find that outsourced innovative activities have different effects on total exports and on the destinations where those goods are exported. Taken together these results show clearly that outsourced R&D can play a significant role in improving firm's participation in global networks if properly supported by internal innovating activities, increasing foreign sales and improving firms' ability to access new foreign markets.

JEL classification: D22, D24, F14, F23, F61, O31, O33

Keywords: firm heterogeneity, innovation, international trade, productivity, R&D outsourcing

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3.1 Introduction

Globalization along with the development of new information technologies (IT) and the reduction of distances and cultural barriers have not only fostered the international fragmentation of production, but have contributed to the expansion of R&D transactions and the creation of internationally integrated innovation networks. Cross-border collaborations between research centres are a wide-spread phenomenon, mainly due to the increasing degree of specialisation of laboratories around the world which have became research leaders in high-tech and high-added value niches. In particular, private firms have gradually evolved from closed innovation systems to open and networked structures, as shown by the increasing share of external innovating activities both in developed and developing countries, leading to a new global distribution of R&D as suggested by Chesbroughs' "open innovation" paradigm (Arora et al. 2001b; Chesbrough 2006; Ernst 2004).

Multinational firms are playing a key role in this global creation of knowledge, driving the internationalisation of firms and increasingly performing their R&D activities overseas or outside their corporate boundaries (OECD 2008). Moreover, the fast rate of new technology adoption combined with the increasing pressure on firms to remain competitive in the international markets have made external R&D activities an important corporate strategy to foster firms productivity and their international performances (Jabbour and Zuniga 2015). As an example, in the last 20 years the total value of external R&D activities in the EU has grown 20 times faster than R&D spending in general, with some companies conducting less than 10% of their R&D in-house, becoming "hunters and gatherers" rather than originators of technology (Leifer 2000). Nowadays, more than 70% of European firms have outsourced part of their R&D activities, opening collaborations not only with organizations located in countries at the edge of the technological frontier, but increasingly offshoring towards developing countries (Santos-Paulino 2011; Dachs et al. 2013). Foreign R&D investment by

European firms so far have been mostly concentrated in the US (10% of the total share of R&D activities outside the EU), Canada (7%) and Japan (2%), but investment has been rapidly redirected towards a small number of developing countries such as China (4%), India (1.5%) and other rapidly emerging economies, mainly because of their low-cost and well-trained researchers, their increasing domestic markets and the proximity to suppliers (Sun, 2007; European Commission, 2014).

A large strand of the literature has investigated the motives driving this phenomenon, analysing the characteristics of outsourced tasks and the specific strategies followed by firms. In particular, the majority of research has been focused on the impact of external R&D on firms' performance in terms of productivity and innovation output, identifying a trade off between the costs and benefits and studying the complementarity between internal and external activities (Arora and Bokhari 2007; Grossman and Rossi-Hansberg 2012; Garcia-Vega and Huergo 2013; Bertrand and Mol 2013; Krzeminska and Eckert 2015).

In general, the innovation capability of the manufacturing sector is becoming an increasingly important issue in high-wage developed countries and is considered as one of the main drivers of the economic recovery and as a way to improve the comparative advantage and the international performance with respect to newly emerging countries. Most of the policy attention on this topic has focused on a specific subcategory of manufacturing firms, mainly dynamic innovators in the high-tech industries dedicating large resources to internal R&D projects (Pisano and Shih 2009). However, recently a growing literature has questioned this research focus, stressing the relevance of the evolving industrial re-organisation taking place in low-tech manufacturing industries. These firms may not be at the edge of the technological frontier, but are actually dedicating an increasing amount of resources to the development of R&D projects in order to challenge the competition from low-cost countries, in particular progressively outsourcing these activities to specialised providers of external knowledge even across borders and business groups boundaries (Hansen and Winther 2014).

The objective of this chapter is to contribute to the empirical literature by assessing the impact of external R&D activities on firms export performance. As we will summarise in the literature review, so far this topic has received little attention from theoretical and empirical researchers. We consider externalised R&D to be a key strategy for internationalized firms, undertaken to achieve both supply-driven and demand-driven objectives. To the best of our knowledge, this is the first empirical contribution to provide evidence on the relationship between external R&D activities and firms' export performance, looking both at domestic and foreign owned companies, both in the high and in the low-tech industries.

The creation of external knowledge and the internationalisation processes of firms form an interconnected and complex relationship between innovation openness, internal knowledge capabilities and internationalisation performance. External R&D activities may complement the already existing internal knowledge base and influence positively the outcome of firms internationalisation, but firms international experience in turn may increase the likelihood of outsourcing R&D activities and the search for potential R&D collaboration and other external knowledge sources. External R&D activities could affect firms' export performance in a number of different ways, for instance by optimizing firms' resources or allowing them to acquire specific knowledge and to improve their ability to respond to global market needs, with different implications for the volume and the foreign destinations of exported goods. Outsourcing R&D activities abroad allow firms to be closer to potential customers and to adapt their products to the local market needs, acquiring the skills to penetrate new markets and to speed up the response to demand shifts. At the same time, the fragmentation of R&D processes could negatively influence firms ability to exploit economies of scale and scope, leading to an increase of the marginal costs of production and affecting foreign sales. In addition, by outsourcing R&D activities outside group boundaries to third agents, firms could be exposed to leakage of key technologies and to the involuntary diffusion of corporate knowledge, hollowing out in this way the result of innovation activities and decreasing the value of exported goods.

Using French firm-level data over a period of 10 years, we take into account several measures of firms external R&D activities, considering both tasks outsourced within or outside the group boundaries, both domestically and internationally, and we find that external R&D activities are significantly interrelated with firms export performance. Specifically, we first analyse firms endogenous self-selection into R&D outsourcing, using a 2-step Heckman model to identify the main drivers of firms propensity to externalize R&D activities and their extent. After obtaining firms expected value of outsourcing R&D from the Heckman estimates, we use them as a measure of outsourced R&D in a system of simultaneous equations which models the impact of external R&D activities on export performance while controlling for the possible reverse causality between outsourced innovation and international performance.

First, we are interested in studying whether outsourced activities substitute or are complementary to the effect of internal R&D on exports, analysing the sustainability of innovative external efforts and firms' internal resources. Secondly, we examine the different effects of outsourced R&D activities on several indicators of firms export performance in order to assess the role played by each external innovation activity in increasing the value of total exports and in improving firms market access. We want to test whether external R&D have a different effect on the value of firms exports and on the destinations where French goods are shipped depending on the market-seeking or resource-optimization strategy followed by firms.

We will show how complementarity does take place between internal and external R&D activities, demonstrating how in-house capabilities still persist once firms start externalizing, and how this joint effect helps firms to improve their export performance. In addition, we find that offshoring R&D activities abroad and outside the group boundaries is a particularly relevant strategy in order to improve firms terms of trade, specifically increasing the value of total exports and pushing firms towards more difficult markets. These results seem to be particularly relevant for domestic firms in low-tech industries, which might use external knowledge not available in-house provided by foreign agents at the edge of the technological frontier in order to increase total exports and their presence in foreign and distant markets. Taken together these results show clearly how external R&D plays a significant role in improving firm's participation in global networks, demonstrating how these strategies are mainly driven by market-demand factors such as customizing products to foreign markets' needs or increasing firms' global footprint.

The rest of the chapter is structured as follows. The next section reviews the previous literature on this topic and presents the theoretical predictions. A brief description of the datasets used follows, presenting some preliminary evidence and statistics. Section 4 describes the principal methodologies and the econometric models employed. In section 5 we discuss and interpret the results of the empirical analysis. Section 6 concludes with a summary of the main results and discusses the policy implications.

3.2 Theoretical Framework and Predictions

In the previous literature, the term external R&D usually refers to innovating activities located outside firm's boundaries. It could be located domestically in the "home" country, or offshored overseas, and a distinction is made between external R&D activities conducted in-house within the group boundaries - insourcing - or at arm's-length, outsourcing particular tasks to extra-group agents (Pain and Welsum 2004; Yeaple 2006; Grossman et al. 2006). The economics and business literatures have widely studied the geographical fragmentation of innovative processes, mainly in order to understand the factors driving this phenomenon and to analyse the consequences for R&D capabilities in-house, the output of innovating activities and the performance of outsourcing firms. In the next sections we will present the main theoretical frameworks which explain the reasons driving the externalisation of R&D activities. We will then analyse the consequences of outsourced innovation for internal R&D capabilities and for firms performances more generally. Finally, based on the previous theoretical and empirical contributions, we will develop our hypothesis and predictions on the effect of outsourced R&D on export performance which we will test in the empirical analysis.

3.2.1 External R&D Driving Factors

The main reasons given for the increasing externalisation of innovation are closely related to the more general phenomena of value chains global fragmentation, since by outsourcing some R&D activities firms could improve their productivity and performance in a number of different ways (Timmer et al. 2014). A recent strand of the literature has identified the main forces driving firms' R&D internationalisation which could be grouped into supply-driven factors and demand-driven factors (Reddy 2000; Criscuolo 2005; Santos-Paulino et al. 2014).

According to the supply-driven theory, the rising cost of R&D, its increasingly multidisciplinary character and the uncertainty of the results push firms to optimize their resources by outsourcing the most standardized R&D activities overseas - e.g. to developing countries - cutting down the overall costs and speeding up the development process (Antras 2005;

Cesaroni 2004; Squicciarini 2008). Several studies demonstrate that the codification of R&D processes facilitate their segmentation and dispersion, helping firms to enhance their productivity, specializing on more valuable innovation-intense tasks and being more flexible in the management of their portfolio of R&D activities (Narula 2001; Puga and Trefler 2005). For instance, Acemoglu et al. (2003) in their model show how firms organization changes as the technology frontier approaches. In fact, in vertically integrated firms managerial capabilities are overloaded since they should be focused both on production and innovation activities, creating organisational inefficiencies and discouraging innovation. Firms could mitigate the managerial overload by outsourcing some of these activities, but this might create new hold-up problems related to the dissipation of internal resources to suppliers. Their model predicts that far from the technology frontier imitation activities are more important and thus vertical integration is preferred. On the contrary, closer to the frontier the value of innovation activities increases, encouraging firms to outsource to a larger extent.

The externalisation of R&D activities, however, is not limited only to standardized tasks, but is carried out in order to access specific knowledge or specialized facilities not available in-house, as predicted in the science-based versus market-based taxonomy (Gerybadze and Reger 1999). According to several studies the geographical delocalization of R&D follows different types of innovative and managerial strategies, based on specific firms characteristics and goals. For instance, knowledge-exploitation R&D activities are usually outsourced in locations with superior innovative capabilities such as top universities and research laboratories. Thanks to this strategical proximity firms are able to enrich their innovative process and to internalise external spillovers derived from research collaborations and the exposure to research centres and other companies at the edge of the technological frontier (Kuemmerle 1999; Florida 1997; Arora et al. 2001a).

Integration into business networks and clusters has always been a key tactic of international outsourcing, often more important than exploiting central economies of scale, and became an even more important strategy for the creation of internationalised R&D networks (Cantwell and Piscitello 2005). Building on rich firm-level data between 1978 and 2000, Quintas et al. (2008) analyse the geographical dispersion of international technology networks. First, the authors show that the number of countries hosting international technological activities is continuously increasing. Secondly, by looking at the business characteristics they explain this emergent phenomenon. As a matter of fact, R&D internationalisation is higher for multinational corporations (MNCs), showing a greater technological diversification and a wider presence in international markets. Similarly, Athreye and Cantwell (2007) using new indexes measuring technology influence study the causal relationship between globalisation and the emergence of new countries as contributors to technology generation. Their findings suggest an important role played by higher level of patenting competitiveness and by technology generation as factors increasing the attractiveness of a country as host of foreign direct R&D investment.

In addition, R&D activities could be undertaken abroad because of demand-driven factors as well. Decentralising R&D facilities close to potential customers, suppliers or partners it is a key strategy for internationalized firms which could improve their ability to respond to global demand shifts, specifically exploiting local R&D centres to adapt their products to different markets' needs and speeding up the penetration of new foreign markets which are particularly difficult to access (Thursby et al. 2007; Yoshida and Ito 2006). For instance, Lewin et al. (2009) study the determinants of firms decision to offshore product development activities abroad. Using survey data on US firms the authors relate the probability of product development offshoring to strategic market-access objectives, previous experiences and other environmental factors. Their results show that offshored product development is still partially explained by shortage of high skilled technical talent and cost savings opportunities, but stress as well how market access and the increasing speed of time to market[1] are becoming major reasons underlying R&D offshoring decisions.

3.2.2 External R&D and Firm Performance

Regardless of the main reasons and strategies driving innovation outsourcing, external R&D activities could have a complex and somehow contradicting impact on global corporate operations and more generally on firms performance. The overall implications of outsourced R&D have been widely analysed by the literature investigating transaction costs, incomplete contracts and organization strategy usually linked with globalization. As previously discussed, on the one hand external R&D activities may constitute a source of competitive advantage fostering specialization and efficiency gains, but on the other hand it could generate negative spillovers undermining internal capabilities, dissipating key resources and deprecating firms innovation and performance (Gorg et al. 2008; Amiti and Wei 2009; Santos-Paulino et al. 2014). For instance, segmenting and dispersing R&D activities could negatively affect firms' performance and the terms of trade, mainly due to the possible leakage of key technologies, the presence of high co-ordination and operational costs and possible diseconomies of scale and scope (Criscuolo and Narula 2005).

The previous literature highlights how the costs and benefits of external R&D activities depend mainly on the strategy followed, the nature of the knowledge outsourced and other firm specific characteristics (Garcia-Vega and Huergo 2013). Grossman and Rossi-Hansberg (2012) for instance demonstrate that international R&D outsourcing could be more produc-

[1]In the business literature, time to market (TTM) is the length of time needed from a product being conceived until its being available for sale. TTM is particularly important in industries where new products are outmoded quickly (Chen et al. 2005; Kahn 2013).

tive than national outsourcing for multinational firms, although it involves higher hidden costs related to monitoring and adapting the development processes in different countries. In addition, the costs related to leakage of key technologies could be particularly high when outsourcing R&D activities outside firms boundaries, disclosing possible product developments to competitors in the national and global markets (Cesaroni 2004). Moreover, although by outsourcing part of their R&D firms can focus on their more productive core knowledge-intensive tasks, this practice could also be detrimental, crowding out the internal capabilities that support firm's absorptive capacity (Geroski 2005; Griffith et al. 2004; Grimpe and Kaiser 2010). In the next sections we will summarise the main empirical evidence on the consequences of outsourced innovation for internal R&D capabilities and for firms performances more generally.

Complementarity of internal and external R&D

The identification of trade-offs related to outsourced innovation is an important part of the previous literature that investigates the compatibility and complementarity between internal and external R&D efforts and the overall effect on firms' performance and innovativeness. The phenomenon of complementarity between internal and external R&D activities have been theoretically explained with the benefits deriving from knowledge creation and the risks related to its transfer. The theoretical predictions supporting the existence of complementarity mainly relate to benefits of knowledge creation through absorptive capacity, economies of scope, and knowledge spillovers. Absorptive capacity refers to firm ability to recognize, assimilate and use external knowledge based on its own pre-existing internal capabilities (Cohen and Levinthal 1990; Tsai and Wang 2009). As a matter of fact, by complementing internal with external R&D, firms could improve their innovating outcomes through learning about new technologies and research methods adopted from third agents (Schmiedeberg 2008). In addition, economies of scope could occur when two or more firms share their research infrastructures and personnel for different R&D activities and projects (Panzar and Willig 1981; Cassiman and Veugelers 2002). Moreover, by exploiting both internal and external innovating capabilities, knowledge spillovers allow cross-fertilization across different projects, in particular regarding research joint-ventures between different industries and public-private partnerships (Henderson and Cockburn 1996; Ornaghi 2006).

Empirically, however, the business and economic literature that investigates R&D complementarity yields mixed results. The first strand of the literature only tests for the co-occurrence of internal and external R&D activities, leaving out any consideration about the possible consequences of this complementarity (e.g. Arora and Gambardella 1990; Cassiman and Veugelers 2002). Starting from these seminal papers, a number of different studies analyse the implications of R&D complementarity for firm innovativeness and more generally for its performance, finding mixed results and sometimes even suggesting that these strategies could be substitutes.[2] Audretsch and Feldman (1996) and Blonigen and Taylor (2000) for example estimate two contrasting results of this interaction between external and internal R&D when differentiating between high and low-tech industries. The first authors find that internal and external R&D tend to be substitutes in low-technology industries but complements in high-technology sectors, characterized by a higher propensity towards knowledge spillovers and towards research collaborations with other firms part of the same clusters. In contrast, Blonigen and Taylor (2000) using a panel of US high-tech firms find a substantial negative correlation between internal R&D intensity and firm propensity to acquire external knowledge. Similarly, Kantor and Whalley (2014) look at the spillover effects from university research activities to the economic growth of local communities using an instrumental variable strategy. The authors find that these effects are significantly larger when local firms are

[2]See for instance: Basant and Fikkert 1996; Fernandez-Bagues, 2004; Cassiman and Veugelers 2006; Schmiedeberg 2008; Parmigiani and Mitchell 2009; Ennen and Richter 2010.

technologically close to universities and when industries adjust to the core research of local higher-education institutions.

A second strand of the literature instead investigates the effects of combined internal and external R&D strategies on firms' performance, identifying a positive relationship between R&D complementarity, firm productivity and the introduction of new innovations (Bonte 2003; Griffith et al. 2004; Chen et al. 2015). For instance, using a dynamic panel data model Lokshin et al. (2008) take into consideration both economies of scale and of scope while analysing R&D activities, estimating a positive impact of external R&D sourcing on firms' productivity only in the case in which sufficient R&D resources have been allocated also internally. In addition, studying Spanish manufacturing firms, Beneito (2006) investigates the complementarity between internal and external R&D and its effects on incremental innovations and on more radical product innovations (e.g. patents) finding evidence of positive and statistical significant impact just for more radical innovations.

Schmiedeberg (2008) instead looks at the role played by complementarity in increasing both the innovative output performance and new products total sales, finding only a weak effect on the former. Similarly, Bertrand and Mol (2013) using a panel of French firms estimate through an Heckman model the different role played by cognitive distances and absorptive capacity in the case of domestic or offshored R&D. The authors find that the absorptive capacity of internal R&D plays a key role in determining the success of foreign outsourcing. In addition, if properly managed, offshored activities seem to have a stronger positive effect on innovation outcome than domestic R&D outsourcing, demonstrating how knowledge acquired abroad might be more effective in increasing the probability of introducing new innovations at home.

Several papers look at the effect of complementarity on the introduction of process innovations. For instance, Reichstein and Salter (2006), Ganotakis and Love (2012) and Naudé et al. (2011) show that both internal and external R&D activities increase the probability of engaging in both product and process innovations. Krzeminska and Eckert (2015) instead using cross-sectional firm-level data on German manufacturers test directly the existence of complementarity effect for product and process innovations. Their results confirm the previous evidence, finding a significant and positive effect of complementarity on the likelihood of introducing product innovations but limited evidence for process innovations.

Summarising the previous literature, firms with a higher internal R&D intensity would be more reactive to spillovers from outsourced innovating activities, and will be able to exploit external knowledge from distant and heterogeneous offshore suppliers thanks to their larger internal absorptive capacity (Cohen and Levinthal 1990; Cassiman and Veugelers 2006). Based on this evidence, it is possible to predict that the positive interconnection between internal and external knowledge inputs would not affect just firms productivity and the likelihood to introduce new product and process innovations. In fact, we expect that the interaction between internal research capabilities and external R&D contribution could positively affect also firms export performance more generally, by internalising the positive spillovers linked to the complexity of outsourced R&D tasks and profiting by the international exposure to foreign competition and to R&D collaboration with external agents (Salomon and Jin 2010):

Hypothesis 1: the larger are the internal R&D capabilities of a firm, the greater would be the effect of external innovating activities on firm export performance.

External R&D, Firms Characteristics and Export Performance

As previously discussed, firm characteristics might play a key role in affecting the impact of external innovating activities on firms performance and innovativeness, given the interconnection between R&D internationalization and the different business strategies (Fu et al. 2012). In this regard, firm exporting status plays a key role in reducing the transaction costs associated with external R&D activities, and in determining the success of international transfers of knowledge thanks to exporters previous experience in foreign markets (Yoshida and Ito 2006; Cusmano et al. 2009; Criscuolo et al. 2010; Garcia-Vega and Huergo 2013). Several studies show how internationalized firms devote larger resources to assimilate foreign knowledge and to absorb innovative spillovers from foreign customers, suppliers and competitors (Criscuolo et al. 2010; Altomonte et al. 2013). For instance, Cassiman and Veugelers (2006) while analysing the complementarity between internal and external innovation activities identify other firm characteristics which affect this relationship. The authors find that exporting status strengthens the complementarity between internal and external innovation activities, mainly because of the competitive environment in which exporters are used to compete and the previous experience they have in international markets.

Similarly, Garcia-Vega and Huergo (2011) investigate the main determinants behind external R&D, focusing particularly on the role played by international trade. Given the very high transaction costs related with the management of outsourced R&D, exporting firms, by exploiting their efficiency advantages, will be less financially constrained than non-exporters in carrying out their external innovating activities. However, some studies show how exporters are also more exposed to technology leakage when offshoring their R&D activities abroad, highlighting the key role played by information asymmetries, institutional environment and the management of knowledge spillovers in determining the outcome of R&D activities externalised in international markets (Chu and Lai 2009; Lu et al. 2012).

In a recent work, Garcia-Vega and Huergo (2013) analyse the relationship between external R&D activities and international trade, investigating the different effects of international and domestic outsourced R&D on firm innovativeness distinguishing between exporters and non-exporters. The authors demonstrate that R&D outsourcing increases firms innovativeness, positively affecting the introduction of new product innovations especially in the case of domestic outsourcing, while international outsourcing seems to play a key role only in improving firms productive processes. Most importantly, their results show how all kinds of externalised innovating activities have a stronger impact on the likelihood of introducing new innovations for exporting firms, while non-exporters seem to benefit only from R&D activities outsourced domestically.

Moreover, Jabbour and Zuniga (2015) using French firms' data demonstrate how firms engaged in R&D offshoring are usually more oriented towards exports. First of all, their results show that SMEs not belonging to a larger group seem to be more active in the international networks of innovation. Secondly, the authors find evidence that the main motivation behind external R&D activities is technological sourcing rather than the reduction of innovation costs, hence much more related with export-oriented strategies such as upgrading or introducing new products to access new foreign markets. Foreign ownership as well seems to play a key role especially with regard to market-oriented external R&D activities. Belonging to a multinational group could facilitate the integration of firms in the global networks of innovation, exploiting the resources and the linkages offered by the headquarters and other sister companies. In addition, foreign ownership might be particularly relevant for exporters, which could foster the adoption of market-specific knowledge and the introduction of new products tailored for foreign markets thanks to the access provided by group affiliates into new countries (Santangelo 2002; Naghavi and Ottaviano 2010; Guadalupe et al. 2012; Tamayo and

Huergo 2015).

Recently, Antonelli and Fassio (2015) investigate the heterogeneity of the sources of external knowledge and their different effects on process and product innovations. Their results show how upstream vertical sources of external knowledge from suppliers play a strong and positive role on the introduction of process innovations, whereas horizontal and downstream vertical sources from competitors and customers have stronger effects on product innovations. In particular, these results stress the importance for a firm of being integrated in the international networks of knowledge, highlighting the differences between upstream/downstream and vertical/horizontal sources of external knowledge, and suggesting the relevance of strategic decisions about the sources of external knowledge to exploit in relation to the innovation objectives which the firm would like to achieve.

However, the direct relationship between firm R&D outsourcing and internationalisation strategies has been mostly neglected by previous literature. Starting from existing theoretical frameworks analysing firms internationalisation processes and open knowledge networks, only a few empirical studies look at the role played by open innovation activities as a key condition for the implementation of successful internationalisation strategies (Leonidou et al. 1998; Dyer and Singh 1998; Stöttinger and Holzmüller 2001). For instance, Calantone et al. (2006) investigate whether firms that are open to external innovations are more likely to improve their export performance. The authors develop a cross-country model considering the US, Korea and Japan incorporating internal and external factors as antecedents to firms export performance, considering product adaptation as a key connecting strategy. Their results show that external inputs and product adaptation strategies are positively associated with export performance and the choice of exporting markets, highlighting as well the reverse role played by export dependence as an important antecedent of product adaptation.

Summarising the previous literature, externalised R&D is considered to be a key strategy for internationalized firms, undertaken to achieve both supply-driven and demand-driven objectives. To improve their international performance exporters might adopt several external R&D activities, outsourcing innovating tasks outside or inside the group boundaries, both domestically and internationally. The theoretical and empirical literature shows how external R&D activities could affect firms' performance in a number of different ways, for instance by optimizing firms' resources or allowing them to acquire specific knowledge and to improve their ability to respond to global market needs. Based on the previous evidence, we expect external innovating activities to affect firms export performance, in particular with different implications of international and domestically outsourced R&D activities on firms international performance, affecting both the volume and the foreign markets destinations of exported goods. The impact of externalised R&D activities on export performance would rely as well on firms strategy and on the push-factors which lead firms to externalize their R&D, if they are supply or demand-driven, or whether firms follow a science-based or a market-based strategy when internationalizing their innovating activities.

Previous theoretical contributions predict that outsourced R&D may have different and somehow contrasting effects on firms performance, influenced by their strategies, characteristics and the costs and benefits related to R&D internationalisation (Dachs et al. 2013). Specifically, internationalised R&D activities may create on the one hand several potential opportunities for exporters but they could as well raise concerns about the possible risks undermining firms export performance. For example, Dachs et al. (2013) analysing the demand-driven determinants of external R&D show how outsourcing R&D activities abroad allow firms to be closer to potential customers and to adapt their products to the local market needs, acquiring the skills to penetrate new markets and to speed up the response to demand shifts. At the same time, the fragmentation of R&D processes could negatively influence firms ability to exploit economies of scale and scope, leading to an increase of the marginal costs of production and affecting foreign sales. In addition, by outsourcing R&D activities outside group boundaries to third agents, firms could be exposed to leakage of key technologies and to the involuntary diffusion of corporate knowledge, hollowing out in this way the result of innovation activities and deprecating the value of exported goods (Moncada-Paterno-Castello et al. 2011):

Hypothesis 2: demand-driven external R&D activities improve exporters performance and their market-access to new foreign markets, through the introduction of new products and tailoring existing goods according to foreign markets needs.

At the same time, following the determinants of R&D internationalisation conceptualised in supply-side theory, innovating activities may be externalized mainly for two reasons. First, innovative activities could be outsourced abroad or in the home country in order to access highly skilled personnel or specific technologies in renowned universities and private R&D laboratories. In this way, exporters might be able to develop brand new innovative products in order to improve their competitiveness in the international markets and to increase the volume of exported goods. Secondly, firms might find it profitable to offshore part of their R&D activities abroad in order to access a low cost supply of R&D, especially externalizing the most standardized innovative processes to R&D centres based in developing countries and characterized by low costs of personnel and more flexible environmental and safeguard requirements (Criscuolo et al. 2005). This kind of strategy could have a conflicting effect on total exports: on the one hand, it could help exporters to reduce the marginal cost of innovations, optimising resources and reshaping export patterns in order to introduce new technological products to dynamic appealing markets. On the other hand, by externalizing such key activities to low-cost destinations, exporters may decrease the overall quality of products exported, especially negatively affecting the value of exports towards high-income and developed countries.

Hypothesis 3: supply-driven R&D internationalisation from firms in developed countries at the edge of the technological frontier would be mainly oriented towards the reduction of the costs of innovation and the rationalization of R&D activities. For these reasons, supply-side external R&D activities might reduce the costs of innovations with possible mixed effects on the overall value of exports and on firms' market-access.

However, as previously discussed, the creation of external knowledge and the internationalisation processes of firms seem to be interconnected, creating a complex relationship between innovation openness, internal knowledge capabilities and internationalisation performance. Several studies in the previous literature find mixed results, suggesting the existence of an endogenous self-selection and two-way causality relationship between exporting and R&D activities (Aw et al. 2008; Harris and Li 2009). Specifically, external R&D activities may complement the already existing internal knowledge base and influence positively the outcome of firms internationalisation. However, firms international experience in turn may increase the likelihood of outsourcing R&D activities and the search for potential R&D collaboration and other external knowledge sources (Becker and Dietz 2004; Kafouros et al. 2008). Furthermore, innovating activities, and more specifically outsourced R&D, might influence firms export performance by diversifying their products and distinguishing themselves from competitors creating in this way a new source of international competitive advantage. Arvanitis et al. (2014) for instance demonstrate the complexity of the relationship between open innovation and exports, highlighting the endogenous link connecting these activities. Employing a structural equation model on a cross-section of surveyed Greek manufacturing firms, the authors test the reciprocal impact of firms internal knowledge base, export performance and R&D openness, finding partial evidence of complementary and substitution effects on firms innovation performance.

Hence, summarising the previous empirical findings it could be suggested that internal and external R&D are endogenously related with firms internationalisation strategies, considering the self-selection of more productive firms into these activities and the two-way causal link connecting firms internal and external knowledge and their export performance:

Hypothesis 4: After firms self-select into external R&D activities and international markets, a two-way causal link exists between export performance and innovation outsourcing, since external R&D activities complementing internal resources affects firms exports and the international experience in turn increase the likelihood of R&D outsourcing.

In the next sections we will test empirically the above mentioned hypothesis at the firm level, showing how external R&D might have a significant impact on export performance and investigating more in depth the contrasting effect of different outsourced R&D activities. The overall impact on total exports would be the sum of the separate effects, depending on whether external R&D activities mainly affect the intensive (export value) or the extensive margin (markets served) of firms engaged in international markets and global networks of knowledge.

3.3 Data Description

3.3.1 Data Sources

We will test the above mentioned hypothesis on French firms using two comprehensive datasets for the period 1999-2007. We focus our attention on innovating firms using as a main dataset the annual survey on the resources devoted to R&D activities (Enquête annuelle sur les moyens consacrés à la R&D) collected by the French Ministry of Education and Research. This dataset provides exhaustive information for over 12,000 firms performing R&D activities. The construction of the survey sample is partially based on the structure of the previous surveys conducted and it consists of four different strata. Three of these strata are exhaustive and form the principle component of the survey. Thus, the survey addresses with a general questionnaire all the firms with an internal R&D expenditure above €2 million, while an exhaustive "short" questionnaire has been submitted to all French firms investing more than €350,000 on innovation, or to all the firms which have been included in the survey sample for the first time. In addition, a fourth strata of the survey is composed of a sample of remaining companies which dedicate a smaller amount of resources to R&D. The sample of the fourth strata is renewed every year, keeping half of the previous year sample and including as a second half other innovating firms not included in the previous survey.

This is a unique dataset and provides a good representation of the innovating activities carried out by the 12,000 French firms which engage in R&D. In particular, the survey includes detailed information on the R&D activities of firms, reporting more than just the total resources dedicated to innovation. For instance, the data provides information about the internal resources devoted to innovation as well as external activities such as R&D outsourced domestically and abroad, or about the resources received by third parties to finance innovation, both from public and private actors. In addition, also available from this survey are data on the number of employees working in the R&D department, the number and the average salary of researchers, the main domain of the research (whether it is mainly theoretical or more focused on biotechnologies, environment, information technologies, materials or social sciences) and the funds and support received by public authorities (international organisations, national government, regions or educational institutes). The dataset also provides information on the outcome of the research efforts of French firms, reporting whether the firm has introduced a new product or process innovation in the last year, and the number of patents registered at the different levels (at the national, European or US Patent Office). Finally, this database includes detailed data about firms characteristics such as total employment, total sales, foreign ownership, industrial classification at the NACE rev.1.1 4-digit level and firms participation to a French or a foreign group.

Secondly, we analyse exporters' activity using transaction-level export data collected by French Customs Agency which provides information about destination country, HS 8-digit-level product classification, value and weight of manufacturing exporters. The information are available for all manufacturing exporters which export at least € 100,000 within the EU or above € 1,000 outside the European Union, covering more than 90% of French total manufactured goods exported.[3] Since the Custom Agency collects detailed export data just for trade in goods, we focus our analysis just on the manufacturing industry in order to carry out a comprehensive investigation of the effect of external R&D across different measures of export performance. Merging these two datasets together, our final sample has almost 16,000 observations and contains comprehensive data about the R&D external activities of 4,500 innovating firms over 9 years providing as well detailed information in terms of export

[3]During this period the threshold for intra-EU exports has changed considerably. Initially, it was equal to almost € 38,000 euros until 2001 when it has been increased to € 100,000. Finally, it was moved to € 150,000 in 2006. For extra-EU exports the threshold has not been changed during our period. Nevertheless, these threshold changes do not affect the quality of our analysis since it has been demonstrated in the previous literature that small exporters account for a relatively small share of the overall French exports (Mayer and Ottaviano 2007).

strategies for approximately 3,500 firms of them which are exporters.

France devotes significant resources to research and development activities (approximately € 48 billion in 2014 which represents 2.26% of its GDP) ranking at the second place in the EU as total investment in R&D and sixth as share of GDP (Eurostat, 2015). In particular, more than 55% of total investment is carried out by the private sector, investing in 2014 around € 31 billion and employing in the R&D departments 1.5% of the national total labour force, ranking third among all European countries. Considering innovation outcomes, France ranked eighth worldwide for the number of patents issued, with a total figure of 43,060 patents granted in 2013 (WIPO, 2015).

In addition, France is particularly open to foreign investment and the internationalization of R&D activities, providing an open business environment for the development of R&D networks, mainly thanks to its key technology industries, the top quality of public education and research laboratories and the compelling compliance of government policies towards R&D and innovation (IFA 2012). For instance, almost 29% of corporate R&D expenditure in France has been made by foreign-owned subsidiaries over the period of interest 1999-2007, while between 2008 and 2012 an additional 200 new R&D investment projects were confirmed in France by foreign companies, effectively sustained by the most generous R&D tax treatment for companies in Europe. In addition, the total value of external R&D activities grew by over 600% in the last twenty years, indicating that R&D outsourcing in France has grown 20 times faster than R&D investment in general (Ministry for Higher Education and Research, 2012).

Our data provides detailed information on external R&D activities at the firm level. In the database each firm indicates its total expenditure for innovation, differentiating between internal and external R&D activities. In particular, firms are asked whether they have outsourced part of their R&D activities domestically to other French actors or if they have offshored abroad. In addition, within each category firms should detail the suppliers of these outsourced activities, specifying respectively the total amount outsourced to universities and public-owned research labs, or to other domestic and foreign private firms, specifically differentiating between affiliates part of the same business group or outside group boundaries.

3.3.2 Firm External R&D Activities

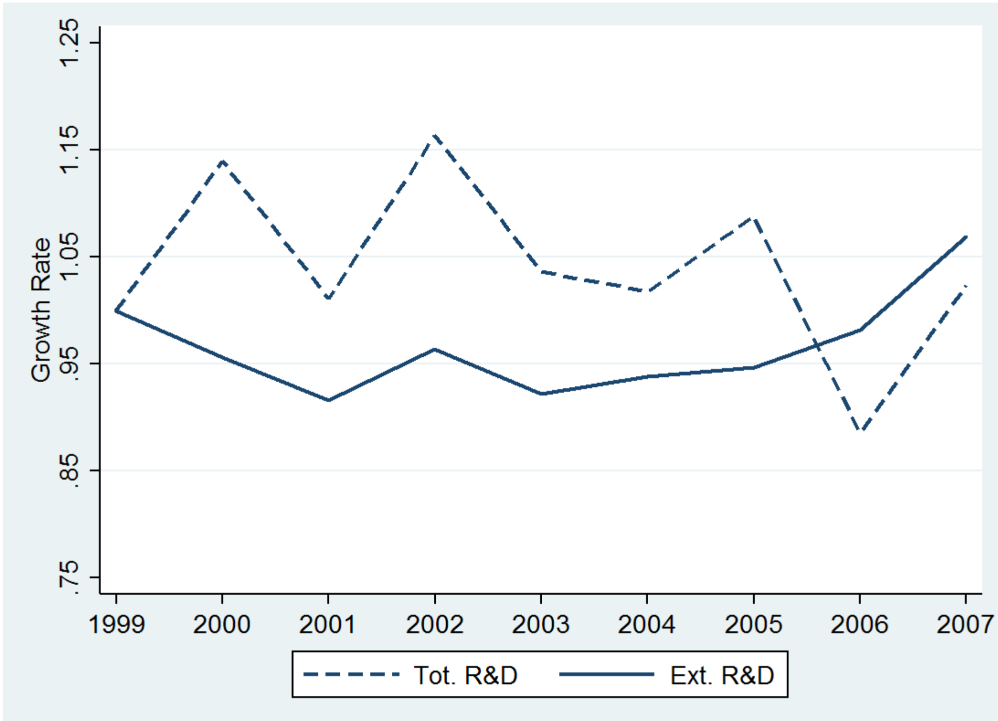
The following figures and tables present some preliminary summary statistics for the main variables of interest for this chapter, regarding the engagement of French innovating firms into the networks of knowledge exchange, the extent of external R&D and the trends in these activities over the last decade differentiating by industrial sector and firm characteristics. First, we differentiate between R&D activities performed within the firm or outsourced externally. In this regard, the variable external R&D collects the whole firm expenditure in outward research, including tasks outsourced to public authorities and labs, to governmental agencies and ministries, to the defence department, to professional and technical centres, to international organizations, to higher education institutions based both in France or abroad and to other private domestic or foreign firms. We are able then to differentiate between R&D activities outsourced domestically or abroad dissecting the previous variable into two new variables "offshored R&D" and "domestic outsourced R&D". Secondly, it is possible to focus just on external R&D activities outsourced to other private firms. In this respect, we built four different measures of corporate external innovation, considering where the tasks have been outsourced, in France (domestic outsourced) or abroad (offshored), and whether the supplier is a sister company part of the same corporate group (IN) or not (OUT).

As previously discussed, the internationalization of R&D activities is a relatively recent phenomenon, as demonstrated by the trend of French firms' external R&D activities over the period 1999-2007 shown in Figure 3.1. There are two apparent trends. First, looking at total and external R&D expenditure it appears that during this period French firms have increasingly externalised their innovating activities, while total investment in R&D have decreased in the later years of the period. This trend confirms the anecdotal evidence of increasingly open international networks of knowledge exchange, not confined within the group perimeters, but gradually based on external and occasional partnerships with foreign third parties. In addition, the data seem to follow in part what recent theories predicted on the new global distribution of overseas R&D expenditure linked to the erosion of the domestically outsourced R&D activities (Dachs and Peters 2014).

Nevertheless, as stressed in the previous literature, complementarity between internal and external R&D activities is crucial for internationalised companies in order to benefit from external knowledge and to reduce the risks related to its transfer. Keeping a relevant part of the innovating activities in-house might enable firms to develop the indispensable absorptive capacity needed to assimilate and use external knowledge and the related spillovers, to learn and understand new technologies and research methods and to exploit economies of scope when sharing research infrastructure and personnel from different R&D projects. In Figure 3.2 we present the distribution of internal, domestically outsourced and offshored R&D investment in log value across French manufacturing industries between 1999 and 2007.

From Figure 3.2 it is possible to observe that even industries characterised by a high propensity towards externalised R&D maintained in-house a predominant share of their innovating activities. As suggested by the previous theories, this strategy might be followed by firms in order to keep at a close distance the core R&D activities needed to internalise exter-

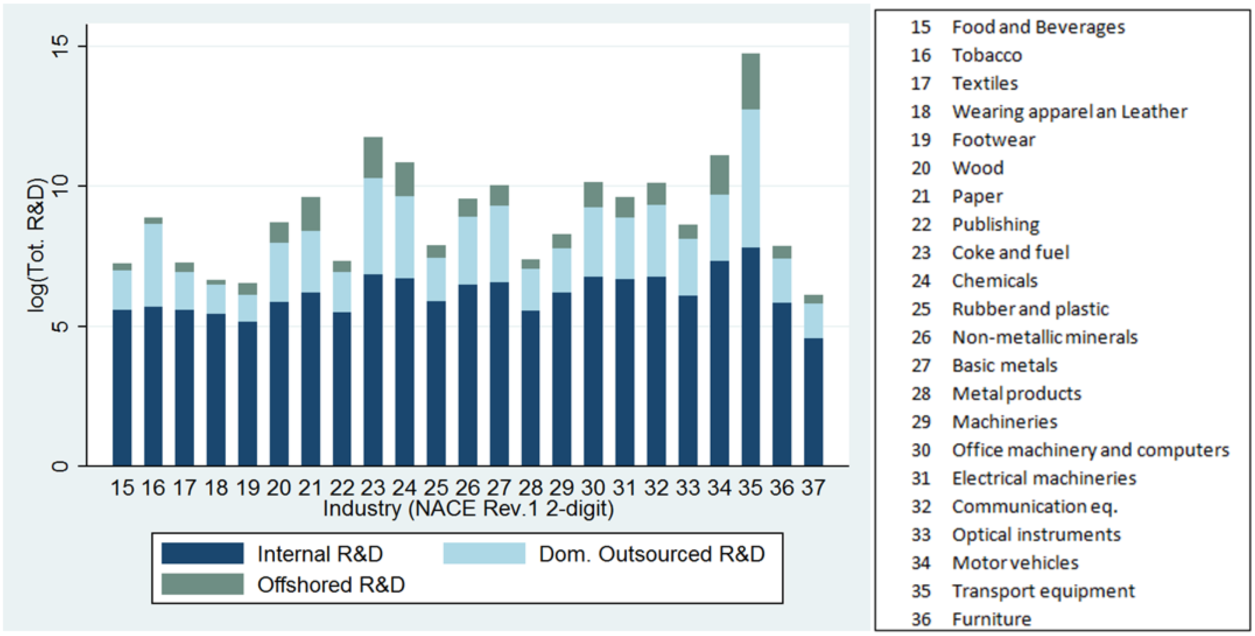
Figure 3.1: Trend of French Firms Internal and External R&D between 1999 and 2007.



Note: Based on R&D survey data, yearly growth rate between year 1999 to 2007 normalised to 1 based on year 1999. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Total R&D measured as the average total expenditure of firms in both internal and external R&D activities. External R&D measured as the average total expenditure of firms in R&D activities outsourced both domestically or abroad to third agents.

nal knowledge spillovers or to protect the most key crucial steps of the innovating processes more prone to technological leakage. In addition, Figure 3.2 shows the manufacturing industries which are more likely to externalise R&D activities domestically or abroad, highlighting again the complementarity between internal and external resources. Note that in particular the coke and nuclear fuel industry, the chemical sector and the manufacturers of transport equipments have a higher R&D intensity than average, externalising a larger part of their innovating activities in particular abroad. Some other industries, despite showing a lower level of R&D investment, dedicate a relatively important part of their resources to external R&D activities, in particular the sectors producing electrical machineries, communication equipments and motor vehicles. However, all these industries despite outsourcing huge R&D resources to third agents still preserve most of their innovating activities internally, providing

Figure 3.2: Complementarity between Internal and External R&D across French Industries.

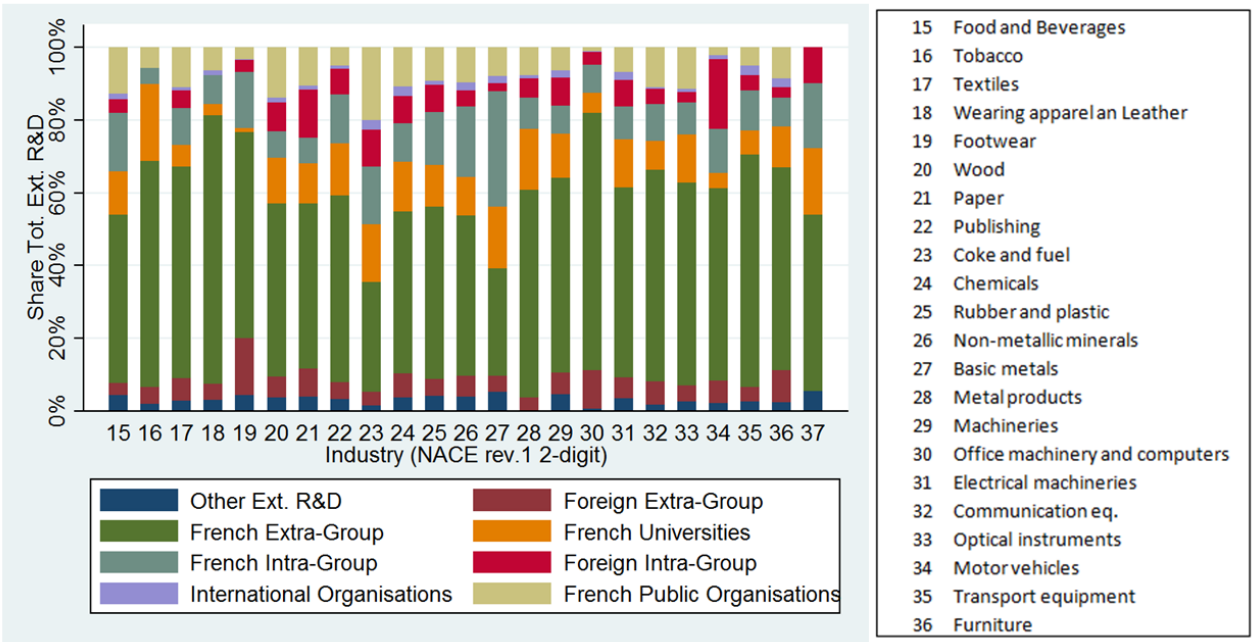


Note: Based on R&D survey data, average values from year 1999 to 2007 for all French manufacturing sectors according to the NACE rev.1.1 2-digit level industrial classification. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Internal R&D measured as the log of the average expenditure of firms in internal R&D activities. Domestic outsourced R&D measured as the log of the average expenditure of firms in external R&D activities not carried out by the firm but by other public or private agents. Offshored R&D measured as the the log of the average expenditure of firms in external R&D activities carried out in foreign countries by private or public agents.

a first evidence of innovative complementarity and of the importance of in-house R&D to exploit the positive spillovers deriving from externalised activities.

In Figure 3.3 we show how it is possible to further disaggregate this analysis by looking at the distribution of externalised R&D activities across industries, differentiating between tasks outsourced domestically or abroad, within or outside the business group, or externalised to domestic and international public organisations and universities. We focus our attention in particular on the main industries which are involved in externalized R&D, namely the production of petroleum products and nuclear fuel (NACE rev.1.1 2-digit code 23), chemical products (24), the manufacture of machinery and electrical equipment (29 and 33) and manufacture of transport equipment (35).

Figure 3.3: Distribution of External R&D Activities across French Industries (mean value)



Note: Elaboration based on R&D survey data, average between year 1999 and 2007 for all French manufacturing sectors according to the NACE rev.1.1 2-digit level industrial classification. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Shares calculated as percentage of total expenditure in external R&D. Variable *French public organisations* measures the total expenditure of firms in external R&D activities carried out by French public authorities, ministries, state-owned labs except for public universities. Variable *International organisations* measures the total expenditure of firms in external R&D activities carried out by International public organisations. Variable *Foreign Intra-Group* measures the total expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group. *French Intra-Group* measures the total expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group. Variable *French Universities* measures the total expenditure of firms in external R&D activities carried out by French private and public universities. *French Extra-Group* measures the total expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group. Variable *Foreign Extra-Group* measures the total expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. Variable *Other External R&D* measures the total expenditure of firms in external R&D activities carried out by other private or public agents not included in the previous categories (professional bodies, high-schools, NGOs etc.).

From Figure 3.3 it can be observed how producers of chemicals and of transport equipments are particularly involved in international networks of knowledge exchange, devoting significantly larger resources to offshored R&D activities. In terms of international partnerships, the chemical industry seems to be the most open in France to research collaborations with third foreign parties outside the group boundaries, probably due to the complexity of innovating processes and the increasing resources required to carry on research in this field (Arora and Gambardella 1990). On the contrary, transport equipment producers seem to rely mainly on internationalized but internalized exchange of knowledge, dedicating most of their external R&D resources to other foreign affiliates part of the same business group. Interestingly, the manufacturers of motor vehicles and of coke and nuclear fuel instead seem to offshore abroad a significant share of their external R&D activities but outside the business group boundaries. These sectors following an arm's-length outsourcing strategy are probably involved in joint partnerships for R&D projects with other international competitors, suppliers or customers, a phenomenon particularly frequent especially for the main motor vehicles manufacturers.

Finally, in Table 3.1 we present some descriptive statistics about the engagement of French innovating firms into the different external R&D activities and their extent during the period 1999-2007, differentiating between exporters and non-exporters. From Table 3.1 we can observe that more than half of the firms in our sample have been involved in external R&D activities during the 1999-2007 period, with a slightly higher participation rate for exporters. Most of the firms have kept their external R&D activities in France, mainly outsourcing part of their innovating efforts to other firms not part of the same French group (36.27% of the total sample). In contrast, only a small share of the general sample have decided to carry on external R&D activities abroad. In particular, exporters in this case seem to have a slightly higher propensity to offshore R&D, with 17% of exporters in the sample who have offshored part of their knowledge abroad against 13% of non-exporters. As stressed in the previous literature, exporters might be facilitated in managing offshored R&D activities abroad given their experience in foreign markets and the direct knowledge of local suppliers and facilities. Interestingly, both in the case of domestic and foreign outsourced R&D, French firms seem to be more oriented towards externalising their R&D activities outside group boundaries rather than within, mainly following a strategy oriented towards the access of new knowledge and facilities not available in house or the purpose of outsourcing the most standardized R&D tasks to specialized providers, possibly suggesting an extended network of international exchange of knowledge which goes beyond multinational groups boundaries.

Table 3.1: Share and extent of French firms participation to external R&D activities by export status

	Total		Exporters		Non-Exporters	
	value	share	value	share	value	share
No. Firms	4,523	100%	3,380	74.72%	1,143	25.28%
Internal R&D	6857.36	100%	7106.96	100%	5698.42	100%
	(37177.1)		(35311.23)		(44824.02)	
External R&D	1797.52	52.63%	2159.57	53.29%	1719.55	49.60%
	(13817.38)		(21058.91)		(11684.32)	
Offshored R&D	490.52	16.03%	516.28	16.53%	484.97	13.65%
	(5748.44)		(5237.65)		(5852.79)	
Dom. Outsourced R&D	1364.36	51.09%	1302.05	51.75%	1653.72	47.97%
	(11949.64)		(9604.56)		(19429.58)	
Offshored R&D IN	204.89	7.66%	215.03	7.81%	202.7	6.95%
	(2555.57)		(2801.01)		(2499.67)	
Offshored R&D OUT	193.81	9.08%	233.46	9.42%	185.27	7.52%
	(3415.63)		(3497.62)		(3398.4)	
Dom. Outs. R&D IN	270.24	10.45%	181.85	10.4%	289.25	10.66%
	(3561.87)		(1816.91)		(3834.93)	
Dom. Outs. R&D OUT	1151.17	36.27%	1104.51	37.05%	1367.83	32.56%
	(13633.12)		(11988.33)		(19534.64)	

Note: Based on R&D survey and French Customs Agency data, average between year 1999 and 2007 for all French manufacturing firms according to the NACE rev.1.1 industrial classification. All monetary values in thousands of Euro deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Shares represent the number of firms in our sample in each category which have undertaken a particular R&D activity over the total number of firms. Firms which have registered positive foreign sales in the period of interest according to the Customs Agency dataset have been included in the category *Exporters* or in the category *Non-Exporters* otherwise. *Internal R&D* measured as the average expenditure of firms in internal R&D activities. *External R&D* measured as the average total expenditure of firms in R&D activities outsourced both domestically or abroad to third agents. *Domestic outsourced R&D* measured as the average expenditure of firms in external R&D activities carried out by other public or private agents based in France. *Offshored R&D* measured as the average expenditure of firms in external R&D activities carried out in foreign countries by private or public agents. Variable *Offshored R&D IN* measures the average expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group. *Dom. Outs. R&D IN* measures the average expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group. *Dom. Outs. R&D OUT* measures the average expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group. Variable *Offshored R&D OUT* measures the average expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group.

Concentrating on the extent of outsourced innovation we can observe that it is domestically outsourced R&D that has attracted the largest resources. In particular, most of these resources have been outsourced mainly to other French extra-group firms, specialized research centres and labs. There are a number of interesting findings when differentiating by export status. First, is worth noting how exporters do not outperform in terms of external R&D value in comparison to non-exporters, but on the contrary the two categories seem to follow different strategies. Although exporters register a higher ratio between external and internal R&D, exporters tend to focus most of their resources to offshored innovating activities abroad, profiting from their international experiences, while non-exporters dedicate a larger share of their resources into domestic networks of knowledge transfer.

In addition, it seems that non-exporters are much more focused on outsourcing part of their innovating activities outside firms' boundaries. This dichotomy could have important implications. From the preliminary statistics it appears that exporters prefer to develop new technologies in-house within group boundaries, highlighting a strong dependency in terms of R&D collaborations between headquarters and subsidiaries, while non-exporters on the contrary tend to rely more on external R&D providers and labs, investing larger resources in acquiring external technologies. This evidence shows how the internal development of new technologies and products is a key strategy for successful exporters aiming to improve their international competitiveness.

3.3.3 External R&D and International Trade

As previously discussed in the literature review, the exchange of knowledge within global networks and the international trade of services and commodities are closely linked, suggesting a complementarity between these two corporate strategies. For instance, export status plays a key role in reducing the transaction costs associated with outsourced R&D, and at the same time international innovating activities could positively affect firms performance in particular in terms of exports. Table 3.2 presents statistics analysing the export performance of French firms and distinguishing companies according to the R&D outsourcing activity.

We present different measures of firm export performance not only considering total ex-

Table 3.2: Export Performance of French innovators and R&D Outsourcers.

	General (4,523)		Only Internal R&D (2,142)	
Variable	Mean	S.D.	Mean	S.D.
Total Exports	51,400	306,000	29,400	163,000
Unit Value	536.55	7568.93	371.80	1923.20
Country Ext. Margin	27	26	24	24
Product Ext. Margin	30	51	25	44
Export Tech. Intensity	2.98	1.54	2.92	1.58
Foreign Market Potential	8.002	5.294	8.372	5.746
Exports extra-EU OECD	17.77	21.24	17.52	21.73
Exports non-OECD	8.66	14.11	8.17	13.66
	Dom.Outs.R&D (2,310)		Offshored R&D (925)	
	Mean	S.D.	Mean	S.D.
Total Exports	39,600	114,000	156,000	670,000
Unit Value	519.93	2470.56	1210.98	18008.16
Country Ext. Margin	27	25	37	33
Product Ext. Margin	30	46	50	76
Export Tech. Intensity	3.04	1.47	3.13	1.45
Foreign Market Potential	8.005	4.867	6.524	3.161
Exports extra-EU OECD	17.41	21.19	17.96	19.28
Exports non-OECD	8.96	15.21	10.32	14.50

Note: Based on R&D survey and French Customs Agency data, average between year 1999 and 2007 for all French manufacturing firms according to the NACE rev.1.1 industrial classification. All monetary values in thousands of Euro deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Firms which have dedicated resources only to internal R&D activities in the period of interest according to the R&D survey dataset have been included in the category *Only Internal R&D*. Firms which have dedicated resources to external R&D activities based in France but not abroad in the period of interest according to the R&D survey dataset have been included in the category *Dom.Outs.R&D*. Firms which have dedicated resources to external R&D activities abroad in the period of interest according to the R&D survey dataset have been included in the category *Offshored R&D*. *Total exports* includes all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA). *Unit value* calculated as the average ratio between firm shipments value and weight or pieces as reported in the CA dataset. *Product extensive margin* calculated as average number of products exported by French firms. *Country extensive margin* calculated as average number of foreign markets served by French firms. *Export tech. intensity* measured at the firm-level as the average value of skill and technology content of each product exported by French firms at the HS-6 digit level, based on the UNCTAD classification of products into 5 different categories: primary goods, resource-intensive commodities, low, medium and high-tech (Basu and Das 2011). *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market. *Extra-EU OECD Exports* measured as the average log of French firms exports to non-EU OECD members (Australia, Canada, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Switzerland, Turkey, USA) as reported in the CA dataset. *Exports non-OECD* measured as the average log of French firms exports to all countries non-OECD members.

ports. For instance, we look carefully at the characteristics of products exported, including the unit value as a proxy of quality calculated as the ratio between shipments' value and weight, the product extensive margins registering the number of products exported by a firm per year, and the technological intensity of exports. In order to measure the technological intensity of exports we followed the UNCTAD classification system of products by skill and technology content at the most disaggregated HS 6-digit level into five different categories: mineral fuels and primary commodities, resource-intensive manufactures, low, medium and high skill and technology-intensive manufacturing goods (Basu and Das 2011).

After categorising products accordingly, we calculated an average exports tech-intensity for each exporter per year. In addition, we focus on the export destinations, analysing the country extensive margin calculated as the number of countries served by each exporter per year, differentiating between exports towards extra-EU OECD and non-OECD countries, and proposing the Foreign Market Potential index as a measure of market access for each exporter.

From Table 3.2 we can see that R&D outsourcers outperform non-outsourcers both in terms of total exports and unit value of exported goods. However, when differentiating between domestic and foreign outsourcing it is evident that offshorers show a better performance than domestic outsourcers according to the different measures of export performance. In particular, it is worth to note that firms that offshore part of their R&D activities abroad export significantly more products, that are also more technologically advanced and have a higher unit value.

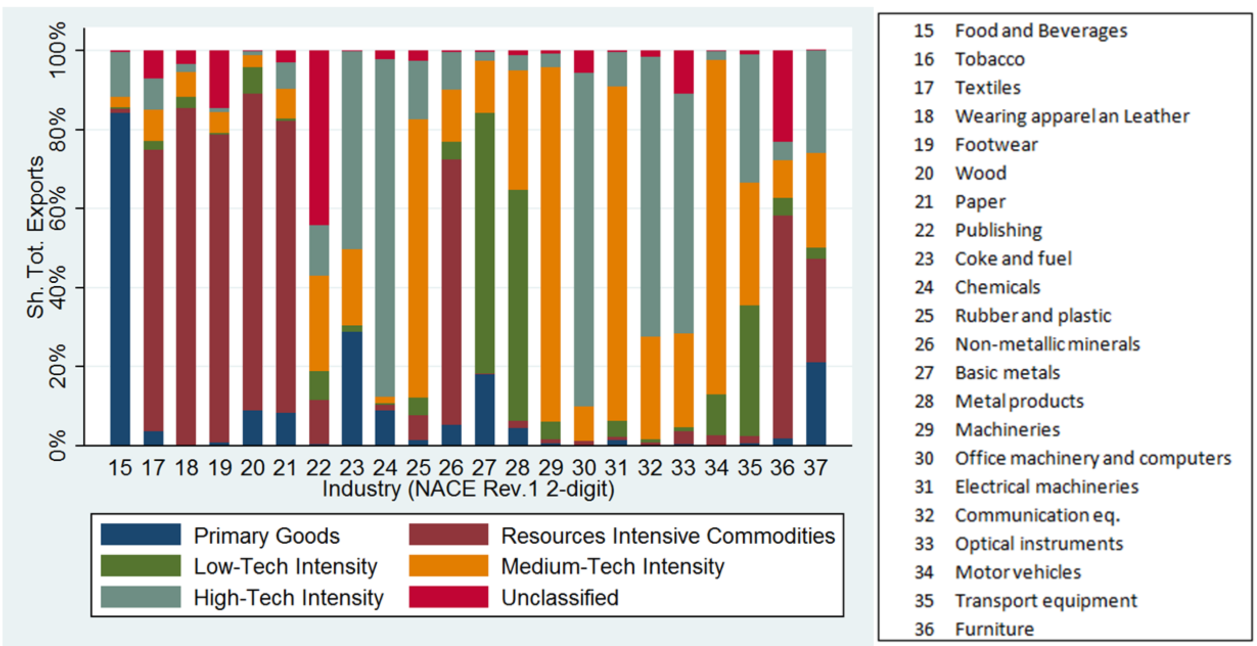
In addition, looking at the export destinations, firms conducting R&D abroad seem to be able to access more foreign markets. In particular, we are able to analyse which foreign markets are mostly targeted by R&D outsourcers. First, we differentiate between exports to extra-EU OECD and to non-OECD countries, in order to analyse whether external R&D activities help French firms to access difficult and far-away markets rather than developed countries. Interestingly, the share of total exports shipped to extra-EU OECD countries seems to be steady across the different groups, highlighting no particular relationship between R&D outsourcing and export to distant but highly developed countries. On the contrary, total exports to non-OECD members are significantly larger for R&D offshorers than for the rest of the innovators, suggesting a possible link between internationalised R&D activities and the access to distant, difficult but quickly growing markets. The previously discussed phenomena seem to be corroborated by the analysis of the Foreign Market Potential (FMP) index in Table 3.2.[4] We have used this index to build a weighted measure of market access for each exporter, averaging the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market. The new firm-level index represents the firm's strategy in international markets: firms with very high scores export mainly to close EU countries or other high-income OECD members which are usually the main trading partners of France. On the contrary, firms with a low FMP index tend to export on average to distant and difficult markets which are not the usual trade partners, mainly characterized by cultural and trade barriers. From the summary statistics in Table 3.2 it seems that R&D offshorers register on average a significantly lower score in respect to other categories, suggesting that these firms are able to export to more difficult or far away markets with a lower foreign market potential index, highlighting a possible connection between offshored innovating activities and market-access to difficult and distant countries as stressed in some previous studies.

In order to further analyse the relationship between external R&D and exports we report in Figure 3.4 the distribution of exported goods technological intensity across manufacturing industries in France. Thanks to the transaction-level dataset for all shipments provided by

[4]This index proposes an accurate estimate of each country's proximity to world markets, synthesizing the evolution of countries economic geography in international trade (Mayer 2009). As further explained in the appendix A.3.1, using a gravity model we have calculated this index for each country trading with France following the Head and Mayer (2004) approach, taking into consideration the sum per capita expenditure of all countries, weighted by bilateral trade costs and adjusting it to take into account the impact of national borders on trade flows. As shown in Figure A.3.1.1 in the appendix, countries which are closer to France, with very low trade barriers and a large internal potential market for French firms rank at the top of the FMP index, while distant and less attractive markets with high barriers to trade which are more difficult to access register very low scores in the FMP index.

the French Custom Agency we estimated the technological intensity of exports at the firm-level and then at the industry-level, by classifying all the products exported by French firms into 5 different categories (primary goods, resource-intensive commodities, low, medium and high-tech) according to the classification system of skill and technology content of products at the HS 6-digit level provided by Basu and Das (2011).

Figure 3.4: Technological Intensity of Exports across French Industries (mean value)

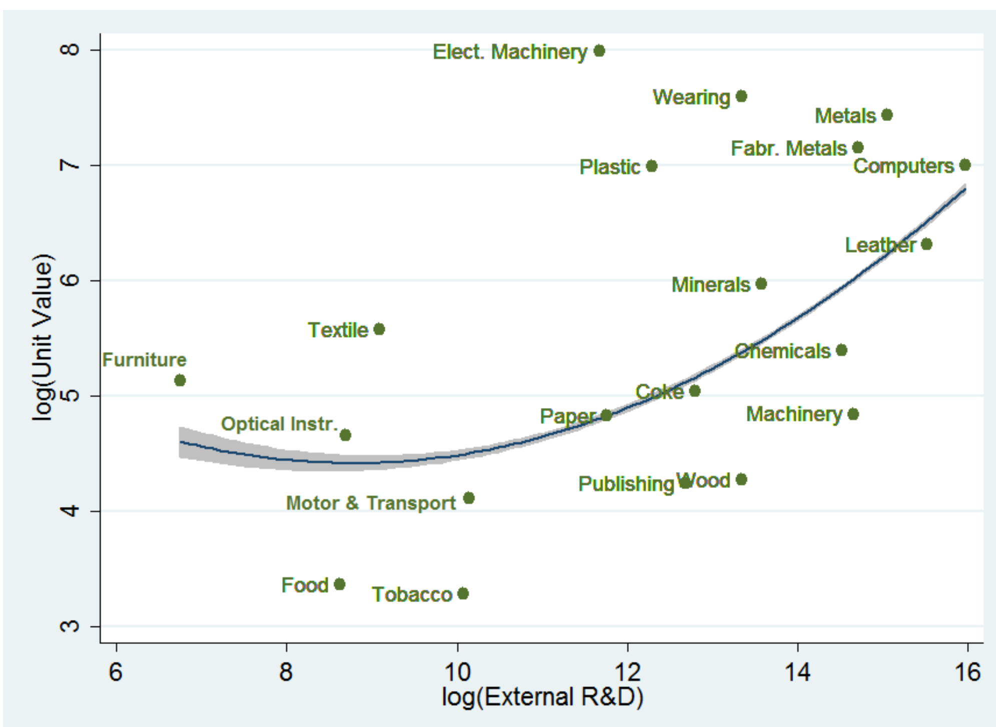


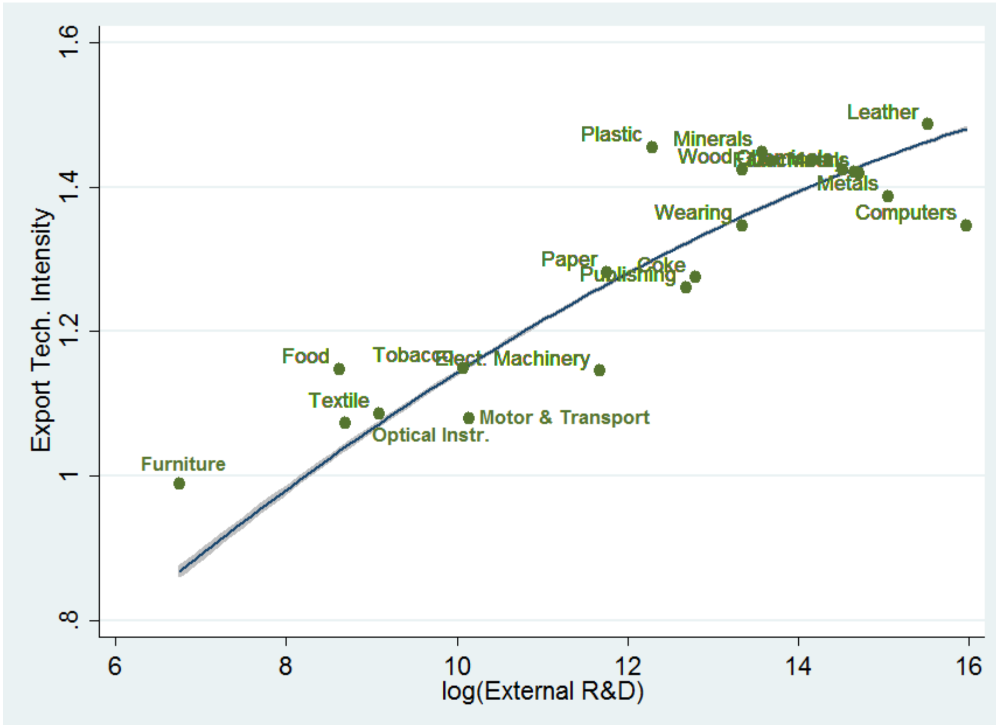
Note: Elaboration based on R&D survey and French Customs data, average between year 1999 and 2007 for all French manufacturing sectors according to the NACE rev.1.1 2-digit level industrial classification. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Shares calculated as percentage of firms total exports as reported in the Custom Agency dataset. Technological intensity of exports measured for each product exported by French firms at the HS-6 digit level then aggregated at the industry-level based on the UNCTAD classification of skill and technology content of products into 5 different categories: primary goods, resource-intensive commodities, low, medium and high-tech (Basu and Das 2011).

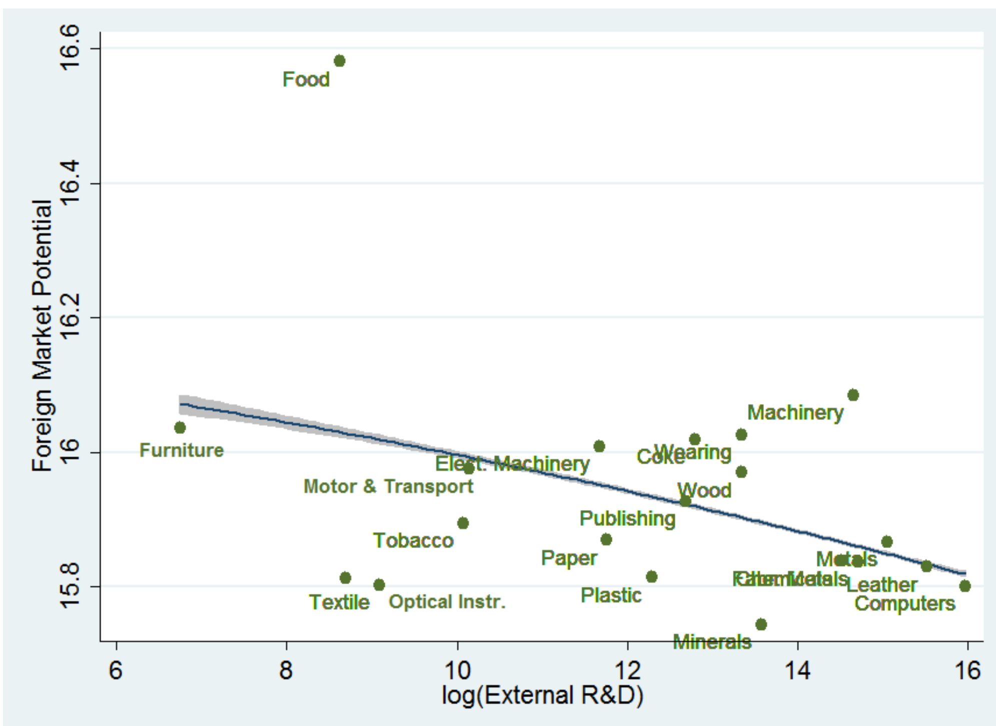
In particular, from Figure 3.4 notice that the manufacturing sectors with relatively higher technological intensity of exports are the same industries which have shown in Figure 3.2 to have a higher propensity towards externalised R&D activities, namely coke and nuclear fuel, chemicals, computers, electrical and optical machineries, communication equipment and transport equipment. In Figure 3.5 we further confirm this evidence by plotting the relationship between different measures of export performance and external R&D activities at the NACE rev.1.1 2-digit industry level.

Figure 3.5 corroborates the previous findings presenting a visual representation of the relationships linking export performance and external R&D activities at the industry level. In particular, it is possible to observe an extremely precise linear relationship between external R&D and firms' total exports. Industries externalizing a larger share of their R&D activities such as electronic devices, machineries and chemicals export more on average than other industries with lower levels of external R&D such as the food and textile industries. A similar relationship seems to arise when comparing external R&D and the technological intensity of goods exported abroad: also in this case, the more an industry is exposed to external R&D the higher is the tech-intensity of exports, especially in the case of computers, chemicals, plastic and metal goods. Finally, it is particularly interesting to note a negative linear relation between externalized R&D and the average market potential of exporters at the industrial level. As previously discussed, this index represents the proximity of a country to France as potential foreign market, providing an accurate measure of the attractiveness of a country as a foreign market in terms of its potential and of the difficulty of access: the higher is the ranking, the more open and attractive is the market to French firms. From Figure 3.5 it is evident that industries more prone to externalize R&D activities register on average a lower foreign market potential index, meaning that firms in these sectors tend to export on average to more difficult and distant markets not usually served by the vast majority of French exporters.

Figure 3.5: External R&D and Export Performance







Note: Linear correlation between industry-level external R&D and export performance. Elaboration based on R&D survey and French Customs data, average between year 1999 and 2007 for all French manufacturing sectors according to the NACE rev.1.1 2-digit level industrial classification. All monetary values deflated using OECD production price indexes at the industry-level for France in 2000 as a baseline. Total exports includes all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA). Unit value calculated as the average ratio between firm shipments value and weight or pieces as reported in the CA dataset. Export technological intensity measured at the firm-level as the average value of skill and technology content of each product exported by French firms at the HS-6 digit level based on the UNCTAD classification of products into 5 different categories: primary goods, resource-intensive commodities, low, medium and high-tech (Basu and Das 2011). Foreign Market Potential (FMP) index measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market. External R&D measured as the average total expenditure of firms in R&D activities outsourced both domestically or abroad to third public or private agents. 5% confidence interval reported as the shadowed area.

3.4 Methodology

In this chapter we are going to test empirically for the first time the above mentioned hypothesis at the firm level, investigating not only the effect of the complementarity between internal and external R&D activities on export performance, but also focusing on the impact of outsourced R&D on the total value of exports and on the destinations served by each exporter.

There are significant challenges posed by this empirical investigation, in particular in relation to the econometric estimation of the relationship between outsourced innovation and exports. The previous economic literature on this topic have identified two major problems, namely selectivity bias and simultaneity bias.

First, the selectivity problem arises from the fact that not all firms engage in innovation and even fewer decide to outsource part of their R&D activities. As previously stressed, our data focus on a group of French innovating firms not randomly drawn from a representative sample, but selected for a survey based on the total resources dedicated to innovative activities. In addition, as we have previously observed, only a small percentage of the French innovative firms are involved in the outsourcing of R&D activities, and even fewer of these participate in the international network of knowledge exchange. Therefore, R&D outsourcing could be considered to be endogenous, since firms decide whether to engage in these activities and then decide the extent of the resources dedicated to outsourced innovation according to the business strategies followed, their productivity and a number of other unobserved characteristics.

Related to this previous point, a second possible source of bias might arise, given that firms export performance might be endogenously related not only with the decision to outsource part of the innovating activities but also with the extent of these operations, creating thus a problem of simultaneity between exporting and R&D outsourcing strategies. As stressed in the previous literature, exporters might have a higher propensity towards outsourcing, dedicating more resources also to externalised R&D activities, generating a two-way causal link between these strategies. Previous theoretical and empirical studies have anticipated how exporters are more likely to undertake external R&D operations given their experience in the international markets, their higher productivity and the connections they might have with external suppliers of manufactured and innovation inputs (Cassiman and Veugelers 2006; Garcia-Vega and Huergo 2011; Garcia-Vega and Huergo 2013; Arvanitis et al. 2014). As a result, the estimators of the effect of external R&D on export performance would be correlated with the endogenous decision of outsourcing R&D activities and with the participation to international markets.

A seminal work by Crepon et al. (1998) provides an econometric approach for the solution of the joint selectivity and simultaneity bias by introducing a 4-stage model which considers the innovative process a series of different sequential stages with a causality link running from the decision to innovate, the extent of the innovative activities, the innovation output and finally its effect on firms' performance, but also considering the reverse causality. Using an asymptotic least square estimator and assuming the disturbance terms to be correlated across all different stages, the authors provide consistent estimates that corrects for both kind of bias. Building on this methodology, Loof and Heshmati (2006) implement a slightly different structural model that does not assume that all disturbances are correlated but separating instead the four-stages into two distinct parts, the selection equations which use an Heckman selection estimator and the analysis on the relationship between innovation and performance estimated using a three-stage least squares model.

Following the above mentioned econometric framework we address both the selectivity and simultaneity bias implementing a 3-stage model which takes into account first the firm R&D externalisation decision before analysing the relationship linking outsourced innovating activities and export performance. For the first part of our analysis we adopt an Heckman selection model in order to take into consideration firms' self-selection into R&D internationalization.

To solve for the first source of bias Heckman and Vytlacil (1998) suggest to replace the endogenous variables affected by self-selection in the model, such as the extent of external R&D activities in our case, with their predicted values which take into account the unobserved latent characteristics affecting the decision to undertake outsourced R&D.[5] In order to correct for this selection bias, in the first step of the Heckman model we estimate the decision of firm i to outsource part of its R&D activities to external agents:

$$\psi_{it} = \alpha_0 + \alpha_1 Z_{it-1} + k_j + k_t + \mathcal{E}_{it} \tag{3.1}$$

where ψ_{it} is an unobserved latent variable measuring the predicted utility of engaging in R&D outsourcing, Z_{it-1} is a vector of firm-level characteristics at time $t-1$ and k_j and k_t are vectors of industry and year fixed-effects. Since we only observe the value of externalised R&D activity as reported by French firms, we estimate the following selection equation using a probit model to describe the probability of R&D outsourcing conditional on a set of exclusion variables ψ_{it-1} which affects firm's outsourcing decision but not the extent of R&D activities externalized, in other words identifying the main determinants of R&D outsourcing,

[5] A number of different empirical papers use this econometric methodology in order to provide consistent estimators which consider the selectivity and simultaneous bias in the analysis of innovation and other empirical topics. See for instance: Crepon et al. (1998); David et al. (2000); Griffith et al. (2006); De Jong and Kemp (2003); Loof and Heshmati (2006); Bessler and Bittelmeyer (2008); Hashi and Stojcic (2013); Yu (2014); Feenstra et al. (2014); Siedschlag and Zhang (2015).

and where $\Phi(.)$ is the cumulative density function of the normal distribution (Cameron and Trivedi 2005):

$$Pr\left(y_{it}=1\right)=\Phi\left(\alpha_0+\alpha_1 Z_{it-1}+\alpha_2\psi_{it-1}+k_j+k_t+\mathcal{E}_{it}\right) \tag{3.2}$$

We explain the propensity of firms to outsource R&D activities as a function of different firm characteristics ψ_{it-1} which affect the likelihood of outsourcing but not its extent.

Following the previous literature, we use a different set of exclusion variables for each possible outsourcing activity, in order to identify the strategy followed and the main determinants of externalized R&D activities (Cameron and Trivedi 2005; Cantwell and Zhang 2011; Castelli and Castellani 2013; Dosso and Vezzani 2015). As factors driving R&D outsourcing we use firms share of domestic and foreign sales measured with respect to total sales to represent market seeking strategies, and the participation of a firm to domestic or foreign group to explain R&D cooperation with other French or foreign affiliates in addition to the standard control variables. In addition, we include public funds received to sustain the innovative efforts and the distance from the technological frontier, calculated as the difference between firms total patents and the average number of patents in the related industry, in order to detect any supply-driven strategy. In particular, when analysing the probability of outsourcing R&D activities domestically we use as a set of exclusion variables, the R&D funds received by public authorities, the participation in a French group, the share of domestic over total sales, and the distance from the industry-specific technological frontier. When considering the probability of offshoring R&D activities abroad we take into account the participation in a foreign-owned group, the share of foreign over total sales and the distance from the industry-specific technological frontier. Z_{it-1} represents a set of control variables at the firm level such as total employment, average salary of researchers, the log of labour productivity measured as the ratio between total sales and number of employees and the internal investment in R&D. All the regressors in the selection model have been lagged by one period to alleviate the potential endogeneity concerns and industry k_j and year dummies k_t have been included to control for any other macroeconomic shock.

Second, we move further by estimating in the second stage of our model the extent of R&D outsourcing E_{it} conditional on the externalisation decision. To do so, we include the inverse Mills ratio obtained in the first stage in this following step as an additional regressors in order to properly estimate the expected extent of firms external R&D activities:

$$E_{it} = \begin{cases} y^*_{it} = \beta_1 Z_{it-1} + \lambda\left(\hat{\beta}_2 E'_{it-1}\right) + k_j + k_t + \mu_{it} & \text{if } y_{it} = 1, \\ 0 & \text{if } y_{it} = 0. \end{cases}$$

where $\hat{\beta}_2$ is obtained from the first-step probit regression of y_{it} on E_{it-1} and $\lambda\left(\hat{\beta}_2 E'_{it-1}\right) = \phi\left(\hat{\beta}_2 E'_{it-1}\right)/\Phi\left(\hat{\beta}_2 E'_{it-1}\right)$ is the estimated inverse Mills ratio. Thus, estimating the previous equation with a generalised Tobit model we are able to implement an Heckman two-step selection procedure which provides the expected values of the firms extent of outsourcing $\bar{E}_{it}$, after controlling for the endogenous selection of firms into outsourced R&D activities, which will be consequently used to replace the actual measures of firms external R&D activities in the following estimation steps.

In the third stage of the estimation we analyse the relationship between externalised R&D activities and firm export performance. First, we are interested in understanding whether outsourced R&D substitutes for firms internal innovating capabilities or if instead both activities are needed to fully exploit the spillover effect to boost export performance. We test directly this complementarity hypothesis by estimating the effect of the interaction between internal

I_{it} and external R&D activities $\bar{E}_{it}$ on the different measures of export performance, using the fitted values for both innovating activities outsourced in France or offshored abroad. By estimating the following export function we should be able to test whether internal R&D capabilities are needed in order to internalize the positive externalities deriving from outsourced innovations and to check for the joint and complementary effect of these two activities $I_{it} * \bar{E}_{it}$ on firms export performance X_{it}:

$$X_{it} = \gamma_0 + \gamma_1 I_{it} * \bar{E}_{it} + \gamma_2 Z_{it} + k_j + k_t + \mathcal{E}_{X_{it}} \tag{3.3}$$

X_{it} represents the different measures of firm i export performance we consider at time t, namely the value of total exports and the Foreign Market Potential (FMP) index. As previously stressed, we include all the main covariates of interest in $\bar{E}_{it}$ which identifies the different expected values of firm i outsourced R&D activities estimated from the previous 2-step Heckman model. In particular, we are interested in dissecting the impact of externalized R&D differentiating between activities outsourced in France or offshored abroad, and distinguishing as well between those activities carried out within the business group boundary or outsourced to third external agents. The previous literature on this topic in fact show how corporate characteristics and strategies affect the outcome of outsourced activities, especially in the case of R&D (e.g. Santangelo 2002; Cassiman and Veugelers 2006; Criscuolo et al. 2010; Fu et al. 2012). For this reason, we further dissect the effect of externalised R&D activities on exports by differentiating between firms that are part of domestic or foreign-owned groups and according to the industry technological intensity as defined by the UNCTAD classification (Basu and Das 2011). In this way, it is possible to identify the effect of external R&D on exports according to the different firm-level characteristics and the strategies followed after controlling for a set of standard firm-level control variables Z_{it} and year-industry fixed effects k_t and k_j.

Second, as stressed in the previous literature, the decision and the extent of R&D outsourcing may be explained by the international activities of firms, since exporters might exploit their experience in the international markets, their higher productivity and the connections they have with external suppliers in order to profit the most from externalised R&D activities. We test this simple linear relationship by estimating the effect of several measures of export performance X_{it} such as total exports and the FMP index on the expected value of different external R&D activities $\bar{E}_{it}$ outsourced in France or abroad, within or outside the group boundaries:

$$\bar{E}_{it} = \gamma_0 + \gamma_1 X_{it} + \gamma_2 I_{it} + \gamma_3 Z_{it} + k_j + k_t + \mathcal{E}_{E_{it}} \tag{3.4}$$

Also in this case we control for the contribution of internal R&D resources I_{it} to the innovation outsourcing process and for a set of standard firm-level control variables Z_{it} such as total employment, researchers average salary, labour productivity and affiliation to a French or a foreign group. Year k_t and NACE rev.1.1 2-digit-level industry k_j fixed effects are included to control for time and industry specific shocks.

In the model by Crepon et al. (1998) the authors assume the existence of full correlation between the error terms of the four stages of estimation of the innovation process. Loof and Heshmati (2006) in their model relax this condition by assuming just a partial correlation between disturbance terms. Our estimation strategy is based on this latter, assuming that the disturbance terms from the first two stages, the decision to outsource R&D activities and its extent, are correlated with each other on the basis of unobservable characteristics of firms. For this reason, we estimate jointly the first two steps using a generalised tobit. Nevertheless, a second potential endogeneity problem in our model is due to the two-way causality link connecting externalised R&D activities and export performance since the explanatory variables might be jointly determined with the dependent variable. In this case the assumption about the absence of correlation between disturbances and explanatory variables $E(X_{it}, \mathcal{E}_{E_{it}})$ and $E(\bar{E}_{it}, \mathcal{E}_{X_{it}})$ will be violated and will not be exogenously determined, leading to biased and inconsistent OLS estimators due to the violation of the non-autocorrelation assumption $cov(\mathcal{E}_{E_{it}}, \mathcal{E}_{X_{it}}) \neq 0$.

For this reason, in the final stage of our estimation strategy equations 3.3 and 3.4 will be part of a system of simultaneous equations in which export-performance at the firm level will appear as a dependent variable in the first equation but will be considered as an independent variable in explaining the extent of outsourced R&D in the second equation and vice versa, under the condition that firm i is externalising part of its R&D activities.

There are two main methods of estimation for systems of simultaneous equations, least squares and maximum likelihood models. Both three-stage least squares (3SLS) and full information maximum likelihood (FIML) system methods use information concerning the endogenous variables present in a system and take into account the error covariances across equations, hence providing estimators which are asymptotically efficient in the absence of specification error. In addition, SUR methods can also be used in order to improve the efficiency of parameter estimates. Like the OLS estimator, SUR methods assume that all the regressors are independent variables, but are able to improve the regression efficiency by estimating the matrix of contemporaneous correlation among error terms across equations using OLS residuals.

For the main set of results we estimate our model using both full information maximum likelihood and three-stage least squares methodologies. The least squares simultaneous equations framework applied to the final stage of our model allows us to overcome the simultaneity bias problem and to derive consistent estimators of the effect of external R&D on export performance, controlling for potential reverse causality with proper instruments (Hornstein and Greene 2012). The 3SLS method combines the features of least squares and SUR methods. As in other least squares estimators, the 3SLS method uses $\hat{Y}$ instead of Y for endogenous regressors, resulting in consistent estimates. As with SUR methods, the 3SLS approach takes the cross-equation error correlations into account to improve large sample efficiency (Wooldridge 2010). The three-stage least squares method requires three different steps. In the first-stage regression the model gets the predicted values for the endogenous regressors. In the second step a two-stage least squares is applied to get the residuals to estimate the cross-equation correlation matrix which is then used in the final 3SLS estimation step. In contrast to the 3SLS, the FIML method involves the minimization of the determinant of the covariance matrix associated with residuals of the system of equations. The maximum likelihood methods assume that the errors are normally distributed and the likelihood function is maximized subject to restrictions on all of the parameters in the system, not just those in the equation being estimated (Heckman 1979). The standard errors are bootsrapped in order to correct for the bias induced by the inclusion of predicted regressors from the previous two-steps of the Heckman selection model and clustered to consider the panel nature of our data. In the next section, we present as main set of results the estimation of the full information maximum likelihood. In addition, as alternative methods, Tables A.3.2.1-A.3.2.12 of the appendix present the results estimating the final stage of our model using the three-stage least squares (3SLS) and seemingly unrelated regression (SUR) approaches to test the robustness of our main results and to demonstrate the necessity of taking into account the interdependence between externalised R&D activities and export performance to derive consistent and unbiased estimators.

Finally, Tables A.3.2.13-A.3.2.15 of the appendix report the results of the estimation of the systems of equations considering the relationship between external R&D and total exports using a FIML model using a survey data analysis framework. As previously explained, the R&D dataset we use for our analysis is based on an annual survey partially based on the structure of the previous surveys conducted and consists of four different strata. Three of these strata are exhaustive and form the principle component of the survey (all the firms with an internal R&D expenditure above €350,000), while a fourth strata of the survey is composed of a sample of remaining companies which dedicate a smaller amount of resources to R&D. The sample of the fourth strata is renewed every year, keeping half of the previous year's sample and including as a second half other innovating firms not included in the previous survey. Survey data usually differ from comprehensive datasets in terms of the design and details of the data collection procedure. For these reasons, in order to find robust estimators in our model we should take into account the sampling weights which measure the different probability of selection for each observation, the cluster sampling applied to consider that individuals are not sampled independently and the stratification of the data collection. Using a survey data analysis approach we are able to get point estimates corrected by the sampling weights, and considering the weighting, clustering, and stratification of the survey design it is possible to estimate more precisely the standard errors given the overall sample size (Heeringa et al. 2010). However, by using only the R&D survey data we restrict our analysis just to total exports, the only export performance variable provided in the R&D dataset.

3.5 Results

In this section we present the estimation results for the relationship connecting outsourced R&D activities and export performance at the firm level, investigating the impact of the complementarity between internal and external R&D activities on export performance, and carefully analysing the effect of external R&D on the total value of exports and on the destinations served by each exporter. For this study we take into consideration both R&D activities externalised domestically and abroad, within the group boundaries or outsourced at the arm's-length. In addition, in our analysis we distinguish between domestic and foreign owned firms to study the joint role played by foreign ownership in firms participation in knowledge exchange networks and in export activities, and differentiating as well between firms in high and low-tech industries to analyse the different strategies followed by innovating leaders and laggards. In order to tackle the selectivity and simultaneity bias posed by the econometric analysis of the relationship between outsourced innovation and export performance we have built a system of equations in which, after controlling for self-selection into knowledge exchange networks, the two-way causality is modelled as export activities affecting the likelihood of R&D outsourcing, and conversely external innovations improving or deprecating the export performance of firms.

We start our analysis by looking at the estimation results of the 2-step Heckman selection model in Table 3.3 used to estimate the expected values of externalised R&D activities taking into account the self-selection bias. Different sets of regressors have been used as exclusion variables in the bivariate sample-selection estimations for R&D outsourced in France or abroad that are expected to affect firms decisions to externalise R&D but not the extent of these activities in the second step. In the case of R&D activities offshored abroad we included in the first-step the affiliation to a foreign group, the share of total sales to foreign markets and the distance from the industrial technological frontier. In this way we should be able to identify the main drivers of R&D internationalization, in order to understand whether these activities are influenced by market or supply-driven factors. From the first-step probit estimations we can observe that offshored R&D activities are mainly market-driven, since the share of foreign markets over total sales has a positive and statistically significant effect on the probability of externalizing innovative activities abroad, in particular in panel C when outsourcing outside the group boundaries. In addition, the affiliation to a foreign group does play a role in promoting international R&D cooperation and the creation of knowledge networks in particular with other affiliates within the same group. On the contrary, the distance of firms from the industrial technological frontier in terms of patents does not appear to affect the internationalization of R&D activities, suggesting that French firms do not offshore R&D abroad due to supply-driven factors such as the need to access more advanced technologies from renowned laboratories and R&D centres in foreign countries.

For R&D activities domestically outsourced in France in panel D, E and F we have included as exclusion variables in the first-step the share of domestic sales, the affiliation to a French group, the distance from the industrial technological frontier and the total amount of public funds received to support corporate R&D efforts. From the first-step probit estimations in columns 7, 9 and 11 of Table 3.3 observe that public funds have a positive effect on the probability of outsourcing R&D activities in France, highlighting the key role played by public resources and subsidies in promoting cooperation and innovative joint-ventures between French firms, public authorities and private laboratories. The affiliation to a French group increases the probability of externalizing R&D activities in France to other affiliates that are part of the same group in column 9, while domestic sales do not have any significant effect in determining the likelihood of outsourcing R&D domestically, suggesting how these activities do not seem to be driven by domestic-market-factors. Interestingly, in column 11 the distance from the technological frontier has a positive effect on the probability of externalizing R&D activities at the arm's-length to other French extra-group agents. This suggests that French firms lagging behind in the innovative race might outsource R&D activities to other domestic firms in order to access particular key technologies not available in-house,

Table 3.3: Estimation of propensity and extent of R&D outsourcing using a Heckman two-step bivariate selection model.

Heckman two-step	(A) Offshoring R&D		(B) Offshoring R&D IN		(C) Offshoring R&D OUT	
	(1)	(2)	(3)	(4)	(5)	(6)
	1st Step	2nd Step	1st Step	2nd Step	1st Step	2nd Step
$Employment_{it-1}$	0.105**	0.129***	0.212***	0.755***	0.0300	0.0807***
	(0.0437)	(0.0334)	(0.0582)	(0.0889)	(0.0494)	(0.0220)
$Av.Salary_{it-1}$	-0.0623	-0.125***	-0.0439	-0.199***	0.0159	-0.0429
	(0.0812)	(0.0443)	(0.113)	(0.0390)	(0.0979)	(0.0345)
$Lab.Productivity_{it-1}$	0.196***	0.195***	0.418***	1.459***	0.117**	0.153***
	(0.0516)	(0.0426)	(0.0720)	(0.167)	(0.0563)	(0.0346)
$InternalR\&D_{it-1}$	0.273***	0.354***	0.246***	0.918***	0.287***	0.415***
	(0.0381)	(0.0462)	(0.0490)	(0.0944)	(0.0434)	(0.0631)
$ForeignSales_{it-1}$	0.0128*		0.00722		0.0148*	
	(0.00726)		(0.00908)		(0.00824)	
$ForeignGroup_{it}$	0.282***		0.617***	2.045***		
	(0.0798)		(0.1000)	(0.242)		
$Tech.Frontier_{it-1}$	0.0002		0.0001		0.0002	
	(0.0003)		(0.0003)		(0.0004)	
$InverseMillsRatio$		0.329*		3.356***		0.898***
		(0.172)		(0.414)		(0.235)
Observations	11,178	11,173	11,178	11,109	11,178	11,173
No.Firms	3,069	3,067	3,069	3,043	3,069	3,067
Heckman two-step	(D) R&D Outsourced France		(E) R&D Outs. France IN		(F) R&D Outs. France OUT	
	(7)	(8)	(9)	(10)	(11)	(12)
	1st Step	2nd Step	1st Step	2nd Step	1st Step	2nd Step
$Employment_{it-1}$	0.129***	0.149***	0.161***	0.0112	0.102***	0.124***
	(0.0329)	(0.0345)	(0.0479)	(0.0261)	(0.0325)	(0.0348)
$Av.Salary_{it-1}$	-0.125**	-0.212***	0.0710	-0.0758**	-0.0994*	-0.260***
	(0.0573)	(0.0571)	(0.0944)	(0.0380)	(0.0578)	(0.0575)
$Lab.Productivity_{it-1}$	0.170***	0.176***	0.268***	0.00146	0.102***	0.186***
	(0.0379)	(0.0398)	(0.0580)	(0.0350)	(0.0378)	(0.0385)
$InternalR\&D_{it-1}$	0.134***	0.416***	0.0905**	0.0927***	0.185***	0.471***
	(0.0309)	(0.0350)	(0.0446)	(0.0236)	(0.0306)	(0.0475)
$R\&DPublicFunds_{it-1}$	0.0984***		0.0782***		0.0605***	
	(0.0127)		(0.0166)		(0.0121)	
$DomesticSales_{it-1}$	-0.153		-0.152		-0.00877	
	(0.117)		(0.163)		(0.116)	
$FrenchGroup_{it}$	0.0557		0.550***	0.0682		
	(0.0576)		(0.0784)	(0.0657)		
$Tech.Frontier_{it-1}$	0.0004		0.0001		0.0008*	
	(0.0004)		(0.0003)		(0.0004)	
$InverseMillsRatio$		-0.673***		-0.467***		0.596**
		(0.190)		(0.109)		(0.254)
Observations	11,156	11,156	11,156	11,151	11,156	11,156
No.Firms	3,064	3,064	3,064	3,062	3,064	3,064

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification. The estimator used is a Heckman two-step bivariate selection model with year and industry dummies included but not reported. First-step estimated using a panel probit model, second-step using a panel tobit model. Robust standard errors reported in parentheses. Statistical significance: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Constant term is included but note reported. The dependent variables in the first-steps are dummy variables equal to 1 if firm reports positive expenditure in the specific external R&D activity and 0 otherwise. In the second-steps the dependent variables are measured as the log value of firm expenditure in each specific external R&D activity. *R&D outsourced France* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France. *Offshoring R&D* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents. *Offshoring R&D IN* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group. *R&D Outs. France IN* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group. *R&D Outs. France OUT* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group. *Offshoring R&D OUT* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. As independent variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, internal R&D measures the firm total expenditure in internal R&D activities, R&D public funds is the log value of the total resources received from French, foreign and international public authorities to stimulate private firms innovative activities, domestic and foreign sales are the log values of firms total sales in France or abroad, technological frontier is calculated as the difference between firms total patents and the average number of patents in the related industry, the inverse Mills ratio is the ratio of the probability density function to the cumulative distribution function of a distribution estimated in the first-step, while foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. Control variables total employment, average salary, labour productivity, internal R&D, domestic and foreign sales, R&D public funds and technological frontier are lagged one year while foreign and French group dummies refer to time t like the dependent variable.

probably to private-owned R&D labs at the edge of the technological frontier. These results, together with the previous evidence, show that while R&D activities offshored abroad seem to be mainly driven by market-driven factors such as the increase in foreign sales, domestically outsourced innovations instead are mainly oriented towards more supply-driven exigencies, such as the access to specialised and more advanced technologies or the intra-group reorganisation and rationalisation of R&D activities.

After estimating the probability of externalising R&D activities domestically and abroad, within or outside the group, we include the computed inverse Mills ratio obtained in the first-step probit estimations in the second-step of the Heckman model as additional regressor. In this way, we are able to properly estimate the expected extent of firms external R&D activities after controlling for the endogenous self-selection of firms into outsourced R&D activities. The tobit estimations of the second-step in columns 2, 4, 6, 8, 10 and 12 confirm the previous results, since the estimated coefficients are consistent in magnitude and statistical significance with the previous ones from the first-step and the inverse Mills ratios estimated in the first-step are always statistically significant. Thus, after controlling for the endogenous self-selection of firms into R&D outsourcing, we obtain the fitted values of firms extent of outsourcing, both domestically or abroad and within or outside the group, which is used in the following systems of equations in order to replace the measures of firms' actual extent of outsourcing R&D and is interacted with the value of resources dedicated to internal innovating activities in order to analyse their joint and complimentary impact on firms export performance. For the main set of results we use a full information maximum likelihood model (FIML) assuming that the errors are normally distributed and the likelihood function is maximized subject to restrictions on all of the parameters in the system, not just those in the equation being estimated.

First, in Table 3.4 we investigate the complementary effect of internal and external R&D activities on firms total exports using a FIML model. In panel A we analyse the system of equations considering both R&D activities offshored abroad and domestically outsourced and firms total exports. In the following 5 columns in panel B we break down offshored and domestically outsourced R&D in order to disentangle the relationship between total exports and innovating activities outsourced within or outside the group boundaries both domestically or abroad. From a preliminary analysis of the main control variables our results are in line with the previous empirical studies. In both panel A and B firms size and productivity in terms of labour force matter both for externalised R&D activities and for total exports, always positively affecting their extent. Also internal R&D resources have a positive and statistically significant impact on the externalisation of innovating activities and on the value of foreign sales, suggesting an interdependence between trade, internal and external R&D resources. On the contrary, researchers average salary seems to have a positive and significant impact on the extent of the R&D externalisation, but does not affect significantly the value of firms total exports in columns 3 and 8. Moreover, the affiliation to a foreign group significantly affects the movement of R&D activities to foreign firms within the same group in column 4, while by being part of a French group firms are more prone to externalise both domestically and abroad. However, while foreign ownership positively affects total exports in column 8, the affiliation to a French business group seems to reduce firms participation to international markets, with a negative and significant effect on foreign sales. Similarly, total exports have a different effect on offshored and domestically outsourced R&D activities. On the one hand, foreign sales and the experience in international markets have a positive and significant impact on the predicted extent of innovating activities outsourced abroad in column 1, but with diametrically opposed impacts when disaggregating between activities offshored to other firms part of the same group or at the arm's-length outside the group boundaries in columns 4 and 5. On the other hand, firms export activities are negatively related with domestically outsourced R&D in column 2, in particular when externalised to French firms not belonging to the same business group in column 7, possibly highlighting the strategies driving firms internationalisation and the domestic externalisation of innovating activities.

After correcting for both selectivity and simultaneity bias, it is possible to analyse the joint impact of internal and externalised R&D activities on firms total exports in column 3 and 8 of Table 3.4. First, note in column 3 that the complementarity between internal and external R&D has opposite effects on total exports when considering innovating activities offshored abroad or outsourced domestically. In fact, the interaction between internal and offshored R&D positively affects total exports, while domestically outsourced innovating activities seem to decrease firms presence abroad. The results are even more interesting when disaggregating offshored and domestically outsourced R&D into activities externalised within or outside the group boundaries in column 8. Column 8 shows a clear difference between R&D outsourced to other affiliates or to external third agents. The interaction between internal and offshored R&D activities to foreign affiliates in fact has a significantly negative impact on firms total exports, while the complementarity between internal resources and R&D offshored abroad to external firms positively affects the value of foreign sales. On the contrary, the complementarity with outsourcing domestically to extra-group French firms seems to negatively affect firms export performance but no significant effect has been detected when considering the interaction between internal resources and R&D activities outsourced to French affiliates. Finally, the covariances between the error terms of externalised R&D and total exports in column 3 and 8 are always statistically significant, except in the case of innovating activities domestically outsourced to French affiliates. This result justifies the adoption of the FIML system of equations to take into account for the simultaneity between outsourced R&D and firms export performance given that the non-autocorrelation assumption is violated and the

Table 3.4: Estimation results of the total exports and external R&D system of equations using a FIML model.

TOTAL EXPORTS	[A]			[B]				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Off.(IN)$	$Off.(OUT)$	$Dom.(IN)$	$Dom.(OUT)$	$Tot.Exports$
$Employment_{it-1}$	0.324***	0.464***	2.017***	0.214***	0.164***	0.178***	0.473***	0.950***
	(0.00577)	(0.0101)	(0.0963)	(0.00423)	(0.00377)	(0.00313)	(0.00884)	(0.0889)
$Av.Salary_{it-1}$	0.0611***	0.0386	0.215	0.0244***	0.0565***	0.0427***	0.0364*	-0.0502
	(0.0136)	(0.0261)	(0.258)	(0.00749)	(0.00903)	(0.00740)	(0.0206)	(0.229)
$Lab.Productivity_{it-1}$	0.210***	0.227***	1.736***	0.173***	0.0637***	0.121***	0.277***	1.180***
	(0.0110)	(0.0210)	(0.178)	(0.00701)	(0.00725)	(0.00623)	(0.0170)	(0.158)
$InternalR\&D_{it-1}$	1.048***	2.403***	3.319***	0.514***	0.562***	0.615***	1.893***	3.566***
	(0.0658)	(0.114)	(1.049)	(0.0390)	(0.0354)	(0.0392)	(0.0943)	(0.919)
$ForeignGroup_{it}$	0.0509***	0.0135	-0.0819	0.101***	0.000899	-0.00978	0.0370	0.572**
	(0.0173)	(0.0310)	(0.317)	(0.00962)	(0.0111)	(0.00913)	(0.0262)	(0.284)
$FrenchGroup_{it}$	0.0400**	0.118***	-0.134	-0.000482	0.0337***	0.297***	0.0675***	-0.617**
	(0.0166)	(0.0294)	(0.295)	(0.00908)	(0.0104)	(0.00923)	(0.0254)	(0.264)
$Tot.Exports_{it-1}$	0.0301***	-0.0454***		-0.0238***	0.00479***	0.00102	-0.0250***	
	(0.00136)	(0.00243)		(0.000714)	(0.000979)	(0.000645)	(0.00221)	
$Int * Offsh.R\&D_{it-1}$			5.198***					
			(0.602)					
$Int * Outs.Dom.R\&D_{it-1}$			-9.766***					
			(1.122)					
$Offsh.R\&D_{it-1}$			2.564**					
			(1.058)					
$Outs.Dom.R\&D_{it-1}$			-2.524***					
			(0.559)					
$Int * Offsh.(IN)_{it-1}$								-5.216***
								(0.853)
$Int * Offsh.(OUT)_{it-1}$								19.36***
								(1.686)
$Int * Outs.Dom.(IN)_{it-1}$								1.019*
								(0.606)
$Int * Outs.Dom.(OUT)_{it-1}$								-5.983***
								(0.642)
$Offsh.(IN)R\&D_{it-1}$								0.624
								(0.675)
$Offsh.(OUT)R\&D_{it-1}$								-21.33***
								(1.787)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.116
								(0.547)
$Outs.Dom.(OUT)R\&D_{it-1}$								8.847***
								(0.667)
$var(\mathcal{E})$	0.103***	0.353***	6.989**	0.0326***	0.0407***	0.0315***	0.247***	7.722***
	(0.00337)	(0.0108)	(3.404)	(0.00137)	(0.00142)	(0.00109)	(0.00767)	(3.685)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			-1.981***					
			(0.0585)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			3.216***					
			(0.0977)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								0.312***
								(0.0241)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								-1.427***
								(0.0436)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								-0.0084
								(0.0114)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								2.335***
								(0.101)
Observations	7,860	7,860	7,860	7,860	7,860	7,860	7,860	7,860

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\epsilon)$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Total exports*** measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

covariances of error terms between equations are significantly different from 0.

This evidence highlights a complex and comprehensive picture of the relationship between firms total exports and externalised R&D activities. First, firms export performance seems to positively affect only the extent of innovating activities offshored abroad to extra-group firms, while it has negative or no significant impact on domestically outsourced R&D. Secondly, the interaction between internal R&D and outsourced innovating activities has contrasting effect on the value of total exports. On the one hand, despite keeping part of their innovating activities in-house, firms outsourcing R&D domestically reduce the value of their exports, in particular if externalising to extra-group French firms. On the other hand, firms total exports seem to be positively affected by the complimentary effect of internal and offshored R&D activities, in particular when externalising to extra-group foreign firms. This is the first evidence to suggest that internal innovating capabilities still matter, allowing firms to absorb the positive spillovers of the externalised activities. In addition, by offshoring to a group foreign partner firms might reduce their total exports. This might be due to the rationalisation and relocation of R&D resources and production processes to a foreign subsidiary part of the same group, thus serving the foreign market with a local branch rather than exporting. On the contrary, by exploiting foreign knowledge not available in-house or within the group, French firms might be able to improve their exports value profiting from positive knowledge spillovers from more specialized R&D centres or with an improved knowledge of the foreign market. On the contrary, R&D domestically outsourced in France to extra-group agents seems to have a negative impact on total exports probably because these activities are mainly driven by domestic and supply-driven factors and by the possibility of reducing the distance from the technological frontier as previously shown in the Heckman selection model in Table 3.3.

We further develop our analysis by investigating the relationship between firms externalised R&D and the Foreign Market Potential (FMP) index in Table 3.5, in order to assess the role played by outsourced innovating activities in shaping firms international market access strategies. In panel A we estimate the system of equations using a FIML model considering the firm-level FMP index and both R&D activities offshored abroad and domestically outsourced, while in the following 5 columns in panel B we break down offshored and domestically outsourced R&D differentiating between innovating activities outsourced within or outside the group boundaries both domestically or abroad.[6]

From a brief analysis of the covariates in the different equations, observe that the statistical significance and magnitude are consistent with Table 3.4, since firm size, labour productivity, salaries paid and internal R&D activities are all important determinants of the predicted extent of outsourced innovation. However, it is interesting to look at the foreign market potential equations in column 3 and 8. In fact, labour productivity and internal R&D have a negative and statistically significant impact on the firm-level FMP index. As explained in appendix A.3.1, firms scoring a relatively lower FMP index tend to export on average a larger share of their total foreign sales to more distant markets, which are not the usual trade partners of France, and are more difficult to access. Thus, productivity and the resources dedicated to internal R&D seem to help firms to access unusual, far-away and difficult foreign markets. However, foreign ownership does not affect firms FMP index, while being part of a French group has a positive and significant effect in column 8, meaning that French groups tend to export to the usual high-income trade partners of France such as countries part of the EU single market and other OECD members. Interestingly, foreign market-access strategies seem to be significantly related with firms R&D outsourcing activities. As we can see from column 2, higher values of FMP index are positively related with R&D activities domesti-

[6] The number of observations in the FMP index analysis is slightly lower than the total exports regression because it has not been possible to calculate a firm-level FMP index for all the firms in our sample.

Table 3.5: Estimation results of the FMP index and external R&D system of equations using a FIML model.

FMP INDEX	**[A]**			**[B]**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Off.(IN)$	$Off.(OUT)$	$Dom.(IN)$	$Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.276***	0.557***	-0.115	0.203***	0.170***	0.181***	0.469***	-0.387***
	(0.00593)	(0.0101)	(0.0917)	(0.00457)	(0.00388)	(0.00343)	(0.00931)	(0.0899)
$Av.Salary_{it-1}$	0.0565***	0.0447*	0.0670	0.0240***	0.0501***	0.0432***	0.0468**	-0.0996
	(0.0137)	(0.0254)	(0.175)	(0.00798)	(0.00869)	(0.00788)	(0.0221)	(0.166)
$Lab.Productivity_{it-1}$	0.176***	0.341***	-0.248*	0.175***	0.0829***	0.131***	0.287***	-0.494***
	(0.0120)	(0.0195)	(0.138)	(0.00726)	(0.00756)	(0.00662)	(0.0173)	(0.133)
$InternalR\&D_{it-1}$	1.020***	2.499***	-4.110***	0.491***	0.562***	0.618***	1.912***	-2.724***
	(0.0623)	(0.121)	(1.011)	(0.0369)	(0.0375)	(0.0406)	(0.0958)	(0.785)
$ForeignGroup_{it}$	-0.0674***	0.0281	-0.348	0.0938***	-0.00287	-0.0126	0.0297	-0.266
	(0.0173)	(0.0302)	(0.217)	(0.0102)	(0.0111)	(0.00986)	(0.0269)	(0.216)
$FrenchGroup_{it}$	0.0635***	0.117***	0.324	0.00981	0.0405***	0.305***	0.0878***	0.374*
	(0.0165)	(0.0290)	(0.200)	(0.00969)	(0.0107)	(0.00998)	(0.0259)	(0.196)
$FMPIndex_{it-1}$	-0.0223***	0.0461***		0.0120***	-0.00978***	0.000467	0.0336***	
	(0.00228)	(0.00425)		(0.00128)	(0.00144)	(0.00112)	(0.00371)	
$Int*Offsh.R\&D_{it-1}$			-8.267***					
			(1.610)					
$Int*Outs.Dom.R\&D_{it-1}$			4.386***					
			(0.851)					
$Offsh.R\&D_{it-1}$			3.978***					
			(1.507)					
$Outs.Dom.R\&D_{it-1}$			-2.890***					
			(0.787)					
$Int*Offsh.(IN)_{it-1}$								4.557***
								(1.002)
$Int*Offsh.(OUT)_{it-1}$								-13.59***
								(1.716)
$Int*Outs.Dom.(IN)_{it-1}$								-0.177
								(0.831)
$Int*Outs.Dom.(OUT)_{it-1}$								3.812***
								(0.815)
$Offsh.(IN)R\&D_{it-1}$								-1.781**
								(0.721)
$Offsh.(OUT)R\&D_{it-1}$								13.75***
								(1.733)
$Outs.Dom.(IN)R\&D_{it-1}$								0.126
								(0.721)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.474***
								(0.735)
$var(\mathcal{E})$	0.0824***	0.301***	42.75***	0.0300***	0.0331***	0.0304***	0.226***	54.32***
	(0.00278)	(0.00992)	(4.299)	(0.00129)	(0.00114)	(0.00113)	(0.00742)	(5.510)
$cov(\mathcal{E}_{Off}*\mathcal{E}_{FMP})$			1.311***					
			(0.0746)					
$cov(\mathcal{E}_{Dom}*\mathcal{E}_{FMP})$			-2.276***					
			(0.129)					
$cov(\mathcal{E}_{Off.IN}*\mathcal{E}_{FMP})$								-0.160***
								(0.0224)
$cov(\mathcal{E}_{Off.OUT}*\mathcal{E}_{FMP})$								1.000***
								(0.0573)
$cov(\mathcal{E}_{Dom.IN}*\mathcal{E}_{FMP})$								0.0171
								(0.0150)
$cov(\mathcal{E}_{Dom.OUT}*\mathcal{E}_{FMP})$								-2.069***
								(0.127)
Observations	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\epsilon)$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and FMP index equations. Statistical significance: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

cally outsourced in France, mainly driven by innovations externalised at the arm's-length as suggested in columns 6 and 7. On the contrary, in the first equation we estimated a negative and significant relationship between firm-level FMP index and offshored R&D, highlighting that firms exporting to high-income and easily accessible markets are less engaged in the externalisation of innovating activities abroad. Looking at columns 4 and 5, this result seems to be mainly driven by offshoring innovating activities to foreign extra-group companies, while the FMP index is still positively related with the externalisation of R&D to other foreign affiliates that are part of the same group.

This relationship is reflected in the analysis of the impact of internal and external R&D complementarity on the FMP index of firms in columns 3 and 8. In fact, offshored R&D combined with internal innovating activities has a negative impact on the FMP index, stressing that by externalising R&D activities abroad French firms are able to access more difficult and distant foreign markets. On the contrary, domestically outsourced innovating activities have a complementary positive impact on the index, pushing firms to exports towards closer and developed foreign markets. This trend is confirmed by the disaggregated analysis. In fact, only R&D activities offshored to extra-group firms have a negative impact on the FMP index, while both activities externalised to foreign affiliates and to other domestic firms tend to increase the FMP index of French exporters.

Indeed, the interaction between internal innovating capabilities and R&D activities offshored outside the group boundaries could not only help French exporters to access new and difficult markets by internalising the external spillovers and acquiring direct knowledge about the taste and needs of local customers. It could help exporters as well in tailoring the products exported for markets characterized by a lower-income demand. For instance, by offshoring the most standardized R&D processes abroad, French exporters could cut down the marginal cost of innovative exported products, adapting them to the local needs and quality standards. As previously stressed, this activity might reduce the overall value of exports, but at the same time it could open the doors of more distant and difficult markets characterized by very large unexploited potential, such as the newly developing countries of Asia and Latin America, and improving the overall export performance of French firms. On the contrary, by internalising new and more advanced technologies and process of production not available in house from other domestic agents, French firms could scale up their products in order to target high-income countries with a demand for relatively higher quality, thus resulting in a larger firm-level FMP index.

After the general analysis of the relationship between firms export performance and externalised R&D using the complete sample of French innovators, we deepen our investigation by distinguishing between domestic and foreign owned firms and between companies part of low-tech or high-tech sectors, following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of their R&D intensity. We expect firms that are part of a French or a foreign group and in low or high-tech sectors to follow different internationalisation and outsourcing strategies, externalising R&D activities because of disparate demand or supply-driven factors, thus with contrasting effects of outsourced innovations on their export performance. Table 3.6 presents the results of the system of equations including externalised R&D and total exports estimated for domestic-owned firms in panels A and B, and foreign-owned firms in panels C and D.

Looking at the interaction terms between internal and external innovating activities, it is possible to notice immediately a diametrically opposite effect of the R&D complementarity on firms total exports. In fact, although offshored R&D has a negative effect while domestically outsourced R&D positively affects total exports of domestic firms in column 3, for

Table 3.6: Estimation results of the total exports and external R&D system of equations using a FIML model - Domestic vs Foreign Groups.

TOTAL EXPORTS	Domestic								Foreign							
	[A]			[B]					[C]			[D]				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $Tot.Exports$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $Tot.Exports$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $Tot.Exports$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $Tot.Exports$
$Employment_{it-1}$	0.324***	0.460***	2.086***	0.206***	0.165***	0.178***	0.470***	1.162***	0.256***	0.580***	0.433**	0.235***	0.163***	0.178***	0.476***	0.747***
	(0.00685)	(0.0120)	(0.113)	(0.00519)	(0.00442)	(0.00378)	(0.0106)	(0.103)	(0.0102)	(0.0165)	(0.190)	(0.00677)	(0.00653)	(0.00522)	(0.0143)	(0.168)
$Av.Salary_{it-1}$	0.0673***	0.0408	0.411	0.0213**	0.0533***	0.0457***	0.0438*	0.130	0.0792***	-0.00468	-0.742	0.0441***	0.0667***	0.0390***	0.0231	-0.399
	(0.0162)	(0.0315)	(0.305)	(0.00839)	(0.0106)	(0.00911)	(0.0245)	(0.260)	(0.0253)	(0.0420)	(0.470)	(0.0137)	(0.0160)	(0.0122)	(0.0355)	(0.424)
$Lab.Productivity_{it-1}$	0.198***	0.202***	1.800***	0.148***	0.0555***	0.110***	0.253***	1.274***	0.161***	0.386***	0.727**	0.213***	0.0786***	0.136***	0.314***	1.026***
	(0.0140)	(0.0265)	(0.201)	(0.00850)	(0.00914)	(0.00826)	(0.0217)	(0.173)	(0.0182)	(0.0301)	(0.319)	(0.0114)	(0.0113)	(0.00964)	(0.0255)	(0.291)
$InternalR\&D_{it-1}$	1.010***	2.302***	-3.436***	0.434***	0.539***	0.640***	1.828***	3.184***	1.043***	2.638***	5.244***	0.648***	0.592***	0.561***	1.994***	2.831**
	(0.0828)	(0.153)	(1.294)	(0.0451)	(0.0463)	(0.0535)	(0.122)	(1.069)	(0.0815)	(0.162)	(1.593)	(0.0569)	(0.0502)	(0.0483)	(0.126)	(1.232)
$FrenchGroup_{it}$	0.0309*	0.120***	-0.354	0.0125	0.0340***	0.295***	0.0586**	-0.781***								
	(0.0182)	(0.0330)	(0.348)	(0.00952)	(0.0116)	(0.0102)	(0.0277)	(0.299)								
$Tot.Exports_{it-1}$	-0.0283***	0.0473***		-0.0238***	0.00427***	0.00215***	-0.0198***		0.0249***	-0.0483***		-0.0239***	0.00540***	-0.000165	-0.0301***	
	(0.00165)	(0.00295)		(0.000839)	(0.00114)	(0.000815)	(0.00266)		(0.00237)	(0.00373)		(0.00109)	(0.00166)	(0.000903)	(0.00346)	
$Int*Offsh.R\&D_{it-1}$			-10.59***								11.81***					
			(1.496)								(1.732)					
$Int*Outs.Dom.R\&D_{it-1}$			5.585***								-5.995***					
			(0.796)								(0.936)					
$Offsh.R\&D_{it-1}$			2.061								-7.095***					
			(1.393)								(1.571)					
$Outs.Dom.R\&D_{it-1}$			-2.220***								4.740***					
			(0.727)								(0.864)					
$Int*Offsh.(IN)_{it-1}$								-7.507***								-3.427***
								(1.193)								(1.231)
$Int*Offsh.(OUT)_{it-1}$								18.59***								19.95***
								(2.125)								(2.305)
$Int*Outs.Dom.(IN)_{it-1}$								2.500***								0.612
								(0.838)								(0.841)
$Int*Outs.Dom.(OUT)_{it-1}$								-5.075***								-6.530***
								(0.808)								(0.851)
$Offsh.(IN)R\&D_{it-1}$								1.511								0.294
								(0.986)								(0.914)
$Offsh.(OUT)R\&D_{it-1}$								-21.12***								-21.21***
								(2.203)								(2.629)
$Outs.Dom.(IN)R\&D_{it-1}$								-2.140***								0.633
								(0.768)								(0.740)
$Outs.Dom.(OUT)R\&D_{it-1}$								8.069***								9.292***
								(0.818)								(0.991)
$var(\mathcal{E})$	0.103***	0.358***	72.46***	0.0298***	0.0403***	0.0351***	0.249***	83.00***	0.101***	0.335***	65.46***	0.0335***	0.0394***	0.0261***	0.230***	69.59***
	(0.00430)	(0.0139)	(4.050)	(0.00159)	(0.00174)	(0.00147)	(0.00999)	(4.695)	(0.00539)	(0.0158)	(5.849)	(0.00198)	(0.00223)	(0.00144)	(0.0110)	(5.875)
$cov(\mathcal{E}_{Off}*\mathcal{E}_{TE})$			2.024***								-1.930***					
			(0.0725)								(0.0910)					
$cov(\mathcal{E}_{Dom}*\mathcal{E}_{TE})$			-3.283***								2.990***					
			(0.120)								(0.155)					
$cov(\mathcal{E}_{Off.IN}*\mathcal{E}_{TE})$								0.399***								0.254***
								(0.0323)								(0.0413)
$cov(\mathcal{E}_{Off.OUT}*\mathcal{E}_{TE})$								-1.467***								-1.351***
								(0.0567)								(0.0613)
$cov(\mathcal{E}_{Dom.IN}*\mathcal{E}_{TE})$								-0.0214								-0.0196
								(0.0145)								(0.0155)
$cov(\mathcal{E}_{Dom.OUT}*\mathcal{E}_{TE})$								2.340***								2.138***
								(0.123)								(0.166)
Observations	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\epsilon)$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

foreign-owned companies the effect is reversed, since only innovating activities externalised abroad significantly increase firms total exports in column 11. However, when distinguishing between R&D activities outsourced within the group or at the arm's-length in panels B and D, the difference between domestic and foreign-owned companies is not that sharp. For both groups of firms, innovating activities offshored to foreign affiliates have a negative impact of total exports in columns 8 and 16, suggesting probably a supply-driven strategy aimed at the re-organisation of the R&D activities within the group boundaries as previously discussed. Moreover, only activities offshored abroad at the arm's-length significantly improve firms total exports, both for domestic and foreign-owned firms. Looking at the aggregate effect, probably the positive impact of innovations offshored outside the group boundaries is stronger and prevalent for foreign-owned firms rather than for domestic firms due to the connections and knowledge provided by their foreign group. On the contrary, we find a positive and significant complementary effect on total exports of R&D activities outsourced to domestic firms part of the same group only for French-owned companies in column 8, while activities outsourced to extra-group French firms maintain a negative and significant effect on total exports both for domestic and foreign-owned companies. This evidence suggests the relevance of the participation to French groups in exploiting the positive spillovers originated in French subsidiaries, improving the knowledge base of domestic-owned firms and consequently their total exports.

However, we do not detect any variability when analysing the effect of externalised R&D activities on the foreign market potential index of domestic and foreign-owned firms in Table 3.7. Consistent with the estimation for the general sample in Table 3.5, note that R&D activities offshored abroad have a negative and significant complementary effect together with internal resources on firms FMP index both for domestic and foreign-owned companies, in particular for activities offshored to foreign extra-group companies in columns 8 and 16. On

Table 3.7: Estimation results of the FMP Index and external R&D system of equations using a FIML model - Domestic vs Foreign Groups.

FMP INDEX	Domestic							
	[A]			[B]				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.276***	0.552***	-0.0255	0.194***	0.172***	0.182***	0.465***	-0.461***
	(0.00709)	(0.0123)	(0.115)	(0.00558)	(0.00464)	(0.00416)	(0.0114)	(0.108)
$Av.Salary_{it-1}$	0.0602***	0.0653**	-0.00623	0.0214**	0.0510***	0.0487***	0.0581**	-0.233
	(0.0165)	(0.0312)	(0.219)	(0.00912)	(0.0104)	(0.00979)	(0.0269)	(0.201)
$Lab.Productivity_{it-1}$	0.172***	0.338***	-0.216	0.157***	0.0811***	0.127***	0.283***	-0.542***
	(0.0166)	(0.0259)	(0.196)	(0.00919)	(0.0104)	(0.00910)	(0.0231)	(0.181)
$InternalR\&D_{it-1}$	1.005***	2.416***	-3.309**	0.415***	0.554***	0.655***	1.857***	-1.948**
	(0.0877)	(0.172)	(1.318)	(0.0484)	(0.0521)	(0.0594)	(0.135)	(0.985)
$FrenchGroup_{it}$	0.0618***	0.110***	0.350	0.0230**	0.0381***	0.302***	0.0840***	0.379*
	(0.0187)	(0.0338)	(0.214)	(0.0107)	(0.0121)	(0.0115)	(0.0303)	(0.211)
$FMPIndex_{it-1}$	-0.0219***	0.0398***		0.0117***	-0.00891***	-0.000420	0.0265***	
	(0.00234)	(0.00478)		(0.00134)	(0.00146)	(0.00126)	(0.00412)	
$Int * Offsh.R\&D_{it-1}$			-7.826***					
			(2.382)					
$Int * Outs.Dom.R\&D_{it-1}$			4.057***					
			(1.243)					
$Offsh.R\&D_{it-1}$			2.395					
			(2.220)					
$Outs.Dom.R\&D_{it-1}$			-2.059*					
			(1.138)					
$Int * Offsh.(IN)_{it-1}$								6.898***
								(1.688)
$Int * Offsh.(OUT)_{it-1}$								-13.37***
								(2.331)
$Int * Outs.Dom.(IN)_{it-1}$								0.270
								(1.159)
$Int * Outs.Dom.(OUT)_{it-1}$								3.057***
								(1.123)
$Offsh.(IN)R\&D_{it-1}$								-2.655**
								(1.326)
$Offsh.(OUT)R\&D_{it-1}$								14.14***
								(2.331)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.457
								(1.046)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.202***
								(1.014)
$var(\mathcal{E})$	0.0855***	0.313***	51.37***	0.0276***	0.0344***	0.0343***	0.233***	68.86***
	(0.00379)	(0.0133)	(5.793)	(0.00157)	(0.00156)	(0.00157)	(0.0101)	(7.669)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			1.468***					
			(0.0951)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			-2.531***					
			(0.165)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								-0.241***
								(0.0319)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								1.162***
								(0.0752)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								0.0243
								(0.0211)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								-2.277***
								(0.160)
$Observations$	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984

FMP INDEX	Foreign							
	[C]			[D]				
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.275***	0.570***	-0.273*	0.225***	0.167***	0.182***	0.478***	-0.427***
	(0.00972)	(0.0169)	(0.144)	(0.00740)	(0.00619)	(0.00557)	(0.0152)	(0.155)
$Av.Salary_{it-1}$	0.0507**	0.00140	0.236	0.0391***	0.0487***	0.0331***	0.0216	0.122
	(0.0235)	(0.0409)	(0.269)	(0.0144)	(0.0150)	(0.0125)	(0.0365)	(0.265)
$Lab.Productivity_{it-1}$	0.184***	0.349***	-0.297	0.199***	0.0878***	0.137***	0.293***	-0.427**
	(0.0163)	(0.0292)	(0.183)	(0.0116)	(0.0102)	(0.00971)	(0.0258)	(0.187)
$InternalR\&D_{it-1}$	1.028***	2.598***	-4.569***	0.598***	0.566***	0.546***	1.981***	-2.770**
	(0.0793)	(0.152)	(1.656)	(0.0534)	(0.0496)	(0.0468)	(0.124)	(1.322)
$FrenchGroup_{it}$								
$FMPIndex_{it-1}$	-0.0225***	0.0613***		0.0128***	-0.0102***	0.00250	0.0480***	
	(0.00510)	(0.00839)		(0.00277)	(0.00337)	(0.00222)	(0.00759)	
$Int * Offsh.R\&D_{it-1}$			-8.254***					
			(1.543)					
$Int * Outs.Dom.R\&D_{it-1}$			4.407***					
			(0.896)					
$Offsh.R\&D_{it-1}$			5.223***					
			(1.379)					
$Outs.Dom.R\&D_{it-1}$			-3.402***					
			(0.807)					
$Int * Offsh.(IN)_{it-1}$								2.998**
								(1.306)
$Int * Offsh.(OUT)_{it-1}$								-13.59***
								(2.516)
$Int * Outs.Dom.(IN)_{it-1}$								-1.938
								(1.291)
$Int * Outs.Dom.(OUT)_{it-1}$								4.440***
								(1.084)
$Offsh.(IN)R\&D_{it-1}$								-1.997*
								(1.027)
$Offsh.(OUT)R\&D_{it-1}$								13.12***
								(2.540)
$Outs.Dom.(IN)R\&D_{it-1}$								1.915*
								(1.142)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.220***
								(1.009)
$var(\mathcal{E})$	0.0753***	0.275***	29.66***	0.0310***	0.0298***	0.0250***	0.208***	37.27***
	(0.00368)	(0.0137)	(5.817)	(0.00186)	(0.00146)	(0.00137)	(0.0102)	(7.401)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			1.043***					
			(0.114)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			-1.825***					
			(0.197)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								-0.0892**
								(0.0381)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								0.767***
								(0.0817)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								0.0278
								(0.0212)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								-1.728***
								(0.213)
$Observations$	2,626	2,626	2,626	2,626	2,626	2,626	2,626	2,626

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\epsilon)$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and FMP index equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

the contrary, R&D outsourced domestically, in particular to extra-group French companies, positively affect the FMP index of French exporters. This evidence is similar to the previous results, and shows that there is no difference between domestic and foreign-owned companies in the use of externalised R&D activities to access international markets. In particular, these results stress once more the importance of R&D activities outsourced at the arm's-length as tools of firms internationalisation strategies, exploiting offshored R&D activities to access more difficult and distant markets, while using domestically outsourced innovations to export to high-income and mature economies.

In the final part of our analysis we examine the relationship between externalised R&D and export performance for firms in low-tech and high-tech industries. Industries are divided into low-tech (panels A and B) and high-tech (panels C and D) following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added.[7] Tables 3.8 and 3.9 present the results of the system of equations estimating the relationships between externalised R&D activities and the export performance of firms in high and low-tech industries.

The complementarity between internal and external R&D activities seems to have a completely different impact on total exports and the FMP index for firms in high-tech and low-tech industries. From Table 3.8 we observe that offshored R&D activities tend to have a positive and significant impact on total exports only for firms in low-tech industries in column

[7]Eurostat classifies industries at NACE rev.1.1 3-digit level in high-technology, medium-high, medium-low and low-tech according to the R&D intensity of firms in each sector. We then aggregate high and medium-high sectors as high-tech industries, while low and medium-low as low-tech sectors. According to this aggregation, high-tech industries include: pharmaceutical products, computer and optical products, air and spacecraft equipments, chemicals, weapons and ammunition, electrical equipment, machinery, motor vehicles, medical instruments and other transport equipment excluding ships. Low-tech industries instead include: media recording equipment, coke and refined petroleum products, rubber and plastic products, non-metallic mineral products, basic metals, metal products except machineries and weapons, ships, food and beverage, tobacco, textiles, wearing apparel, leather, wood, paper, furniture and other manufacturing medical instruments.

Table 3.8: Estimation results of the total exports and external R&D system of equations using a FIML model - Low vs High-Tech Industries.

TOTAL EXPORTS	Low-Tech								High-Tech							
	[A]			[B]					[C]			[D]				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$Tot.Exports$	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$Tot.Exports$
$Employment_{it-1}$	0.242***	0.560***	0.636***	0.194***	0.155***	0.168***	0.455***	1.023***	0.335***	0.478***	2.174***	0.226***	0.171***	0.185***	0.489***	0.954***
	(0.00982)	(0.0171)	(0.139)	(0.00719)	(0.00626)	(0.00504)	(0.0158)	(0.134)	(0.00652)	(0.0117)	(0.118)	(0.00471)	(0.00435)	(0.00366)	(0.00998)	(0.110)
$Av.Salary_{it-1}$	-0.0123	-0.0527	0.506	-0.00681	0.00516	0.00506	-0.0439	0.608*	0.0837***	0.118***	-0.0504	0.0413***	0.0860***	0.0635***	0.0792***	-0.565**
	(0.0237)	(0.0357)	(0.382)	(0.0103)	(0.0142)	(0.0115)	(0.0306)	(0.327)	(0.0167)	(0.0309)	(0.325)	(0.00935)	(0.0108)	(0.00885)	(0.0254)	(0.285)
$Lab.Productivity_{it-1}$	0.161***	0.422***	1.061***	0.176***	0.0808***	0.144***	0.331***	1.327***	0.187***	0.183***	1.668***	0.168***	0.0530***	0.103***	0.238***	1.117***
	(0.0133)	(0.0249)	(0.240)	(0.00874)	(0.00800)	(0.00706)	(0.0212)	(0.220)	(0.0146)	(0.0288)	(0.234)	(0.00961)	(0.0101)	(0.00861)	(0.0230)	(0.211)
$InternalR\&D_{it-1}$	1.078***	2.486***	5.344***	0.512***	0.595***	0.690***	1.847***	2.495*	1.011***	2.300***	-2.594**	0.504***	0.528***	0.558***	1.873***	4.089***
	(0.0958)	(0.209)	(1.718)	(0.0569)	(0.0537)	(0.0681)	(0.147)	(1.337)	(0.0669)	(0.125)	(1.305)	(0.0416)	(0.0392)	(0.0392)	(0.103)	(1.120)
$ForeignGroup_{it}$	-0.0450	0.0509	0.164	0.106***	0.0184	-0.00106	0.0554	0.392	-0.0605***	-0.00574	-0.204	0.0935***	-0.0110	-0.0167	0.0220	0.756**
	(0.0288)	(0.0485)	(0.562)	(0.0139)	(0.0178)	(0.0136)	(0.0417)	(0.484)	(0.0204)	(0.0371)	(0.384)	(0.0116)	(0.0131)	(0.0111)	(0.0310)	(0.342)
$FrenchGroup_{it}$	0.0323	0.0816*	0.0833	-0.00132	0.0228	0.286***	0.0620*	-0.0522	0.0366*	0.142***	-0.451	-0.00533	0.0376***	0.302***	0.0667**	-1.029***
	(0.0253)	(0.0444)	(0.516)	(0.0120)	(0.0155)	(0.0129)	(0.0376)	(0.445)	(0.0208)	(0.0364)	(0.362)	(0.0117)	(0.0129)	(0.0117)	(0.0320)	(0.320)
$Tot.Exports_{it-1}$	0.0229***	-0.0491***		-0.0246***	0.00274*	-0.000167	-0.0315***		-0.0279***	0.0461***		-0.0234***	0.00500***	0.00189**	-0.0214***	
	(0.00214)	(0.00395)		(0.00107)	(0.00142)	(0.00108)	(0.00380)		(0.00158)	(0.00283)		(0.000846)	(0.00116)	(0.000744)	(0.00252)	
$Int * Offsh.R\&D_{it-1}$			13.40***								-8.398***					
			(1.716)								(1.344)					
$Int * Outs.Dom.R\&D_{it-1}$			-7.213***								4.491***					
			(0.952)								(0.719)					
$Offsh.R\&D_{it-1}$			-9.986***								-1.013					
			(1.679)								(1.228)					
$Outs.Dom.R\&D_{it-1}$			6.299***								-0.648					
			(0.932)								(0.652)					
$Int * Offsh.(IN)_{it-1}$								-2.361*								-6.764***
								(1.251)								(1.105)
$Int * Offsh.(OUT)_{it-1}$								16.99***								21.20***
								(2.134)								(2.225)
$Int * Outs.Dom.(IN)_{it-1}$								0.133								2.906***
								(0.919)								(0.916)
$Int * Outs.Dom.(OUT)_{it-1}$								-7.130***								-5.591***
								(0.963)								(0.900)
$Offsh.(IN)R\&D_{it-1}$								-2.148**								1.469*
								(1.021)								(0.807)
$Offsh.(OUT)R\&D_{it-1}$								-19.07***								-22.64***
								(2.203)								(2.418)
$Outs.Dom.(IN)R\&D_{it-1}$								1.210								-2.261***
								(0.825)								(0.836)
$Outs.Dom.(OUT)R\&D_{it-1}$								9.711***								8.515***
								(0.974)								(0.925)
$var(\mathcal{E})$	0.101***	0.345***	66.78***	0.0293***	0.0379***	0.0300***	0.242***	69.70***	0.0972***	0.342***	72.00***	0.0322***	0.0392***	0.0303***	0.236***	79.93***
	(0.00499)	(0.0162)	(5.095)	(0.00207)	(0.00187)	(0.00149)	(0.0117)	(5.140)	(0.00395)	(0.0128)	(4.256)	(0.00154)	(0.00172)	(0.00123)	(0.00928)	(4.680)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			-1.891***								1.954***					
			(0.0867)								(0.0704)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			3.158***								-3.221***					
			(0.150)								(0.117)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								0.238***								0.344***
								(0.0353)								(0.0295)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								-1.262***								-1.436***
								(0.0582)								(0.0551)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								-0.0467**								-0.0067
								(0.0187)								(0.0135)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								2.390***								2.260***
								(0.160)								(0.122)
Observations	2,810	2,810	2,810	2,810	2,810	2,810	2,810	2,810	5,050	5,050	5,050	5,050	5,050	5,050	5,050	5,050

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\mathcal{E})$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between ***Low-Tech*** and ***High-Tech*** industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Total exports*** measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; ***Offshored*** measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; ***Off.(IN)*** measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; ***Dom.(IN)*** measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; ***Dom. (OUT)*** measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; ***Off. (OUT)*** measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table 3.9: Estimation results of the FMP Index and external R&D system of equations using a FIML model - Low vs High-Tech Industries.

FMP INDEX	Low-Tech								High-Tech							
	[A]			[B]					[C]			[D]				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $FMPIndex$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $FMPIndex$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $FMPIndex$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $FMPIndex$
$Employment_{it-1}$	0.253***	0.534***	-0.124	0.181***	0.154***	0.167***	0.445***	-0.429***	0.321***	0.525***	-1.545***	0.217***	0.180***	0.191***	0.489***	-0.436***
	(0.0111)	(0.0181)	(0.141)	(0.00807)	(0.00704)	(0.00568)	(0.0168)	(0.139)	(0.00638)	(0.0114)	(0.148)	(0.00494)	(0.00427)	(0.00403)	(0.0105)	(0.112)
$Av.Salary_{it-1}$	-0.00516	-0.0236	-0.378*	-0.00368	0.00978	0.0105	-0.0140	-0.476**	0.0894***	0.0791***	-0.364*	0.0390***	0.0719***	0.0603***	0.0773***	0.171
	(0.0208)	(0.0388)	(0.225)	(0.0108)	(0.0128)	(0.0118)	(0.0332)	(0.217)	(0.0167)	(0.0306)	(0.213)	(0.0103)	(0.0108)	(0.00955)	(0.0273)	(0.213)
$Lab.Productivity_{it-1}$	0.185***	0.398***	-0.318*	0.170***	0.0895***	0.146***	0.326***	-0.595***	0.184***	0.263***	-0.974***	0.176***	0.0763***	0.118***	0.255***	-0.474**
	(0.0139)	(0.0238)	(0.171)	(0.00867)	(0.00850)	(0.00750)	(0.0208)	(0.171)	(0.0150)	(0.0317)	(0.179)	(0.0106)	(0.0113)	(0.00972)	(0.0249)	(0.188)
$InternalR\&D_{it-1}$	1.060***	2.477***	-3.616***	0.480***	0.569***	0.670***	1.847***	-1.557	1.009***	2.394***	2.478**	0.484***	0.542***	0.570***	1.901***	-3.208***
	(0.102)	(0.210)	(1.162)	(0.0554)	(0.0585)	(0.0696)	(0.155)	(0.996)	(0.0622)	(0.130)	(1.173)	(0.0412)	(0.0411)	(0.0406)	(0.105)	(1.232)
$ForeignGroup_{it}$	-0.0375	0.0727	-0.0957	0.108***	0.0211	0.00434	0.0777*	-0.139	-0.0800***	-0.0199	0.366	0.0784***	-0.0202	-0.0260**	-0.00346	-0.432*
	(0.0273)	(0.0478)	(0.345)	(0.0148)	(0.0171)	(0.0147)	(0.0431)	(0.341)	(0.0192)	(0.0376)	(0.230)	(0.0122)	(0.0132)	(0.0120)	(0.0318)	(0.248)
$FrenchGroup_{it}$	0.0565**	0.110**	0.338	0.0100	0.0392**	0.296***	0.0931**	0.306	0.0505***	0.135***	0.133	0.00397	0.0376***	0.306***	0.0790**	0.479*
	(0.0245)	(0.0448)	(0.301)	(0.0134)	(0.0155)	(0.0144)	(0.0399)	(0.294)	(0.0190)	(0.0384)	(0.236)	(0.0123)	(0.0135)	(0.0125)	(0.0321)	(0.254)
$FMPIndex_{it-1}$	-0.0274***	0.0484***		0.0105***	-0.0122***	-0.000995	0.0380***		0.0265***	-0.0342***		0.0127***	-0.00789***	0.00104	0.0317***	
	(0.00381)	(0.00567)		(0.00186)	(0.00230)	(0.00161)	(0.00535)		(0.00291)	(0.00502)		(0.00160)	(0.00168)	(0.00140)	(0.00464)	
$Int * Offsh.R\&D_{it-1}$			-11.80***								8.533***					
			(1.752)								(1.582)					
$Int * Outs.Dom.R\&D_{it-1}$			5.926***								-4.274***					
			(0.956)								(0.790)					
$Offsh.R\&D_{it-1}$			8.302***								-0.304					
			(1.703)								(1.420)					
$Outs.Dom.R\&D_{it-1}$			-5.070***								1.224*					
			(0.943)								(0.714)					
$Int * Offsh.(IN)_{it-1}$								2.899*								5.134***
								(1.536)								(1.272)
$Int * Offsh.(OUT)_{it-1}$								-14.72***								-13.19***
								(1.970)								(2.790)
$Int * Outs.Dom.(IN)_{it-1}$								1.445								-2.929***
								(1.049)								(1.287)
$Int * Outs.Dom.(OUT)_{it-1}$								5.611***								2.955**
								(1.181)								(1.267)
$Offsh.(IN)R\&D_{it-1}$								-0.196								-1.700*
								(1.064)								(0.895)
$Offsh.(OUT)R\&D_{it-1}$								14.06***								13.04***
								(1.973)								(2.731)
$Outs.Dom.(IN)R\&D_{it-1}$								-1.697								2.745***
								(1.133)								(0.914)
$Outs.Dom.(OUT)R\&D_{it-1}$								-6.971***								-4.550***
								(1.059)								(1.136)
$var(\mathcal{E})$	0.0827***	0.295***	43.30***	0.0275***	0.0317***	0.0287***	0.221***	53.02***	0.0768***	0.287***	39.65***	0.0291***	0.0315***	0.0292***	0.217***	53.28***
	(0.00435)	(0.0152)	(5.942)	(0.00211)	(0.00164)	(0.00155)	(0.0112)	(7.221)	(0.00316)	(0.0114)	(5.139)	(0.00145)	(0.00137)	(0.00127)	(0.00900)	(6.950)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			1.347***								-1.224***					
			(0.105)								(0.0913)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			-2.275***								2.079***					
			(0.176)								(0.149)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								-0.109***								-0.184***
								(0.0292)								(0.0290)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								0.949***								0.967***
								(0.0754)								(0.0715)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								-0.0474**								0.0170
								(0.0217)								(0.0191)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								-2.132***								-1.961***
								(0.175)								(0.159)
Observations	2,421	2,421	2,421	2,421	2,421	2,421	2,421	2,421	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a FIML model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Row $var(\mathcal{E})$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and FMP index equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between *Low-Tech* and *High-Tech* industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

3, while it reduces foreign sales of high-tech sectors in column 11. On the contrary, domestically outsourced activities seem to stimulate companies sales abroad for firms in high-tech manufacturing sectors, with a negative impact instead in low-tech industries. This result is explained by a more disaggregated analysis of R&D activities outsourced within or outside the group boundaries. Regarding offshored activities both in low and high-tech industries we estimate a positive impact of arm's-length activities on total exports while a negative effect of R&D activities carried on by foreign affiliates in columns 8 and 16. On the contrary, the positive complementary effect of R&D activities domestically outsourced on exports in high-tech industries seems to be mainly driven by a positive and significant effect of innovating activities outsourced to French affiliates in column 16, while in low-tech industries prevails the negative mpact of R&D outsourced to extra-group French firms in column 8. Similarly, we estimate a comparable relationship between external R&D activities and firms FMP index in low-tech and high-tech industries in Table 3.9. Again, the complementarity between internal and offshored R&D seems to help firms in low-tech industries to export to more distant and difficult foreign markets in panels A and B, especially in the case of activities offshored at the arm's-length, while domestically outsourced activities push these firms towards more developed countries in column 8. On the contrary, in high-tech industries in panels C and D, offshored R&D activities improve the access to high-income and easily accessible markets, while firms outsourcing domestically to French affiliates are more prone to export towards distant and difficult foreign markets in column 16. These results highlight a dichotomy between R&D outsourcing strategies in high-tech and low-tech industries, showing how offshored and domestically outsourced innovating activities are used by firms in order to achieve different market-driven objectives depending on their innovating intensity.

We also undertook additional robustness checks. In the appendix we present several alternative estimation methods to show the consistency of our methodology and the robustness of our results. Tables A.3.2.1-A.3.2.6 present the results estimating the final stage of our model using a three-stage least squares (3SLS) model, while Tables A.3.2.7-A.3.2.12 applying a seemingly unrelated regression (SUR). Finally, Tables A.3.2.13-A.3.2.15 in the appendix report the results of the estimation of the systems of equations using a FIML model in the framework of a survey data analysis. Even using different econometric techniques to address the interdependence between externalised R&D activities and firms export performance and considering the weighting, clustering, and stratification of the survey data, the results of our main estimations using a FIML model are consistent with all the robustness checks in the appendix, corroborating the consistency and unbiasedness of our estimators.

3.6 Conclusions

In this chapter we have investigated empirically the relationship between external R&D activities and firms export performance for a representative sample of French innovators. To the best of our knowledge this is the first empirical study analysing not only the effect of firms internationalisation on the externalisation of innovation, but also the reverse impact of outsourced R&D on firms export performance. Following the previous literature, we tested several theoretical predictions about the different and somehow contrasting effects that outsourced R&D might have on trade performance, looking at the value of exports and at the destinations served, conditional on firms strategy, the benefits and costs of R&D internationalisation. First, we tested the complementary effect of internal and external R&D on export performance, expecting that larger internal R&D capabilities might amplify the effect of external innovating activities on firm export performance. Secondly, we would expect that demand-driven external R&D activities might improve exporters performance and their market-access to new foreign markets, through the introduction of new products and tailoring existing goods according to foreign markets needs. On the contrary, we would assume that supply-driven R&D internationalisation would be mainly oriented towards the reduction of the costs of innovation and the rationalization of R&D activities within groups. For these reasons, supply-side external R&D activities might reduce the costs of innovations with possible mixed effects on the overall value of exports and on firms market-access.

To test our hypothesis, we have considered several measures of firms external R&D activities, taking into account both tasks outsourced domestically or abroad, both within group boundaries or at the arm's-length. First, we have adopted a 2-steps Heckman model to take into consideration firms self-selection into R&D internationalization, analysing as well the main determinants of external R&D activities for French firms, whether they have been undertaken to achieve supply or demand-driven objectives. Secondly, using the predicted value from the Heckman selection model, we have built a system of simultaneous equations which tackles the two-way causality bias connecting externalised R&D activities and export performance. In this way we have modelled the complementary effect of internal and external R&D activities on firms export performance, while acknowledging that exporters might have a higher propensity towards R&D outsourcing, dedicating more resources both to internal and externalised R&D activities, given their experience in the international markets, their higher productivity and the connections they might have with external suppliers of manufactured and innovation inputs.

First, our results have demonstrated the two-way causality linking externalised innovation and export performance, in particular when analysing R&D activities offshored abroad. Secondly, we have shown that complementarity between internal and external R&D significantly affects firms export performance, highlighting the key role played by internal capabilities in internalising the positive spillovers deriving from external innovating activities outsourced in France or abroad. Moreover, we have found that market-driven activities, such as R&D offshored abroad to extra-group firms, are the major strategies improving firms export performance, in particular helping exporters to access more difficult and less attractive markets and increasing the total value of exports. R&D activities outsourced domestically instead seem to negatively affect firms total exports in general, but helping French companies to target high-income markets such as the nearby EU single market and other OECD members, probably upgrading exports quality and the technological intensity. In addition, R&D activities externalised at the arm's-length seem to be particularly beneficial in terms of export performance, suggesting a market-driven factor behind these strategies, while outsourcing within the group appears to be mainly dictated by rationalisation and supply-driven purposes, with an overall negative impact on exports. Moreover, as expected, foreign-owned companies profit the most from offshored R&D, while domestic firms export performance is mainly affected by innovating activities outsourced to other French firms. Finally, we have found a diametrically opposed effect of outsourced R&D on the export performance of firms in high-tech or low-tech industries. On the one hand, companies in low-tech industries are able to improve their export performance thanks to R&D activities offshored at the arm's-length, in particular by exporting to more difficult and distant markets. On the other hand, high-tech firms by offshoring R&D abroad tend to reduce their total exports, profiting the most instead from innovating activities outsourced domestically to other French firms and thus exporting to more difficult markets.

Taken together these results show clearly the interdependence between internationalisation strategies and outsourced innovation, highlighting the significant role played by external R&D in improving French firms participation to global networks, demonstrating how these strategies are mainly driven by market-demand factors, such as accessing new difficult markets and customizing their exports for foreign markets needs. Previous theoretical contributions have predicted how external R&D activities could affect firms productivity and trade performance in a number of different ways, for instance optimizing firms resources, allowing them to acquire specific knowledge or improving their ability to respond to global market needs. Our empirical analysis has identified the main factors driving firms to externalize their R&D, evaluating the overall interdependence between externalised innovative strategies and export performance.

Appendix A3

A.3.1 FMP Index Estimation

We analyse the internationalisation strategies followed by French firms in terms of market access based on the estimation of the Foreign Market Potential (FMP) index. This index represents an accurate measure of countries proximity to world markets, synthesizing the evolution of countries economic geography in international trade (Mayer 2009). In fact, the FMP index allows to estimate the attractiveness of countries as foreign markets for the rest of trade partners.

The gravity trade literature highlights how proximity to large markets shapes international trade patterns. Based on the "new economic geography" models, empirical studies propose several estimation methods to measure countries' proximity to world markets, usually defined as market potential. Redding and Venables (2004) propose an indicator of market potential measured as the sum of expenditure of all countries in the world, weighted by bilateral trade costs and other geographical determinants. Also Head and Mayer (2004) introduce a related but alternative methodology, adjusting the market potential measurement to take into account the impact of national borders on trade flows and the real per capita income of foreign markets.

To develop a firm-level measure of market access, we have calculated first this index for each country trading with France following the Head and Mayer (2004) and Disdier and Head (2008) approaches, taking into consideration the sum per capita expenditure of all trade partners of France, weighted by the bilateral trade costs and adjusting it to take into account the impact of national borders on trade flows between France and the rest of the world.

The derivation of this model makes use of gravity equations which explain the pattern of bilateral trade flows between country pairs. Considering an exporting country i and an importing country j, the total expenditure for foreign goods X_j should be allocated between all the different exporting countries, identifying in this way Π_{ij} as the proportion of income allocated to each country i. In order to derive a gravity equation we need to express Π_{ij} in the following multiplicatively separable form:

$$\Pi_{ij} = \frac{A_i \phi_{ij}}{\Phi_j} \tag{A.3.1.1}$$

where A_i represents the capabilities of exporter i, in our case France, $0 \leq \phi_{ij} \leq 1$ represents the ease of access to market j for exporters in i, and Φ_j measures the degree of international competition in that market. By imposing the standard micro-foundations requirements, we could define $s_j^X = \frac{X_j}{X}$ as country j share of world expenditure and then:

$$\Phi_i^* = \sum_j \frac{\phi_{ij} s_j^X}{\Phi_j} \tag{A.3.1.2}$$

which provides an expenditure-weighted average of relative market access to individual foreign markets. We are able then to express bilateral trade between two countries as:

$$X_{ij} = A_i \phi_{ij} \frac{X_j}{\Phi_j} \tag{A.3.1.3}$$

We estimate this equation using a bilateral trade dataset and specifying a vector of trade costs composing ϕ_{ij} and absorbing exporter capabilities A_i as a fixed effect for the exporting country i and importer's specific characteristics as fixed effect for the importing country j identifying in this way an index of foreign market potential given by:

$$FMP_{ij} = \widehat{\phi_{ij}} exp(\widehat{FE_{ij}}) \tag{A.3.1.4}$$

To empirically estimate this foreign market potential index we run a fixed effect gravity model which requires bilateral trade flows between France and its trading partners over the period of interest, obtained from the UN COMTRADE database, and a vector of trade impediments and facilitators for each country pair obtained from the CEPII database. We take into consideration geographical distances, common borders, language, past colonial history, population, GDP per capita, and dummies for participation to common regional trade agreements (RTAs), currency unions (CUs) and membership to the WTO:

$$\begin{aligned} X_{ij} =& \beta_0 + \beta_1 Dist_{ijt} + \beta_2 Colony_{ijt} + \beta_3 GDPcap_{jt} + \beta_4 \Delta GDP_{jt} + \beta_5 Pop_{jt} + \beta_6 Contig_{ijt} \\ &+ \beta_7 Lang_{ijt} + \beta_8 WTO_{jt} + \beta_9 RTA_{ijt} + \beta_{10} Lex_{ijt} + \beta_{11} CU_{ijt} + k_{ij} + k_t \end{aligned} \tag{A.3.1.5}$$

The results of the estimation presented in table A.3.1.1 are in line with the previous literature. For instance, the coefficient for distance is very close to -1 and also the other control variables such as common language, RTA and GATT membership have comparable effects.

This gravity equation enables a computation of the foreign market potential index for all trade partners of France over the 1999-2007 period as shown in figure A.3.1.1. From a first glance of the FMP index distribution across France trade partners some interesting evidence emerge. First, it is quite clear the existence of a strong relationship between market potential, distance and income per capita. Larger countries which are closer to France, with

Table A.3.1.1: Estimation of the Foreign Market Potential index using a gravity model

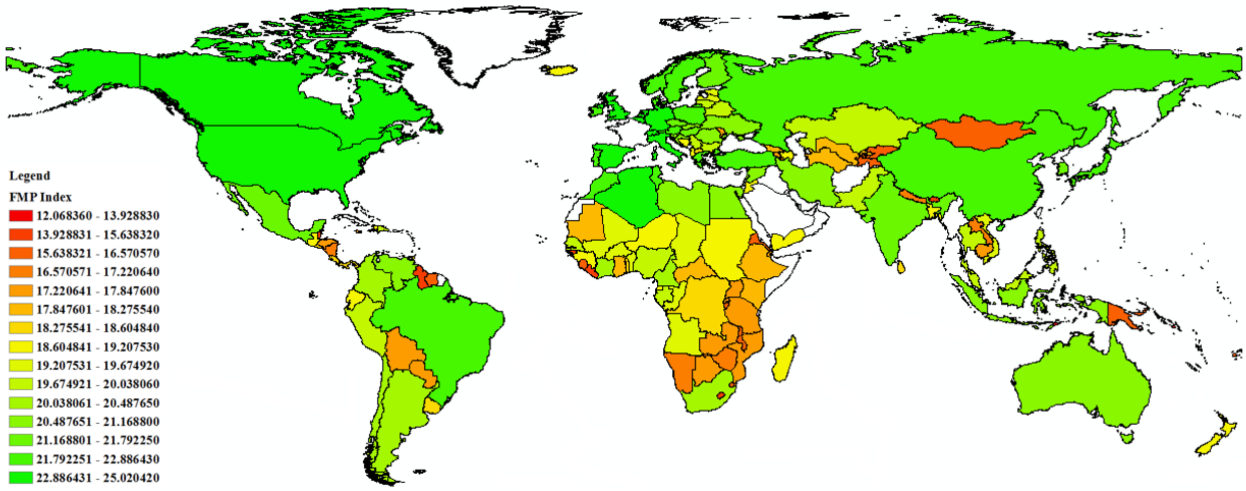
Bilateral Exports	
$Distance_{ijt}$	-0.846***
	(0.112)
$Colony_{ijt}$	0.929***
	(0.229)
$GDP(capita)_{jt}$	-0.147
	(0.235)
ΔGDP_{jt}	1.119***
	(0.240)
$Population_{jt}$	-0.275
	(0.299)
$Contiguity_{ijt}$	-0.273
	(0.289)
$Language_{ijt}$	0.706***
	(0.253)
WTO_{ijt}	0.0370
	(0.0872)
RTA_{ijt}	0.0317
	(0.0789)
Lex_{ijt}	0.400***
	(0.148)
$CurrencyUnion_{ijt}$	0.0141
	(0.0623)
Observations	1,590
No. of Pairs	184

Note: Estimation based on UN COMTRADE and the CEPII Gravity database for the period 1999-2007 using a fixed effect gravity model following the Head and Mayer (2004) approach. The dependent variable is the log value of the export flows between France and its trading partners over the period of interest from the UN COMTRADE database. As covariates we include from the CEPII Gravity database the following variables: $Distance_{ijt}$ a weighted measure of distance between France and each trade partner estimated by (Mayer and Zignago 2011) and based on bilateral distances between the biggest cities of two countries weighted by the share of the city in the overall country's population; $Colony_{ijt}$ a dummy variable equal to 1 if France has ever been the colonizer of country j and 0 otherwise; ΔGDP_{jt} measuring the growth rate of real GDP and $GDP(capita)_{jt}$ dividing the real GDP by the $Population$ of country j as reported in the World Bank Development Indicators (WDI); $Contiguity_{ijt}$ a dummy variable indicating whether the two countries are contiguous; $Language_{ijt}$ a dummy variable equal to 1 if France and country j share the same common language (French) and 0 otherwise; Lex_{ijt} a dummy variable equal to 1 if France and country j share the same legislative system and 0 otherwise; WTO_{ijt}, RTA_{ijt} and $CurrencyUnion_{ijt}$ if France and country j are jointly part of the WTO, regional trade agreements and currency unions as reported by the WTO website. Year dummies and constant term included but not reported. Clustered standard errors at the country-pair level reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

very low trade barriers and a large potential internal market for French firms rank at the top of the FMP index. This is the case in particular of large trade partner within the EU such as Germany, Italy or the UK which are the top markets in terms of FMP for French firms because of their advantageous location, their internal demand and the common membership to the EU single market.

Income per capita is particularly relevant, as shown by the high score of far-away rich

Figure A.3.1.1: Foreign Market Potential Index distribution across countries.



Note: Elaboration based on UN COMTRADE and the CEPII Gravity database for 2007. Foreign Market Potential (FMP) index measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, using a fixed effects gravity model taking into account bilateral trade flows between France and its trading partners, the sum per capita expenditure of all countries, weighted by bilateral trade costs and adjusting it to take into account the impact of national borders and a vector of trade impediments and facilitators for each country pair such as geographical distances, common borders, language, past colonial history, population, GDP per capita, and dummies for participation to common regional trade agreements (RTAs), currency unions (CUs) and membership to the WTO. FMP index distribution across countries classified in 15 quantiles according to natural breaks and represented with darker or lighter intensities of green and red according to the higher or lower value of the index. Red shaded countries scored a bilateral FMP index lower than the average, while green shaded countries scored a bilateral FMP index above the average.

economies such as the USA, Canada and Japan and other OECD countries, all at the top of the FMP distribution. China and India are another good example for developing countries. Both have a quite high FMP index despite the long distance from France, the lack of colonial ties and common culture, and the relatively lower income per capita. Nevertheless, the market potential index of these two countries has continuously increased during the period for French exporters mainly because of the very large internal population and the increasing pace of economic growth experienced in the last decades. Interestingly, also the group of North-African countries of Morocco, Algeria and Tunisia score a very high FMP index, again thanks to the proximity of these markets to French exporters and to the cultural and colonial ties between these countries and France. On the contrary, distant and less attractive markets with high cultural and economic barriers which are more difficult to access register as expected very low scores in the FMP index, such as Sub-Saharan Africa, South-America and some Central and East-Asian countries.

We then use the FMP index to build a firm-level weighted measure of market access for each French exporter. To do so, we weight the FMP index for all countries served by each French exporter by the total value of firm shipments towards each foreign market, averaging per firm and year. Thus, the new firm-level FMP index represents the company exporting strategy in the international markets. Firms with very high FMP index export mainly towards close EU countries or other high-income markets which are usually the main trading partners of France. On the contrary, firms with relatively lower FMP index tend to export to distant and difficult markets which are not the usual French exporting markets, mainly characterized by cultural and trade barriers, such as extra-EU, African, South-American and central Asian countries.

A.3.2 Additional Test and Robustness

Table A.3.2.1: Estimation results of the total exports and external R&D system of equations using a 3SLS model.

TOTAL EXPORTS	**[A]**			**[B]**				
	(1) *Offshored*	(2) *Outs.Dom.*	(3) *Tot.Exports*	(4) *Off.(IN)*	(5) *Off.(OUT)*	(6) *Dom.(IN)*	(7) *Dom.(OUT)*	(8) *Tot.Exports*
$Employment_{it-1}$	0.291***	0.521***	1.578***	0.213***	0.185***	0.178***	0.442***	1.744***
	(0.00297)	(0.00552)	(0.111)	(0.00221)	(0.00191)	(0.00180)	(0.00481)	(0.0576)
$Av.Salary_{it-1}$	0.0639***	0.0338**	0.534***	0.0245***	0.0547***	0.0427***	0.0390***	0.899***
	(0.00826)	(0.0161)	(0.174)	(0.00502)	(0.00502)	(0.00498)	(0.0134)	(0.0960)
$Lab.Productivity_{it-1}$	0.175***	0.288***	1.691***	0.172***	0.0862***	0.121***	0.243***	1.344***
	(0.00644)	(0.0121)	(0.131)	(0.00484)	(0.00438)	(0.00436)	(0.0115)	(0.0950)
$InternalR\&D_{it-1}$	1.021***	2.450***	2.377	0.513***	0.580***	0.616***	1.868***	0.847
	(0.0317)	(0.0648)	(1.824)	(0.0224)	(0.0207)	(0.0222)	(0.0549)	(0.742)
$ForeignGroup_{it}$	0.0590***	0.0275	-0.921***	0.101***	0.00610	-0.00969	0.0292*	1.359***
	(0.00883)	(0.0171)	(0.204)	(0.00576)	(0.00597)	(0.00595)	(0.0157)	(0.123)
$FrenchGroup_{it}$	0.0472***	0.105***	-0.242	-0.000320	0.0291***	0.297***	0.0744***	-1.269***
	(0.0102)	(0.0195)	(0.189)	(0.00627)	(0.00646)	(0.00674)	(0.0170)	(0.127)
$Tot.Exports_{it-1}$	0.00442***	0.000934		-0.0232***	0.0117***	-0.000327	0.000747*	
	(0.000919)	(0.00170)		(0.000494)	(0.000481)	(0.00121)	(0.000444)	
$Int * Offsh.R\&D_{it-1}$			2.802*					
			(1.637)					
$Int * Outs.Dom.R\&D_{it-1}$			-3.981					
			(2.974)					
$Offsh.R\&D_{it-1}$			-1.553***					
			(0.292)					
$Outs.Dom.R\&D_{it-1}$			7.384***					
			(1.601)					
$Int * Offsh.(IN)_{it-1}$								-1.490***
								(0.358)
$Int * Offsh.(OUT)_{it-1}$								6.161**
								(2.512)
$Int * Outs.Dom.(IN)_{it-1}$								0.714
								(1.023)
$Int * Outs.Dom.(OUT)_{it-1}$								2.123**
								(0.969)
$Offsh.(IN)R\&D_{it-1}$								-3.145***
								(1.194)
$Offsh.(OUT)R\&D_{it-1}$								-37.39***
								(2.454)
$Outs.Dom.(IN)R\&D_{it-1}$								2.133**
								(0.896)
$Outs.Dom.(OUT)R\&D_{it-1}$								15.02***
								(0.955)
Observations	7,860	7,860	7,860	7,860	7,860	7,860	7,860	7,860
R^2	0.783	0.775	0.214	0.811	0.787	0.834	0.770	0.750

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Total exports*** measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int{*}Offsh.R\&D$, $Int{*}Outs.Dom.R\&D$, $Int{*}Offsh.(IN)$, $Int{*}Offsh.(OUT)$, $Int{*}Outs.Dom.(IN)$ and $Int{*}Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.2: Estimation results of the FMP index and external R&D system of equations using a 3SLS model.

FMP INDEX	**[A]**			**[B]**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.293***	0.529***	-0.883***	0.204***	0.180***	0.182***	0.451***	-1.213***
	(0.00297)	(0.00555)	(0.0940)	(0.00215)	(0.00180)	(0.00174)	(0.00465)	(0.0808)
$Av.Salary_{it-1}$	0.0635***	0.0335*	-0.275**	0.0243***	0.0542***	0.0434***	0.0395**	-0.501***
	(0.00898)	(0.0174)	(0.121)	(0.00568)	(0.00604)	(0.00570)	(0.0159)	(0.112)
$Lab.Productivity_{it-1}$	0.190***	0.319***	-0.748***	0.175***	0.0913***	0.132***	0.272***	-0.993***
	(0.00703)	(0.0130)	(0.0995)	(0.00457)	(0.00424)	(0.00412)	(0.0114)	(0.109)
$InternalR\&D_{it-1}$	1.035***	2.474***	1.235	0.491***	0.571***	0.619***	1.896***	1.561**
	(0.0338)	(0.0692)	(0.870)	(0.0194)	(0.0193)	(0.0211)	(0.0513)	(0.727)
$ForeignGroup_{it}$	-0.0625***	0.0203	0.125	0.0939***	0.0003	-0.0124**	0.0246	-0.583***
	(0.0101)	(0.0195)	(0.140)	(0.00609)	(0.00619)	(0.00626)	(0.0163)	(0.129)
$FrenchGroup_{it}$	0.0592***	0.124***	0.199	0.00967	0.0379***	0.305***	0.0923***	0.523***
	(0.0104)	(0.0200)	(0.138)	(0.00648)	(0.00661)	(0.00687)	(0.0174)	(0.142)
$FMPIndex_{it-1}$	0.00427**	0.00348		0.0128***	0.00609***	0.00138	0.00579**	
	(0.00181)	(0.00332)		(0.00104)	(0.00106)	(0.000966)	(0.00273)	
$Int * Offsh.R\&D_{it-1}$			-0.449					
			(1.439)					
$Int * Outs.Dom.R\&D_{it-1}$			-0.478					
			(0.745)					
$Offsh.R\&D_{it-1}$			4.090***					
			(1.423)					
$Outs.Dom.R\&D_{it-1}$			-1.192					
			(0.740)					
$Int * Offsh.(IN)_{it-1}$								-1.121
								(2.065)
$Int * Offsh.(OUT)_{it-1}$								-2.776***
								(0.910)
$Int * Outs.Dom.(IN)_{it-1}$								0.867
								(0.916)
$Int * Outs.Dom.(OUT)_{it-1}$								7.876***
								(1.014)
$Offsh.(IN)R\&D_{it-1}$								0.974
								(0.828)
$Offsh.(OUT)R\&D_{it-1}$								14.55***
								(2.139)
$Outs.Dom.(IN)R\&D_{it-1}$								-1.124
								(0.775)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.012***
								(0.887)
Observations	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610
R^2	0.788	0.779	0.125	0.820	0.794	0.838	0.776	0.213

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Foreign Market Potential (FMP) index*** measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; ***Offshored*** measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.3: Estimation results of the total exports and external R&D system of equations using a 3SLS model - Domestic vs Foreign Groups.

TOTAL EXPORTS	**Domestic**								**Foreign**							
	[A]			**[B]**					**[C]**			**[D]**				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $Tot.Exports$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $Tot.Exports$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $Tot.Exports$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $Tot.Exports$
$Employment_{it-1}$	0.289***	0.517***	1.448***	0.204***	0.185***	0.179***	0.440***	1.723***	0.294***	0.528***	1.682***	0.234***	0.184***	0.178***	0.444***	1.862***
	(0.00373)	(0.00697)	(0.143)	(0.00272)	(0.00226)	(0.00214)	(0.00572)	(0.0656)	(0.00463)	(0.00865)	(0.212)	(0.00366)	(0.00317)	(0.00310)	(0.00815)	(0.0990)
$Av.Salary_{it-1}$	0.0657***	0.0434**	0.593***	0.0212***	0.0543***	0.0458***	0.0425**	0.815***	0.0630***	0.0178	0.322	0.0447***	0.0575***	0.0389***	0.0370	1.163***
	(0.0101)	(0.0198)	(0.200)	(0.00548)	(0.00632)	(0.00669)	(0.0168)	(0.110)	(0.0155)	(0.0303)	(0.296)	(0.0106)	(0.0103)	(0.00964)	(0.0276)	(0.186)
$Lab.Productivity_{it-1}$	0.160***	0.263***	1.651***	0.147***	0.0776***	0.111***	0.221***	1.127***	0.199***	0.332***	1.766***	0.211***	0.101***	0.136***	0.281***	1.750***
	(0.00813)	(0.0153)	(0.165)	(0.00540)	(0.00524)	(0.00536)	(0.0138)	(0.103)	(0.0104)	(0.0197)	(0.252)	(0.00849)	(0.00629)	(0.00601)	(0.0167)	(0.197)
$InternalR\&D_{it-1}$	0.980***	2.351***	5.007**	0.433***	0.557***	0.640***	1.803***	2.170**	1.079***	2.588***	5.335*	0.646***	0.612***	0.561***	1.963***	2.202
	(0.0439)	(0.0916)	(2.087)	(0.0282)	(0.0275)	(0.0333)	(0.0748)	(0.887)	(0.0495)	(0.0991)	(3.121)	(0.0335)	(0.0283)	(0.0275)	(0.0734)	(1.425)
$FrenchGroup_{it}$	0.0445***	0.0980***	-0.453*	0.0131**	0.0259***	0.295***	0.0702***	-1.103***								
	(0.0112)	(0.0221)	(0.232)	(0.00658)	(0.00727)	(0.00766)	(0.0191)	(0.144)								
$Tot.Exports_{it-1}$	-0.00254**	0.00507**		-0.0226***	-0.0109***	0.00181***	0.00212		-0.00665***	-0.00453		-0.0227***	-0.0124***	-0.000294	-0.00302*	
	(0.00119)	(0.00216)		(0.000554)	(0.000583)	(0.000580)	(0.00148)		(0.00149)	(0.00277)		(0.000736)	(0.000702)	(0.000631)	(0.00177)	
$Int*Offsh.R\&D_{it-1}$			-8.368**								7.651*					
			(3.680)								(4.532)					
$Int*Outs.Dom.R\&D_{it-1}$			5.447***								-4.301*					
			(2.008)								(2.545)					
$Offsh.R\&D_{it-1}$			-10.86***								-28.81***					
			(3.451)								(4.479)					
$Outs.Dom.R\&D_{it-1}$			4.891***								15.02***					
			(1.890)								(2.533)					
$Int*Offsh.(IN)_{it-1}$								-16.85***								-15.43***
								(2.003)								(2.157)
$Int*Offsh.(OUT)_{it-1}$								6.489**								10.91**
								(3.210)								(4.239)
$Int*Outs.Dom.(IN)_{it-1}$								1.639								0.353
								(1.364)								(1.876)
$Int*Outs.Dom.(OUT)_{it-1}$								2.199*								0.593
								(1.217)								(1.745)
$Offsh.(IN)R\&D_{it-1}$								-2.632								-3.246*
								(1.692)								(1.961)
$Offsh.(OUT)R\&D_{it-1}$								-35.45***								-43.12***
								(2.880)								(4.234)
$Outs.Dom.(IN)R\&D_{it-1}$								1.951								1.308
								(1.253)								(1.684)
$Outs.Dom.(OUT)R\&D_{it-1}$								14.00***								18.29***
								(1.137)								(1.725)
Observations	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R^2	0.799	0.789	0.235	0.810	0.797	0.850	0.786	0.759	0.746	0.737	0.175	0.783	0.761	0.780	0.726	0.760

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.4: Estimation results of the total exports and external R&D system of equations using a 3SLS model - Low vs High-Tech Industries.

TOTAL EXPORTS	**Low-Tech**								**High-Tech**							
		[A]				**[B]**				**[C]**				**[D]**		
	(1) *Offshored*	(2) *Outs.Dom.*	(3) *Tot.Exports*	(4) *Offsh.(IN)*	(5) *Offsh.(OUT)*	(6) *Outs.Dom.(IN)*	(7) *Outs.Dom.(OUT)*	(8) *Tot.Exports*	(9) *Offshored*	(10) *Outs.Dom.*	(11) *Tot.Exports*	(12) *Offsh.(IN)*	(13) *Offsh.(OUT)*	(14) *Outs.Dom.(IN)*	(15) *Outs.Dom.(OUT)*	(16) *Tot.Exports*
$Employment_{it-1}$	0.278***	0.508***	1.784***	0.194***	0.175***	0.169***	0.423***	1.899***	0.301***	0.534***	1.550***	0.224***	0.192***	0.185***	0.458***	1.640***
	(0.00531)	(0.00961)	(0.179)	(0.00372)	(0.00312)	(0.00295)	(0.00807)	(0.0844)	(0.00344)	(0.00654)	(0.146)	(0.00259)	(0.00221)	(0.00214)	(0.00565)	(0.0791)
$Av.Salary_{it-1}$	0.00323	-0.0749***	0.831***	-0.00668	0.0135	0.00559	-0.0575**	0.886***	0.0974***	0.0951***	0.287	0.0419***	0.0774***	0.0634***	0.0919***	0.778***
	(0.0144)	(0.0275)	(0.246)	(0.00757)	(0.00844)	(0.00805)	(0.0223)	(0.147)	(0.0109)	(0.0210)	(0.222)	(0.00689)	(0.00691)	(0.00659)	(0.0182)	(0.133)
$Lab.Productivity_{it-1}$	0.204***	0.361***	1.884***	0.177***	0.104***	0.145***	0.294***	1.746***	0.155***	0.237***	1.635***	0.166***	0.0735***	0.103***	0.208***	1.091***
	(0.00919)	(0.0172)	(0.224)	(0.00672)	(0.00526)	(0.00518)	(0.0144)	(0.190)	(0.00872)	(0.0166)	(0.169)	(0.00659)	(0.00600)	(0.00571)	(0.0155)	(0.122)
$InternalR\&D_{it-1}$	1.073***	2.494***	1.526	0.512***	0.592***	0.690***	1.852***	0.432	0.967***	2.373***	3.903	0.503***	0.556***	0.558***	1.832***	0.903
	(0.0522)	(0.106)	(3.244)	(0.0350)	(0.0319)	(0.0379)	(0.0824)	(1.240)	(0.0376)	(0.0787)	(2.380)	(0.0248)	(0.0231)	(0.0245)	(0.0627)	(1.123)
$ForeignGroup_{it}$	-0.0423***	0.0471	-0.514	0.106***	0.0198**	-0.000967	0.0531**	1.668***	-0.0718***	0.0132	-1.464***	0.0931***	-0.00381	-0.0167**	0.0114	1.192***
	(0.0157)	(0.0294)	(0.351)	(0.00917)	(0.00975)	(0.00961)	(0.0262)	(0.194)	(0.0112)	(0.0217)	(0.263)	(0.00699)	(0.00711)	(0.00705)	(0.0188)	(0.147)
$FrenchGroup_{it}$	0.0370**	0.0749**	0.389	-0.00128	0.0253***	0.286***	0.0578**	-0.554***	0.0499***	0.119***	-0.673***	-0.00476	0.0292***	0.301***	0.0790***	-1.693***
	(0.0161)	(0.0307)	(0.331)	(0.00946)	(0.00983)	(0.0100)	(0.0263)	(0.198)	(0.0125)	(0.0239)	(0.236)	(0.00780)	(0.00768)	(0.00776)	(0.0201)	(0.172)
$Tot.Exports_{it-1}$	-0.00743***	-0.00581*		-0.0248***	-0.0136***	-0.00120	-0.00471**		-0.00298***	0.00448**		-0.0223***	-0.0107***	0.00174***	0.00178	
	(0.00169)	(0.00316)		(0.000844)	(0.000829)	(0.000797)	(0.00212)		(0.00105)	(0.00197)		(0.000556)	(0.000540)	(0.000505)	(0.00140)	
$Int*Offsh.R\&D_{it-1}$			-5.192								-5.945					
			(5.180)								(3.852)					
$Int*Outs.Dom.R\&D_{it-1}$			2.856								4.039*					
			(3.039)								(2.102)					
$Offsh.R\&D_{it-1}$			-8.333*								-20.94***					
			(4.858)								(3.639)					
$Outs.Dom.R\&D_{it-1}$			3.368								10.47***					
			(2.851)								(2.018)					
$Int*Offsh.(IN)_{it-1}$								-8.160***								-18.23***
								(2.554)								(1.709)
$Int*Offsh.(OUT)_{it-1}$								0.921								9.576***
								(4.022)								(2.983)
$Int*Outs.Dom.(IN)_{it-1}$								0.910								1.426
								(1.496)								(1.631)
$Int*Outs.Dom.(OUT)_{it-1}$								1.203								1.817
								(1.853)								(1.377)
$Offsh.(IN)R\&D_{it-1}$								-11.48***								0.771
								(2.310)								(1.526)
$Offsh.(OUT)R\&D_{it-1}$								-25.70***								-44.23***
								(3.821)								(2.980)
$Outs.Dom.(IN)R\&D_{it-1}$								0.948								2.064
								(1.307)								(1.438)
$Outs.Dom.(OUT)R\&D_{it-1}$								13.60***								16.59***
								(1.793)								(1.345)
Observations	2,810	2,810	2,810	2,810	2,810	2,810	2,810	2,810	5,050	5,050	5,050	5,050	5,050	5,050	5,050	5,050
R^2	0.769	0.753	0.196	0.796	0.754	0.828	0.732	0.726	0.794	0.786	0.239	0.819	0.804	0.845	0.784	0.774

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between *Low-Tech* and *High-Tech* industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.5: Estimation results of the FMP Index and external R&D system of equations using a 3SLS model - Domestic vs Foreign Groups.

FMP INDEX	Domestic								Foreign							
	[A]			[B]					[C]			[D]				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $FMPIndex$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $FMPIndex$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $FMPIndex$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $FMPIndex$
$Employment_{it-1}$	0.292***	0.526***	-0.843***	0.194***	0.181***	0.183***	0.450***	-1.239***	0.297***	0.540***	-0.981***	0.226***	0.179***	0.183***	0.456***	-1.202***
	(0.00389)	(0.00727)	(0.113)	(0.00287)	(0.00251)	(0.00240)	(0.00654)	(0.104)	(0.00526)	(0.00997)	(0.156)	(0.00421)	(0.00353)	(0.00318)	(0.00909)	(0.159)
$Av.Salary_{it-1}$	0.0685***	0.0515**	-0.395**	0.0215***	0.0558***	0.0489***	0.0500***	-0.571***	0.0538***	-0.00305	-0.00172	0.0393***	0.0505***	0.0332***	0.0184	-0.304*
	(0.0112)	(0.0218)	(0.159)	(0.00637)	(0.00728)	(0.00703)	(0.0193)	(0.137)	(0.0172)	(0.0346)	(0.185)	(0.0110)	(0.0107)	(0.00994)	(0.0286)	(0.181)
$Lab.Productivity_{it-1}$	0.187***	0.313***	-0.755***	0.158***	0.0899***	0.128***	0.268***	-0.957***	0.196***	0.332***	-0.742***	0.199***	0.0947***	0.137***	0.281***	-0.924***
	(0.00907)	(0.0166)	(0.142)	(0.00585)	(0.00600)	(0.00602)	(0.0162)	(0.132)	(0.0107)	(0.0210)	(0.164)	(0.00860)	(0.00652)	(0.00643)	(0.0178)	(0.172)
$InternalR\&D_{it-1}$	1.013***	2.403***	2.527**	0.415***	0.558***	0.655***	1.849***	2.955***	1.058***	2.555***	1.252	0.599***	0.583***	0.548***	1.950***	0.858
	(0.0490)	(0.101)	(1.171)	(0.0278)	(0.0296)	(0.0350)	(0.0818)	(0.934)	(0.0434)	(0.0909)	(1.673)	(0.0314)	(0.0280)	(0.0278)	(0.0745)	(1.307)
$FrenchGroup_{it}$	0.0567***	0.119***	0.216	0.0230***	0.0352***	0.302***	0.0890***	0.420**								
	(0.0127)	(0.0247)	(0.158)	(0.00752)	(0.00852)	(0.00886)	(0.0229)	(0.189)								
$FMPIndex_{it-1}$	0.00245	-0.000639		0.0118***	0.00531***	0.000337	0.00274		0.00936**	0.0151**		0.0140***	0.00856***	0.00418**	0.0149***	
	(0.00210)	(0.00385)		(0.00123)	(0.00133)	(0.00123)	(0.00337)		(0.00376)	(0.00684)		(0.00234)	(0.00232)	(0.00212)	(0.00578)	
$Int*Offsh.R\&D_{it-1}$			-1.414								-1.557					
			(2.187)								(1.661)					
$Int*Outs.Dom.R\&D_{it-1}$			0.905								0.725					
			(1.099)								(0.998)					
$Offsh.R\&D_{it-1}$			3.559*								3.800**					
			(2.093)								(1.675)					
$Outs.Dom.R\&D_{it-1}$			-0.771								-1.433					
			(1.056)								(0.967)					
$Int*Offsh.(IN)_{it-1}$								-1.463								-3.333
								(2.789)								(3.090)
$Int*Offsh.(OUT)_{it-1}$								-3.514***								-0.885
								(1.238)								(1.203)
$Int*Outs.Dom.(IN)_{it-1}$								0.556								0.104
								(1.317)								(1.638)
$Int*Outs.Dom.(OUT)_{it-1}$								11.05***								6.246***
								(1.791)								(1.711)
$Offsh.(IN)R\&D_{it-1}$								0.704								-1.025
								(1.495)								(1.395)
$Offsh.(OUT)R\&D_{it-1}$								16.05***								13.83***
								(2.828)								(3.151)
$Outs.Dom.(IN)R\&D_{it-1}$								-1.033								-0.346
								(1.198)								(1.503)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.543***								-4.468***
								(1.232)								(1.195)
Observations	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	2,626	2,626	2,626	2,626	2,626	2,626	2,626	2,626
R^2	0.803	0.793	0.125	0.822	0.807	0.852	0.792	0.236	0.756	0.745	0.118	0.786	0.767	0.790	0.737	0.173

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.6: Estimation results of the FMP Index and external R&D system of equations using a 3SLS model - Low vs High-Tech Industries.

FMP INDEX	**Low-Tech**								**High-Tech**							
	[A]			**[B]**					**[C]**			**[D]**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.272***	0.499***	-0.739***	0.182***	0.165***	0.167***	0.420***	-1.171***	0.308***	0.552***	-1.057***	0.217***	0.190***	0.192***	0.474***	-1.305***
	(0.00582)	(0.0105)	(0.151)	(0.00428)	(0.00354)	(0.00334)	(0.00902)	(0.139)	(0.00357)	(0.00676)	(0.116)	(0.00268)	(0.00239)	(0.00235)	(0.00618)	(0.111)
$Av.Salary_{it-1}$	0.0126	-0.0556*	-0.504***	-0.00324	0.0201**	0.0109	-0.0370	-0.650***	0.0896***	0.0786***	-0.174	0.0389***	0.0717***	0.0603***	0.0776***	-0.382***
	(0.0151)	(0.0287)	(0.185)	(0.00787)	(0.00896)	(0.00873)	(0.0239)	(0.175)	(0.0118)	(0.0229)	(0.151)	(0.00705)	(0.00730)	(0.00694)	(0.0197)	(0.148)
$Lab.Productivity_{it-1}$	0.204***	0.363***	-0.760***	0.171***	0.101***	0.146***	0.301***	-1.196***	0.176***	0.279***	-0.733***	0.176***	0.0823***	0.118***	0.246***	-0.887***
	(0.00982)	(0.0183)	(0.165)	(0.00726)	(0.00619)	(0.00615)	(0.0172)	(0.179)	(0.00895)	(0.0166)	(0.134)	(0.00644)	(0.00589)	(0.00537)	(0.0151)	(0.144)
$InternalR\&D_{it-1}$	1.064***	2.470***	1.089	0.480***	0.572***	0.670***	1.842***	2.344*	0.993***	2.426***	1.035	0.484***	0.553***	0.571***	1.883***	1.100
	(0.0573)	(0.116)	(1.462)	(0.0350)	(0.0339)	(0.0394)	(0.0923)	(1.327)	(0.0397)	(0.0859)	(1.228)	(0.0240)	(0.0237)	(0.0252)	(0.0667)	(1.229)
$ForeignGroup_{it}$	-0.0329*	0.0646**	0.121	0.108***	0.0237**	0.00443	0.0719**	-0.796***	-0.0848***	-0.0103	0.213	0.0786***	-0.0167**	-0.0257***	-0.00900	-0.518***
	(0.0171)	(0.0326)	(0.234)	(0.0102)	(0.0105)	(0.0103)	(0.0280)	(0.223)	(0.0123)	(0.0239)	(0.169)	(0.00709)	(0.00775)	(0.00773)	(0.0205)	(0.163)
$FrenchGroup_{it}$	0.0569***	0.110***	0.164	0.0101	0.0394***	0.296***	0.0926***	0.432*	0.0554***	0.125***	0.211	0.00379	0.0340***	0.306***	0.0847***	0.626***
	(0.0175)	(0.0336)	(0.235)	(0.0107)	(0.0111)	(0.0112)	(0.0295)	(0.228)	(0.0145)	(0.0283)	(0.171)	(0.00796)	(0.00839)	(0.00860)	(0.0224)	(0.203)
$FMPIndex_{it-1}$	0.000717	-0.00219		0.0112***	0.00417**	-0.000408	0.00176		0.00622***	0.00683		0.0135***	0.00705***	0.00221*	0.00810**	
	(0.00290)	(0.00524)		(0.00178)	(0.00173)	(0.00148)	(0.00438)		(0.00233)	(0.00434)		(0.00135)	(0.00139)	(0.00128)	(0.00354)	
$Int*Offsh.R\&D_{it-1}$			-3.833**								1.741					
			(1.818)								(2.242)					
$Int*Outs.Dom.R\&D_{it-1}$			0.973								-1.250					
			(1.049)								(1.107)					
$Offsh.R\&D_{it-1}$			6.223***								3.815*					
			(1.814)								(2.028)					
$Outs.Dom.R\&D_{it-1}$			-2.309**								-1.175					
			(1.020)								(1.006)					
$Int*Offsh.(IN)_{it-1}$								-3.752								0.154
								(3.144)								(3.392)
$Int*Offsh.(OUT)_{it-1}$								-2.291**								-2.975**
								(0.810)								(1.503)
$Int*Outs.Dom.(IN)_{it-1}$								0.294								0.869
								(1.394)								(1.523)
$Int*Outs.Dom.(OUT)_{it-1}$								8.265***								8.164***
								(2.183)								(1.306)
$Offsh.(IN)R\&D_{it-1}$								3.067*								0.136
								(1.738)								(1.056)
$Offsh.(OUT)R\&D_{it-1}$								13.20***								15.01***
								(2.978)								(3.440)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.674								-1.291
								(1.272)								(1.351)
$Outs.Dom.(OUT)R\&D_{it-1}$								-4.923***								-5.074***
								(1.628)								(1.456)
Observations	2,421	2,421	2,421	2,421	2,421	2,421	2,421	2,421	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189
R^2	0.772	0.750	0.142	0.801	0.753	0.830	0.730	0.230	0.799	0.792	0.124	0.831	0.815	0.850	0.793	0.212

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a 3SLS model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between ***Low-Tech*** and ***High-Tech*** industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.7: Estimation results of the total exports and external R&D system of equations using a SUR model.

TOTAL EXPORTS	[A]			[B]				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Offshored	*Outs.Dom.*	*Tot.Exports*	*Off.(IN)*	*Off.(OUT)*	*Dom.(IN)*	*Dom.(OUT)*	*Tot.Exports*
$Employment_{it-1}$	0.291***	0.521***	1.578***	0.213***	0.185***	0.178***	0.442***	1.744***
	(0.00297)	(0.00552)	(0.111)	(0.00221)	(0.00191)	(0.00180)	(0.00481)	(0.0576)
$Av.Salary_{it-1}$	0.0639***	0.0338**	0.534***	0.0245***	0.0547***	0.0427***	0.0390***	0.899***
	(0.00826)	(0.0161)	(0.174)	(0.00502)	(0.00502)	(0.00498)	(0.0134)	(0.0960)
$Lab.Productivity_{it-1}$	0.175***	0.288***	1.691***	0.172***	0.0862***	0.121***	0.243***	1.344***
	(0.00644)	(0.0121)	(0.131)	(0.00484)	(0.00438)	(0.00436)	(0.0115)	(0.0950)
$InternalR\&D_{it-1}$	1.021***	2.450***	2.377	0.513***	0.580***	0.616***	1.868***	0.847
	(0.0317)	(0.0648)	(1.824)	(0.0224)	(0.0207)	(0.0222)	(0.0549)	(0.742)
$ForeignGroup_{it}$	-0.0590***	0.0275	-0.921***	0.101***	0.00610	-0.00969	0.0292*	1.359***
	(0.00883)	(0.0171)	(0.204)	(0.00576)	(0.00597)	(0.00595)	(0.0157)	(0.123)
$FrenchGroup_{it}$	0.0472***	0.105***	-0.242	-0.000320	0.0291***	0.297***	0.0744***	-1.269***
	(0.0102)	(0.0195)	(0.189)	(0.00627)	(0.00646)	(0.00674)	(0.0170)	(0.127)
$Tot.Exports_{it-1}$	-0.00442***	0.000934		-0.0232***	-0.0117***	0.000747*	-0.000327	
	(0.000919)	(0.00170)		(0.000494)	(0.000481)	(0.000444)	(0.00121)	
$Int*Offsh.R\&D_{it-1}$			3.981					
			(2.974)					
$Int*Outs.Dom.R\&D_{it-1}$			-2.802*					
			(1.637)					
$Offsh.R\&D_{it-1}$			-15.53***					
			(2.921)					
$Outs.Dom.R\&D_{it-1}$			7.384***					
			(1.601)					
$Int*Offsh.(IN)_{it-1}$								-14.90***
								(1.358)
$Int*Offsh.(OUT)_{it-1}$								6.161**
								(2.512)
$Int*Outs.Dom.(IN)_{it-1}$								0.714
								(1.023)
$Int*Outs.Dom.(OUT)_{it-1}$								-2.123**
								(0.969)
$Offsh.(IN)R\&D_{it-1}$								-3.145***
								(1.194)
$Offsh.(OUT)R\&D_{it-1}$								-37.39***
								(2.454)
$Outs.Dom.(IN)R\&D_{it-1}$								2.133**
								(0.896)
$Outs.Dom.(OUT)R\&D_{it-1}$								15.02***
								(0.955)
Observations	7,860	7,860	7,860	7,860	7,860	7,860	7,860	7,860
R^2	0.783	0.775	0.214	0.811	0.787	0.834	0.770	0.750

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.8: Estimation results of the FMP index and external R&D system of equations using a SUR model.

FMP Index	**[A]**			**[B]**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Off.(IN)$	$Off.(OUT)$	$Dom.(IN)$	$Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.293***	0.529***	-0.883***	0.204***	0.180***	0.182***	0.451***	-1.213***
	(0.00297)	(0.00555)	(0.0940)	(0.00215)	(0.00180)	(0.00174)	(0.00465)	(0.0808)
$Av.Salary_{it-1}$	0.0635***	0.0335*	-0.275**	0.0243***	0.0542***	0.0434***	0.0395**	-0.501***
	(0.00898)	(0.0174)	(0.121)	(0.00568)	(0.00604)	(0.00570)	(0.0159)	(0.112)
$Lab.Productivity_{it-1}$	0.190***	0.319***	-0.748***	0.175***	0.0913***	0.132***	0.272***	-0.993***
	(0.00703)	(0.0130)	(0.0995)	(0.00457)	(0.00424)	(0.00412)	(0.0114)	(0.109)
$InternalR\&D_{it-1}$	1.035***	2.474***	1.235	0.491***	0.571***	0.619***	1.896***	1.561**
	(0.0338)	(0.0692)	(0.870)	(0.0194)	(0.0193)	(0.0211)	(0.0513)	(0.727)
$ForeignGroup_{it}$	-0.0625***	0.0203	0.125	0.0939***	3.04e-05	-0.0124**	0.0246	-0.583***
	(0.0101)	(0.0195)	(0.140)	(0.00609)	(0.00619)	(0.00626)	(0.0163)	(0.129)
$FrenchGroup_{it}$	0.0592***	0.124***	0.199	0.00967	0.0379***	0.305***	0.0923***	0.523***
	(0.0104)	(0.0200)	(0.138)	(0.00648)	(0.00661)	(0.00687)	(0.0174)	(0.142)
$FMPIndex_{it-1}$	0.00427**	0.00348		0.0128***	0.00609***	0.00138	0.00579**	
	(0.00181)	(0.00332)		(0.00104)	(0.00106)	(0.000966)	(0.00273)	
$Int * Offsh.R\&D_{it-1}$			-0.449					
			(1.439)					
$Int * Outs.Dom.R\&D_{it-1}$			-0.478					
			(0.745)					
$Offsh.R\&D_{it-1}$			4.090***					
			(1.423)					
$Outs.Dom.R\&D_{it-1}$			-1.192					
			(0.740)					
$Int * Offsh.(IN)_{it-1}$								7.876***
								(1.014)
$Int * Offsh.(OUT)_{it-1}$								-2.776***
								(0.910)
$Int * Outs.Dom.(IN)_{it-1}$								0.867
								(0.916)
$Int * Outs.Dom.(OUT)_{it-1}$								-1.121
								(2.065)
$Offsh.(IN)R\&D_{it-1}$								0.974
								(0.828)
$Offsh.(OUT)R\&D_{it-1}$								14.55***
								(2.139)
$Outs.Dom.(IN)R\&D_{it-1}$								-1.124
								(0.775)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.012***
								(0.887)
$Observations$	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610
R^2	0.788	0.779	0.125	0.820	0.794	0.838	0.776	0.213

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Foreign Market Potential (FMP) index*** measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.9: Estimation results of the total exports and external R&D system of equations using a SUR model - Domestic vs Foreign Groups.

TOTAL EXPORTS	**Domestic**								**Foreign**							
		[A]				**[B]**				**[C]**				**[D]**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$Tot.Exports$	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$Tot.Exports$
$Employment_{it-1}$	0.289***	0.517***	1.448***	0.204***	0.185***	0.179***	0.440***	1.723***	0.294***	0.528***	1.682***	0.234***	0.184***	0.178***	0.444***	1.862***
	(0.00373)	(0.00697)	(0.143)	(0.00272)	(0.00226)	(0.00214)	(0.00572)	(0.0656)	(0.00463)	(0.00865)	(0.212)	(0.00366)	(0.00317)	(0.00310)	(0.00815)	(0.0990)
$Av.Salary_{it-1}$	0.0657***	0.0434**	0.593***	0.0212***	0.0543***	0.0458***	0.0425**	0.815***	0.0630***	0.0178	0.322	0.0447***	0.0575***	0.0389***	0.0370	1.163***
	(0.0101)	(0.0198)	(0.200)	(0.00548)	(0.00632)	(0.00669)	(0.0168)	(0.110)	(0.0155)	(0.0303)	(0.296)	(0.0106)	(0.0103)	(0.00964)	(0.0276)	(0.186)
$Lab.Productivity_{it-1}$	0.160***	0.263***	1.651***	0.147***	0.0776***	0.111***	0.221***	1.127***	0.199***	0.332***	1.766***	0.211***	0.101***	0.136***	0.281***	1.750***
	(0.00813)	(0.0153)	(0.165)	(0.00540)	(0.00524)	(0.00536)	(0.0138)	(0.103)	(0.0104)	(0.0197)	(0.252)	(0.00849)	(0.00629)	(0.00601)	(0.0167)	(0.197)
$InternalR\&D_{it-1}$	0.980***	2.351***	5.007**	0.433***	0.557***	0.640***	1.803***	2.170**	1.079***	2.588***	5.335*	0.646***	0.612***	0.561***	1.963***	2.202
	(0.0439)	(0.0916)	(2.087)	(0.0282)	(0.0275)	(0.0333)	(0.0748)	(0.887)	(0.0495)	(0.0991)	(3.121)	(0.0335)	(0.0283)	(0.0275)	(0.0734)	(1.425)
$FrenchGroup_{it}$	0.0445***	0.0980***	-0.453*	0.0131**	0.0259***	0.295***	0.0702***	-1.103***								
	(0.0112)	(0.0221)	(0.232)	(0.00658)	(0.00727)	(0.00766)	(0.0191)	(0.144)								
$Tot.Exports_{it-1}$	-0.00254**	0.00507**		-0.0226***	-0.0109***	0.00181***	0.00212		-0.00665***	-0.00453		-0.0227***	-0.0124***	-0.000294	-0.00302*	
	(0.00119)	(0.00216)		(0.000554)	(0.000583)	(0.000580)	(0.00148)		(0.00149)	(0.00277)		(0.000736)	(0.000702)	(0.000631)	(0.00177)	
$Int*Offsh.R\&D_{it-1}$			-8.368**								7.651*					
			(3.680)								(4.532)					
$Int*Outs.Dom.R\&D_{it-1}$			5.447***								-4.301*					
			(2.008)								(2.545)					
$Offsh.R\&D_{it-1}$			-10.86***								-28.81***					
			(3.451)								(4.479)					
$Outs.Dom.R\&D_{it-1}$			4.891***								15.02***					
			(1.890)								(2.533)					
$Int*Offsh.(IN)_{it-1}$								-16.85***								-15.43***
								(2.003)								(2.157)
$Int*Offsh.(OUT)_{it-1}$								6.489**								10.91**
								(3.210)								(4.239)
$Int*Outs.Dom.(IN)_{it-1}$								1.639								0.353
								(1.364)								(1.876)
$Int*Outs.Dom.(OUT)_{it-1}$								2.199*								0.593
								(1.217)								(1.745)
$Offsh.(IN)R\&D_{it-1}$								-2.632								-3.246*
								(1.692)								(1.961)
$Offsh.(OUT)R\&D_{it-1}$								-35.45***								-43.12***
								(2.880)								(4.234)
$Outs.Dom.(IN)R\&D_{it-1}$								1.951								1.308
								(1.253)								(1.684)
$Outs.Dom.(OUT)R\&D_{it-1}$								14.00***								18.29***
								(1.137)								(1.725)
$Observations$	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R^2	0.799	0.789	0.235	0.810	0.797	0.850	0.786	0.759	0.746	0.737	0.175	0.783	0.761	0.780	0.726	0.760

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.10: Estimation results of the total exports and external R&D system of equations using a SUR model - Low vs High-Tech Industries.

TOTAL EXPORTS	**Low-Tech**								**High-Tech**							
	[A]			**[B]**					**[C]**			**[D]**				
	(1) *Offshored*	(2) *Outs.Dom.*	(3) *Tot.Exports*	(4) *Offsh.(IN)*	(5) *Offsh.(OUT)*	(6) *Outs.Dom.(IN)*	(7) *Outs.Dom.(OUT)*	(8) *Tot.Exports*	(9) *Offshored*	(10) *Outs.Dom.*	(11) *Tot.Exports*	(12) *Offsh.(IN)*	(13) *Offsh.(OUT)*	(14) *Outs.Dom.(IN)*	(15) *Outs.Dom.(OUT)*	(16) *Tot.Exports*
$Employment_{it-1}$	0.278***	0.508***	1.784***	0.194***	0.175***	0.169***	0.423***	1.899***	0.301***	0.534***	1.550***	0.224***	0.192***	0.185***	0.458***	1.640***
	(0.00531)	(0.00961)	(0.179)	(0.00372)	(0.00312)	(0.00295)	(0.00807)	(0.0844)	(0.00344)	(0.00654)	(0.146)	(0.00259)	(0.00221)	(0.00214)	(0.00565)	(0.0791)
$Av.Salary_{it-1}$	0.00323	-0.0749***	0.831***	-0.00668	0.0135	0.00559	-0.0575**	0.886***	0.0974***	0.0951***	0.287	0.0419***	0.0774***	0.0634***	0.0919***	0.778***
	(0.0144)	(0.0275)	(0.246)	(0.00757)	(0.00844)	(0.00805)	(0.0223)	(0.147)	(0.0109)	(0.0210)	(0.222)	(0.00689)	(0.00691)	(0.00659)	(0.0182)	(0.133)
$Lab.Productivity_{it-1}$	0.204***	0.361***	1.884***	0.177***	0.104***	0.145***	0.294***	1.746***	0.155***	0.237***	1.635***	0.166***	0.0735***	0.103***	0.208***	1.091***
	(0.00919)	(0.0172)	(0.224)	(0.00672)	(0.00526)	(0.00518)	(0.0144)	(0.190)	(0.00872)	(0.0166)	(0.169)	(0.00659)	(0.00600)	(0.00571)	(0.0155)	(0.122)
$InternalR\&D_{it-1}$	1.073***	2.494***	1.526	0.512***	0.592***	0.690***	1.852***	0.432	0.967***	2.373***	-3.903	0.503***	0.556***	0.558***	1.832***	-0.903
	(0.0522)	(0.106)	(3.244)	(0.0350)	(0.0319)	(0.0379)	(0.0824)	(1.240)	(0.0376)	(0.0787)	(2.380)	(0.0248)	(0.0231)	(0.0245)	(0.0627)	(1.123)
$ForeignGroup_{it}$	-0.0423***	0.0471	-0.514	0.106***	0.0198**	-0.000967	0.0531**	1.668***	-0.0718***	0.0132	-1.464***	0.0931***	-0.00381	-0.0167**	0.0114	1.192***
	(0.0157)	(0.0294)	(0.351)	(0.00917)	(0.00975)	(0.00961)	(0.0262)	(0.194)	(0.0112)	(0.0217)	(0.263)	(0.00699)	(0.00711)	(0.00705)	(0.0188)	(0.147)
$FrenchGroup_{it}$	0.0370**	0.0749**	0.389	-0.00128	0.0253***	0.286***	0.0578**	-0.554***	0.0499***	0.119***	-0.673***	-0.00476	0.0292***	0.301***	0.0790***	-1.693***
	(0.0161)	(0.0307)	(0.331)	(0.00946)	(0.00983)	(0.0100)	(0.0263)	(0.198)	(0.0125)	(0.0239)	(0.236)	(0.00780)	(0.00768)	(0.00776)	(0.0201)	(0.172)
$Tot.Exports_{it-1}$	-0.00743***	-0.00581*		-0.0248***	-0.0136***	-0.00120	-0.00471**		-0.00298***	0.00448**		-0.0223***	-0.0107***	0.00174***	0.00178	
	(0.00169)	(0.00316)		(0.000844)	(0.000829)	(0.000797)	(0.00212)		(0.00105)	(0.00197)		(0.000556)	(0.000540)	(0.000505)	(0.00140)	
$Int * Offsh.R\&D_{it-1}$			-5.192								-5.945					
			(5.180)								(3.852)					
$Int * Outs.Dom.R\&D_{it-1}$			2.856								4.039*					
			(3.039)								(2.102)					
$Offsh.R\&D_{it-1}$			-8.333*								-20.94***					
			(4.858)								(3.639)					
$Outs.Dom.R\&D_{it-1}$			3.368								10.47***					
			(2.851)								(2.018)					
$Int * Offsh.(IN)_{it-1}$								-8.160***								-18.23***
								(2.554)								(1.709)
$Int * Offsh.(OUT)_{it-1}$								0.921								9.576***
								(4.022)								(2.983)
$Int * Outs.Dom.(IN)_{it-1}$								0.910								1.426
								(1.496)								(1.631)
$Int * Outs.Dom.(OUT)_{it-1}$								1.203								1.817
								(1.853)								(1.377)
$Offsh.(IN)R\&D_{it-1}$								-11.48***								0.771
								(2.310)								(1.526)
$Offsh.(OUT)R\&D_{it-1}$								-25.70***								-44.23***
								(3.821)								(2.980)
$Outs.Dom.(IN)R\&D_{it-1}$								0.948								2.064
								(1.307)								(1.438)
$Outs.Dom.(OUT)R\&D_{it-1}$								13.60***								16.59***
								(1.793)								(1.345)
Observations	2,810	2,810	2,810	2,810	2,810	2,810	2,810	2,810	5,050	5,050	5,050	5,050	5,050	5,050	5,050	5,050
R^2	0.769	0.753	0.196	0.796	0.754	0.828	0.732	0.726	0.794	0.786	0.239	0.819	0.804	0.845	0.784	0.774

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between *Low-Tech* and *High-Tech* industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measuring all intra-EU shipments over €100,000 and extra-EU over €1,000 as reported by the French Custom Agency (CA); *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.11: Estimation results of the FMP Index and external R&D system of equations using a SUR model - Domestic vs Foreign Groups.

FMP INDEX	**Domestic**								**Foreign**							
		[A]				**[B]**				**[C]**				**[D]**		
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $FMPIndex$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $FMPIndex$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $FMPIndex$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $FMPIndex$
$Employment_{it-1}$	0.292***	0.526***	-0.843***	0.194***	0.181***	0.183***	0.450***	-1.239***	0.297***	0.540***	-0.981***	0.226***	0.179***	0.183***	0.456***	-1.202***
	(0.00389)	(0.00727)	(0.113)	(0.00287)	(0.00251)	(0.00240)	(0.00654)	(0.104)	(0.00526)	(0.00997)	(0.156)	(0.00421)	(0.00353)	(0.00318)	(0.00909)	(0.159)
$Av.Salary_{it-1}$	0.0685***	0.0515**	-0.395**	0.0215***	0.0558***	0.0489***	0.0500***	-0.571***	0.0538***	-0.00305	-0.00172	0.0393***	0.0505***	0.0332***	0.0184	-0.304*
	(0.0112)	(0.0218)	(0.159)	(0.00637)	(0.00728)	(0.00703)	(0.0193)	(0.137)	(0.0172)	(0.0346)	(0.185)	(0.0110)	(0.0107)	(0.00994)	(0.0286)	(0.181)
$Lab.Productivity_{it-1}$	0.187***	0.313***	-0.755***	0.158***	0.0899***	0.128***	0.268***	-0.957***	0.196***	0.332***	-0.742***	0.199***	0.0947***	0.137***	0.281***	-0.924***
	(0.00907)	(0.0166)	(0.142)	(0.00585)	(0.00600)	(0.00602)	(0.0162)	(0.132)	(0.0107)	(0.0210)	(0.164)	(0.00860)	(0.00652)	(0.00643)	(0.0178)	(0.172)
$InternalR\&D_{it-1}$	1.013***	2.403***	2.527**	0.415***	0.558***	0.655***	1.849***	2.955***	1.058***	2.555***	-1.252	0.599***	0.583***	0.548***	1.950***	-0.858
	(0.0490)	(0.101)	(1.171)	(0.0278)	(0.0296)	(0.0350)	(0.0818)	(0.934)	(0.0434)	(0.0909)	(1.673)	(0.0314)	(0.0280)	(0.0278)	(0.0745)	(1.307)
$FrenchGroup_{it}$	0.0567***	0.119***	0.216	0.0230***	0.0352***	0.302***	0.0890***	0.420**								
	(0.0127)	(0.0247)	(0.158)	(0.00752)	(0.00852)	(0.00886)	(0.0229)	(0.189)								
$FMPIndex_{it-1}$	0.00245	-0.000639		0.0118***	0.00531***	0.000337	0.00274		0.00936**	0.0151**		0.0140***	0.00856***	0.00418**	0.0149***	
	(0.00210)	(0.00385)		(0.00123)	(0.00133)	(0.00123)	(0.00337)		(0.00376)	(0.00684)		(0.00234)	(0.00232)	(0.00212)	(0.00578)	
$Int*Offsh.R\&D_{it-1}$			0.905								-1.557					
			(2.187)								(1.661)					
$Int*Outs.Dom.R\&D_{it-1}$			-1.414								0.725					
			(1.099)								(0.998)					
$Offsh.R\&D_{it-1}$			3.559*								3.800**					
			(2.093)								(1.675)					
$Outs.Dom.R\&D_{it-1}$			-0.771								-1.433					
			(1.056)								(0.967)					
$Int*Offsh.(IN)_{it-1}$								11.05***								6.246***
								(1.791)								(1.711)
$Int*Offsh.(OUT)_{it-1}$								-1.463								-3.333
								(2.789)								(3.090)
$Int*Outs.Dom.(IN)_{it-1}$								0.556								0.104
								(1.317)								(1.638)
$Int*Outs.Dom.(OUT)_{it-1}$								-3.514***								-0.885
								(1.238)								(1.203)
$Offsh.(IN)R\&D_{it-1}$								0.704								-1.025
								(1.495)								(1.395)
$Offsh.(OUT)R\&D_{it-1}$								16.05***								13.83***
								(2.828)								(3.151)
$Outs.Dom.(IN)R\&D_{it-1}$								-1.033								-0.346
								(1.198)								(1.503)
$Outs.Dom.(OUT)R\&D_{it-1}$								-5.543***								-4.468***
								(1.232)								(1.195)
Observations	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	2,626	2,626	2,626	2,626	2,626	2,626	2,626	2,626
R^2	0.803	0.793	0.125	0.822	0.807	0.852	0.792	0.236	0.756	0.745	0.118	0.786	0.767	0.790	0.737	0.173

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.12: Estimation results of the FMP Index and external R&D system of equations using a SUR model - Low vs High-Tech Industries.

FMP INDEX	**Low-Tech**								**High-Tech**							
	[A]			**[B]**					**[C]**			**[D]**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$	$Offshored$	$Outs.Dom.$	$FMPIndex$	$Offsh.(IN)$	$Offsh.(OUT)$	$Outs.Dom.(IN)$	$Outs.Dom.(OUT)$	$FMPIndex$
$Employment_{it-1}$	0.272***	0.499***	-0.739***	0.182***	0.165***	0.167***	0.420***	-1.171***	0.308***	0.552***	-1.057***	0.217***	0.190***	0.192***	0.474***	-1.305***
	(0.00582)	(0.0105)	(0.151)	(0.00428)	(0.00354)	(0.00334)	(0.00902)	(0.139)	(0.00357)	(0.00676)	(0.116)	(0.00268)	(0.00239)	(0.00235)	(0.00618)	(0.111)
$Av.Salary_{it-1}$	0.0126	-0.0556*	-0.504***	-0.00324	0.0201**	0.0109	-0.0370	-0.650***	0.0896***	0.0786***	-0.174	0.0389***	0.0717***	0.0603***	0.0776***	-0.382***
	(0.0151)	(0.0287)	(0.185)	(0.00787)	(0.00896)	(0.00873)	(0.0239)	(0.175)	(0.0118)	(0.0229)	(0.151)	(0.00705)	(0.00730)	(0.00694)	(0.0197)	(0.148)
$Lab.Productivity_{it-1}$	0.204***	0.363***	-0.760***	0.171***	0.101***	0.146***	0.301***	-1.196***	0.176***	0.279***	-0.733***	0.176***	0.0823***	0.118***	0.246***	-0.887***
	(0.00982)	(0.0183)	(0.165)	(0.00726)	(0.00619)	(0.00615)	(0.0172)	(0.179)	(0.00895)	(0.0166)	(0.134)	(0.00644)	(0.00589)	(0.00537)	(0.0151)	(0.144)
$InternalR\&D_{it-1}$	1.064***	2.470***	1.089	0.480***	0.572***	0.670***	1.842***	2.344*	0.993***	2.426***	1.035	0.484***	0.553***	0.571***	1.883***	1.100
	(0.0573)	(0.116)	(1.462)	(0.0350)	(0.0339)	(0.0394)	(0.0923)	(1.327)	(0.0397)	(0.0859)	(1.228)	(0.0240)	(0.0237)	(0.0252)	(0.0667)	(1.229)
$ForeignGroup_{it}$	-0.0329*	0.0646**	0.121	0.108***	0.0237**	0.00443	0.0719**	-0.796***	-0.0848***	-0.0103	0.213	0.0786***	-0.0167**	-0.0257***	-0.00900	-0.518***
	(0.0171)	(0.0326)	(0.234)	(0.0102)	(0.0105)	(0.0103)	(0.0280)	(0.223)	(0.0123)	(0.0239)	(0.169)	(0.00709)	(0.00775)	(0.00773)	(0.0205)	(0.163)
$FrenchGroup_{it}$	0.0569***	0.110***	0.164	0.0101	0.0394***	0.296***	0.0926***	0.432*	0.0554***	0.125***	0.211	0.00379	0.0340***	0.306***	0.0847***	0.626***
	(0.0175)	(0.0336)	(0.235)	(0.0107)	(0.0111)	(0.0112)	(0.0295)	(0.228)	(0.0145)	(0.0283)	(0.171)	(0.00796)	(0.00839)	(0.00860)	(0.0224)	(0.203)
$FMPIndex_{it-1}$	0.000717	-0.00219		0.0112***	0.00417**	-0.000408	0.00176		0.00622***	0.00683		0.0135***	0.00705***	0.00221*	0.00810**	
	(0.00290)	(0.00524)		(0.00178)	(0.00173)	(0.00148)	(0.00438)		(0.00233)	(0.00434)		(0.00135)	(0.00139)	(0.00128)	(0.00354)	
$Int*Offsh.R\&D_{it-1}$			-3.833**								1.741					
			(1.818)								(2.242)					
$Int*Outs.Dom.R\&D_{it-1}$			0.973								-1.250					
			(1.049)								(1.107)					
$Offsh.R\&D_{it-1}$			6.223***								3.815*					
			(1.814)								(2.028)					
$Outs.Dom.R\&D_{it-1}$			-2.309**								-1.175					
			(1.020)								(1.006)					
$Int*Offsh.(IN)_{it-1}$								8.265***								8.164***
								(2.183)								(1.306)
$Int*Offsh.(OUT)_{it-1}$								-3.752								0.154
								(3.144)								(3.392)
$Int*Outs.Dom.(IN)_{it-1}$								0.294								0.869
								(1.394)								(1.523)
$Int*Outs.Dom.(OUT)_{it-1}$								-2.291								-2.975**
								(1.810)								(1.503)
$Offsh.(IN)R\&D_{it-1}$								3.067*								0.136
								(1.738)								(1.056)
$Offsh.(OUT)R\&D_{it-1}$								13.20***								15.01***
								(2.978)								(3.440)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.674								-1.291
								(1.272)								(1.351)
$Outs.Dom.(OUT)R\&D_{it-1}$								-4.923***								-5.074***
								(1.628)								(1.456)
Observations	2,421	2,421	2,421	2,421	2,421	2,421	2,421	2,421	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189
R^2	0.772	0.750	0.142	0.801	0.753	0.830	0.730	0.230	0.799	0.792	0.124	0.831	0.815	0.850	0.793	0.212

Note: Estimation based on R&D survey and French Customs Agency data between year 1999 and 2007 for all French manufacturing innovators according to the NACE rev.1.1 industrial classification using a SUR model with year and industry dummies included but not reported. Bootstrapped standard errors with 500 repetitions reported in parentheses. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between ***Low-Tech*** and ***High-Tech*** industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Foreign Market Potential (FMP) index* measured as explained in the appendix A.3.1 following the Head and Mayer (2004) approach, averaging at the firm-level the FMP index of all the countries served by each exporter and weighting it by the total value of firm's shipments towards each foreign market; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.13: Estimation results of the total exports and external R&D system of equations using a FIML model in a survey data framework.

TOTAL EXPORTS	[A]			[B]				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Offshored$	$Outs.Dom.$	$Tot.Exports$	$Off.(IN)$	$Off.(OUT)$	$Dom.(IN)$	$Dom.(OUT)$	$Tot.Exports$
$Employment_{it-1}$	1.316***	1.306***	2.185***	1.807***	1.694***	1.044***	0.955***	1.236***
	(0.0255)	(0.0308)	(0.0922)	(0.0399)	(0.0349)	(0.0247)	(0.0177)	(0.0739)
$Av.Salary_{it-1}$	-15.30***	-4.411**	0.331	-21.26***	-16.30***	-22.13***	-6.269***	-2.230
	(1.964)	(1.989)	(3.610)	(2.588)	(3.293)	(1.371)	(1.864)	(3.463)
$Lab.Productivity_{it-1}$	1.994***	1.208***	1.592***	3.048***	2.366***	1.570***	0.734***	1.557***
	(0.0553)	(0.0667)	(0.190)	(0.0982)	(0.0892)	(0.0551)	(0.0385)	(0.166)
$InternalR\&D_{it-1}$	-4.657***	0.971***	3.465***	-10.20***	-6.829***	-7.780***	-0.923***	2.017*
	(0.215)	(0.230)	(1.203)	(0.378)	(0.321)	(0.249)	(0.146)	(1.107)
$ForeignGroup_{it}$	0.540***	0.0254	-0.0936	2.937***	0.488***	-0.712***	-0.0883	-1.125***
	(0.0771)	(0.0815)	(0.213)	(0.127)	(0.110)	(0.0778)	(0.0564)	(0.226)
$FrenchGroup_{it}$	0.484***	0.724***	0.787***	0.909***	0.523***	4.414***	0.397***	0.232
	(0.0861)	(0.0895)	(0.228)	(0.143)	(0.121)	(0.0837)	(0.0634)	(0.222)
$Tot.Exports_{it-1}$	0.106***	-0.319***		0.274***	-0.300***	0.00143	0.0132***	
	(0.00971)	(0.0163)		(0.0111)	(0.0142)	(0.00528)	(0.00474)	
$Int * Offsh.R\&D_{it-1}$			0.282**					
			(0.123)					
$Int * Outs.Dom.R\&D_{it-1}$			-0.466**					
			(0.191)					
$Offsh.R\&D_{it-1}$			0.249*					
			(0.140)					
$Outs.Dom.R\&D_{it-1}$			-1.317***					
			(0.208)					
$Int * Offsh.(IN)_{it-1}$								-0.857***
								(0.0803)
$Int * Offsh.(OUT)_{it-1}$								1.126***
								(0.168)
$Int * Outs.Dom.(IN)_{it-1}$								0.0690*
								(0.0370)
$Int * Outs.Dom.(OUT)_{it-1}$								-0.0620
								(0.151)
$Offsh.(IN)R\&D_{it-1}$								-0.0742
								(0.0690)
$Offsh.(OUT)R\&D_{it-1}$								-0.287**
								(0.143)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.0869***
								(0.0313)
$Outs.Dom.(OUT)R\&D_{it-1}$								0.291**
								(0.129)
$var(\mathcal{E})$	-20.88***	-8.975***	-4.331**	-34.48***	-20.07***	-16.58***	-9.085***	-5.065***
	(0.397)	(0.439)	(1.722)	(0.705)	(0.633)	(0.435)	(0.282)	(1.387)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			-3.559***					
			(0.314)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			13.34***					
			(0.565)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								13.66***
								(0.534)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								-18.07***
								(0.405)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								-0.0666
								(0.0923)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								0.862***
								(0.144)
Observations	5,725	5,725	5,725	5,700	5,700	5,700	5,700	5,700

Note: Estimation based on R&D survey data between year 1999 and 2007 for French manufacturing innovators according to the NACE rev.1.1 industrial classification applying a FIML model with year and industry dummies (included but not reported) in a survey data framework considering the sampling weights, clustering and stratification of the survey design using the STATA command "SVY". Row $var(\mathcal{E})$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Constant term is included but note reported. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: *Total exports* measured as the log value of firms foreign sales; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int{*}Offsh.R\&D$, $Int{*}Outs.Dom.R\&D$, $Int{*}Offsh.(IN)$, $Int{*}Offsh.(OUT)$, $Int{*}Outs.Dom.(IN)$ and $Int{*}Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.14: Estimation results of the total exports and external R&D system of equations using a FIML model in a survey data framework - Domestic vs Foreign Groups.

TOTAL EXPORTS	**Domestic**								**Foreign**							
	[A]			**[B]**					**[C]**			**[D]**				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $Tot.Exports$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $Tot.Exports$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $Tot.Exports$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $Tot.Exports$
$Employment_{it-1}$	1.298***	1.365***	2.292***	2.434***	0.887***	1.160***	1.036***	1.370***	1.331***	1.194***	1.929***	1.858***	1.705***	0.866***	0.875***	1.157***
	(0.0344)	(0.0383)	(0.120)	(0.0490)	(0.0467)	(0.0303)	(0.0230)	(0.0946)	(0.0374)	(0.0522)	(0.144)	(0.0556)	(0.0632)	(0.0445)	(0.0273)	(0.122)
$Av.Salary_{it-1}$	-14.90***	-3.876*	0.647	-20.94***	-16.73***	-22.22***	-5.577***	4.109*	-17.86***	-6.405	0.888	-20.30***	-18.07**	-20.48***	-9.333**	-1.904
	(2.116)	(2.103)	(3.930)	(3.910)	(2.535)	(1.397)	(2.033)	(2.465)	(4.402)	(4.719)	(7.895)	(5.217)	(7.400)	(4.553)	(3.662)	(8.241)
$Lab.Productivity_{it-1}$	1.817***	1.138***	1.691***	3.615***	1.288***	1.457***	0.667***	1.568***	2.232***	1.299***	1.477***	3.376***	2.580***	1.718***	0.887***	1.478***
	(0.0789)	(0.0858)	(0.239)	(0.130)	(0.103)	(0.0745)	(0.0542)	(0.225)	(0.0743)	(0.107)	(0.302)	(0.130)	(0.158)	(0.0813)	(0.0547)	(0.276)
$InternalR\&D_{it-1}$	-5.282***	1.063***	2.437	-10.84***	-8.244***	-7.078***	-1.080***	1.018	-3.735***	0.879***	2.600	-7.792***	-6.569***	-8.868***	-0.542***	1.930
	(0.312)	(0.325)	(1.943)	(0.561)	(0.436)	(0.339)	(0.212)	(1.434)	(0.273)	(0.310)	(1.856)	(0.453)	(0.450)	(0.351)	(0.187)	(1.815)
$FrenchGroup_{it}$	0.490***	0.649***	0.510**	0.849***	0.547***	4.259***	0.341***	-0.113								
	(0.0951)	(0.0939)	(0.238)	(0.154)	(0.132)	(0.0885)	(0.0685)	(0.236)								
$Tot.Exports_{it-1}$	0.121***	-0.315***		-0.205***	0.326***	0.00218	-0.0140**		0.0875***	-0.324***		0.227***	-0.345***	0.00118	0.00975	
	(0.0135)	(0.0203)		(0.0152)	(0.0159)	(0.00690)	(0.00604)		(0.0136)	(0.0278)		(0.0150)	(0.0280)	(0.00843)	(0.00718)	
$Int*Offsh.R\&D_{it-1}$			-0.412**								0.367*					
			(0.185)								(0.223)					
$Int*Outs.Dom.R\&D_{it-1}$			0.640**								-0.639*					
			(0.283)								(0.344)					
$Offsh.R\&D_{it-1}$			0.0599								0.247					
			(0.207)								(0.248)					
$Outs.Dom.R\&D_{it-1}$			-1.005***								-1.347***					
			(0.307)								(0.388)					
$Int*Offsh.(IN)_{it-1}$								-0.858***								-0.795***
								(0.134)								(0.135)
$Int*Offsh.(OUT)_{it-1}$								1.188***								0.678***
								(0.213)								(0.248)
$Int*Outs.Dom.(IN)_{it-1}$								-0.00455								0.0282
								(0.0463)								(0.0793)
$Int*Outs.Dom.(OUT)_{it-1}$								0.0584								-0.286
								(0.180)								(0.286)
$Offsh.(IN)R\&D_{it-1}$								0.0592								-0.102
								(0.117)								(0.111)
$Offsh.(OUT)R\&D_{it-1}$								0.183								-0.574***
								(0.189)								(0.212)
$Outs.Dom.(IN)R\&D_{it-1}$								0.00104								-0.0700
								(0.0394)								(0.0703)
$Outs.Dom.(OUT)R\&D_{it-1}$								-0.197								0.541**
								(0.148)								(0.254)
$var(\mathcal{E})$	-19.51***	-9.045***	-4.787*	-33.69***	-17.33***	-17.19***	-8.652***	-1.762	-22.22***	-8.576***	-0.778	-35.10***	-20.33***	-16.02***	-9.758***	-5.279**
	(0.549)	(0.567)	(2.464)	(0.979)	(0.739)	(0.579)	(0.386)	(2.004)	(0.574)	(0.726)	(2.735)	(0.975)	(1.123)	(0.696)	(0.419)	(2.307)
$cov(\mathcal{E}_{Off}*\mathcal{E}_{TE})$			3.916***								-3.045***					
			(0.443)								(0.431)					
$cov(\mathcal{E}_{Dom}*\mathcal{E}_{TE})$			-13.77***								12.53***					
			(0.729)								(0.914)					
$cov(\mathcal{E}_{Off.IN}*\mathcal{E}_{TE})$								15.71***								9.837***
								(0.750)								(0.727)
$cov(\mathcal{E}_{Off.OUT}*\mathcal{E}_{TE})$								-19.23***								-17.37***
								(0.495)								(0.722)
$cov(\mathcal{E}_{Dom.IN}*\mathcal{E}_{TE})$								0.00624								-0.283**
								(0.124)								(0.131)
$cov(\mathcal{E}_{Dom.OUT}*\mathcal{E}_{TE})$								-1.082***								0.910***
								(0.192)								(0.185)
Observations	3,329	3,329	3,329	3,307	3,307	3,307	3,307	3,307	2,396	2,396	2,396	2,393	2,393	2,393	2,393	2,393

Note: Estimation based on R&D survey data between year 1999 and 2007 for French manufacturing innovators according to the NACE rev.1.1 industrial classification applying a FIML model with year and industry dummies (included but not reported) in a survey data framework considering the sampling weights, clustering and stratification of the survey design using the STATA command "SVY". Row $var(\mathcal{E})$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. In section *Domestic* we estimate the effect just for firms which are not part of a foreign business group. In section *Foreign* instead we include only firms that are part of a foreign business group. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Total exports*** measured as the log value of firms foreign sales; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int*Offsh.R\&D$, $Int*Outs.Dom.R\&D$, $Int*Offsh.(IN)$, $Int*Offsh.(OUT)$, $Int*Outs.Dom.(IN)$ and $Int*Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Table A.3.2.15: Estimation results of the total exports and external R&D system of equations using a FIML model in a survey data framework - Low vs High-Tech Industries.

TOTAL EXPORTS	Low-Tech								High-Tech							
	[A]			[B]					[C]			[D]				
	(1) $Offshored$	(2) $Outs.Dom.$	(3) $Tot.Exports$	(4) $Offsh.(IN)$	(5) $Offsh.(OUT)$	(6) $Outs.Dom.(IN)$	(7) $Outs.Dom.(OUT)$	(8) $Tot.Exports$	(9) $Offshored$	(10) $Outs.Dom.$	(11) $Tot.Exports$	(12) $Offsh.(IN)$	(13) $Offsh.(OUT)$	(14) $Outs.Dom.(IN)$	(15) $Outs.Dom.(OUT)$	(16) $Tot.Exports$
$Employment_{it-1}$	1.372***	1.301***	2.270***	1.762***	1.751***	1.151***	0.957***	1.138***	1.411***	1.346***	2.291***	2.454***	1.010***	1.031***	1.063***	1.032***
	(0.0498)	(0.0458)	(0.149)	(0.0821)	(0.0584)	(0.0516)	(0.0298)	(0.132)	(0.0230)	(0.0381)	(0.118)	(0.0335)	(0.0379)	(0.0265)	(0.0195)	(0.0965)
$Av.Salary_{it-1}$	-9.250***	-0.656	3.342	-12.84***	-9.423***	-20.04***	-1.020	-1.156	-21.07***	-8.661***	-2.140	-25.05***	-25.86***	-23.87***	-12.93***	15.15***
	(1.490)	(1.737)	(4.204)	(1.984)	(3.141)	(1.309)	(1.307)	(4.197)	(2.989)	(3.261)	(5.912)	(4.363)	(3.944)	(3.122)	(2.786)	(4.868)
$Lab.Productivity_{it-1}$	1.695***	1.135***	1.736***	2.558***	2.073***	1.302***	0.695***	1.496***	2.293***	1.250***	1.554***	3.942***	1.859***	1.790***	0.841***	0.726***
	(0.0993)	(0.106)	(0.326)	(0.204)	(0.146)	(0.111)	(0.0574)	(0.283)	(0.0596)	(0.0838)	(0.240)	(0.0950)	(0.0793)	(0.0605)	(0.0484)	(0.215)
$InternalR\&D_{it-1}$	-4.469***	1.275***	7.930***	-10.45***	-6.696***	-6.471***	-0.375	1.982	-4.036***	1.116***	1.827	-8.462***	-7.004***	-8.175***	-0.742***	0.579
	(0.393)	(0.401)	(2.427)	(0.743)	(0.575)	(0.469)	(0.238)	(1.833)	(0.219)	(0.265)	(1.498)	(0.384)	(0.326)	(0.283)	(0.156)	(1.475)
$ForeignGroup_{it}$	1.079***	0.272**	-0.134	3.863***	0.897***	-0.373**	0.338***	-1.516***	-0.0456	-0.262***	-0.221	2.268***	-0.562***	-0.958***	-0.487***	2.506***
	(0.133)	(0.124)	(0.375)	(0.240)	(0.178)	(0.156)	(0.0835)	(0.397)	(0.0767)	(0.101)	(0.264)	(0.117)	(0.116)	(0.0878)	(0.0643)	(0.280)
$FrenchGroup_{it}$	0.802***	0.974***	1.179***	1.572***	0.906***	4.817***	0.549***	0.281	0.181**	0.520***	0.555*	0.294**	0.271**	4.173***	0.243***	-0.198
	(0.150)	(0.134)	(0.373)	(0.265)	(0.200)	(0.162)	(0.0941)	(0.362)	(0.0810)	(0.111)	(0.289)	(0.129)	(0.122)	(0.0916)	(0.0709)	(0.280)
$Tot.Exports_{it-1}$	0.110***	-0.293***		0.347***	-0.294***	0.00400	-0.0141		0.0845***	-0.318***		-0.121***	0.305***	-0.0147***	-0.00619	
	(0.0184)	(0.0249)		(0.0238)	(0.0235)	(0.0123)	(0.00928)		(0.00808)	(0.0194)		(0.00976)	(0.0158)	(0.00557)	(0.00488)	
$Int * Offsh.R\&D_{it-1}$			0.0413								-0.444***					
			(0.215)								(0.170)					
$Int * Outs.Dom.R\&D_{it-1}$			-0.551								0.829***					
			(0.412)								(0.239)					
$Offsh.R\&D_{it-1}$			0.660***								0.0422					
			(0.240)								(0.191)					
$Outs.Dom.R\&D_{it-1}$			-2.595***								-0.920***					
			(0.448)								(0.257)					
$Int * Offsh.(IN)_{it-1}$								-0.849***								-0.891***
								(0.158)								(0.101)
$Int * Offsh.(OUT)_{it-1}$								1.129***								1.075***
								(0.286)								(0.207)
$Int * Outs.Dom.(IN)_{it-1}$								0.0504								-0.00324
								(0.0521)								(0.0628)
$Int * Outs.Dom.(OUT)_{it-1}$								-0.230								0.261
								(0.257)								(0.210)
$Offsh.(IN)R\&D_{it-1}$								-0.0196								0.161*
								(0.143)								(0.0861)
$Offsh.(OUT)R\&D_{it-1}$								-0.280								0.339*
								(0.260)								(0.179)
$Outs.Dom.(IN)R\&D_{it-1}$								-0.0483								-0.0409
								(0.0452)								(0.0539)
$Outs.Dom.(OUT)R\&D_{it-1}$								0.397*								-0.295*
								(0.220)								(0.175)
$var(\mathcal{E})$	-21.42***	-10.08***	-9.890***	-35.08***	-20.94***	-17.54***	-10.18***	-3.362	-22.20***	-8.989***	-2.923	-37.30***	-20.50***	-16.76***	-9.357***	5.464***
	(0.703)	(0.731)	(3.209)	(1.404)	(1.058)	(0.856)	(0.419)	(2.411)	(0.434)	(0.538)	(2.117)	(0.722)	(0.596)	(0.496)	(0.342)	(2.051)
$cov(\mathcal{E}_{Off} * \mathcal{E}_{TE})$			-3.888***								2.385***					
			(0.539)								(0.244)					
$cov(\mathcal{E}_{Dom} * \mathcal{E}_{TE})$			11.39***								-13.49***					
			(0.845)								(0.673)					
$cov(\mathcal{E}_{Off.IN} * \mathcal{E}_{TE})$								16.30***								9.521***
								(0.971)								(0.513)
$cov(\mathcal{E}_{Off.OUT} * \mathcal{E}_{TE})$								-15.02***								-16.29***
								(0.723)								(0.413)
$cov(\mathcal{E}_{Dom.IN} * \mathcal{E}_{TE})$								-0.0939								0.784***
								(0.179)								(0.131)
$cov(\mathcal{E}_{Dom.OUT} * \mathcal{E}_{TE})$								0.00821								0.717***
								(0.265)								(0.138)
$Observations$	1,867	1,867	1,867	1,842	1,842	1,842	1,842	1,842	3,858	3,858	3,858	3,858	3,858	3,858	3,858	3,858

Note: Estimation based on R&D survey data between year 1999 and 2007 for French manufacturing innovators according to the NACE rev.1.1 industrial classification applying a FIML model with year and industry dummies (included but not reported) in a survey data framework considering the sampling weights, clustering and stratification of the survey design using the STATA command "SVY". Row $var(\mathcal{E})$ indicates the variance of the error term in each equation, while $cov(.)$ indicate the covariances of error terms between external R&D and total exports equations. Statistical significance: *** p<0.01, ** p<0.05, * p<0.1. Constant term is included but note reported. Firms are divided between ***Low-Tech*** and ***High-Tech*** industries following the Eurostat sectoral classification at the NACE rev.1.1 3-digit level on the basis of the R&D intensity of economic activities measured as R&D expenditures in relation to value added. As dependent variables in the system of equations we include the expected value estimated from the 2-step Heckman model of the following variables: ***Total exports*** measured as the log value of firms foreign sales; *Outs. Dom.* measures the expenditure of firms in external R&D activities carried out by other public or private agents based in France; *Offshored* measures the expenditure of firms in external R&D activities carried out in foreign countries by private or public agents; *Off.(IN)* measures the expenditure of firms in external R&D activities carried out by foreign affiliates part of the same business group; *Dom.(IN)* measures the expenditure of firms in external R&D activities carried out by domestic affiliates based in France and part of the same business group; *Dom. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in France but not part of the same business group; *Off. (OUT)* measures the expenditure of firms in external R&D activities carried out by private firms based in foreign countries and not part of the same business group. The independent variables of interest are $Int * Offsh.R\&D$, $Int * Outs.Dom.R\&D$, $Int * Offsh.(IN)$, $Int * Offsh.(OUT)$, $Int * Outs.Dom.(IN)$ and $Int * Outs.Dom.(OUT)$ which are interaction terms between the expected value of each external R&D activities estimated from the 2-step Heckman model and the resources dedicated to internal innovating activities. As additional control variables we include total employment as the log of the numbers of employees, average salary is the log of average wage paid per researcher, labour productivity calculated as the log value of the ratio between firms total output and number of employees, foreign and French group are two dummy variables equal to 1 if firm is part of a foreign or French business group and 0 otherwise. All independent variables are lagged one year except for foreign and French group dummies which refer to time t like the dependent variables.

Conclusions, Limitations and Future Research

Over the previous few decades, both developed and developing countries have experienced increasing flows of international trade and capital and, to a smaller extent, population migration and cultural interconnections. In particular, the development of new IT and the reduction of distance and cultural barriers have not only fostered the international fragmentation of production, but have contributed to the expansion of complex networks of goods, services and knowledge transactions.

Increased globalization has stimulated unprecedented economic growth across the globe by creating jobs, reducing prices and decreasing the income gap between developed and developing countries. However, the same phenomenon, and especially international trade, has also brought economic, political, and social disruption in different regions. Globalization has triggered an ongoing shift in balance in the world economy, changing the distribution of exports and FDI across countries, with a relative decline of developed countries and the rise of developing economies. At a time of economic difficulties in most developed countries, with high level of unemployment and fiscal austerity, complaints of unfair international competition and claims for rising trade protectionism and reversing the globalization patterns have started to emerge.

However, the response to deeper globalization should not be a move back to economic protectionism. On the contrary, in order to maximize the benefits related with globalization, firms should be pro-actively engaged in internationalization and innovation strategies, opening new foreign markets thanks to the introduction of new innovative products and processes, replacing and destroying the old products and industrial productive processes. Hence, in this thesis we have tested this predictions looking at the particular case of European countries, which are particularly suitable given the lively debate about the consequences of globalisation and free-trade and their role in the amplification of the economic recession, the loss of jobs and the erosion of salaries and the welfare state. Continuous investment in technologies and knowledge, and not trade protectionism, will help mature economies to fully specialise in high-tech and high-end industries, positively internalizing the externalities linked to globalization and the global value chains of production and R&D, with a continuous creation of new "revolutionary" internationally competitive advantage.

In this thesis we analysed first the effectiveness of protectionism in developed countries, particularly looking at EU anti-dumping measures on Chinese products, investigating whether they constitute a curse or a blessing for European firms. Using product, sector and firm-level data from the EU and France we provided a comprehensive analysis of this trade-defence instrument, considering the impact on EU trade flows, on protected European industries and on the performance of French import-competing and import-dependent firms.

Taken together, our results suggest that EU anti-dumping measures successfully target Chinese dumped products, leading to an increase in the level of prices and decreasing import volumes from China which are in turn substituted by a larger domestic production and by imported goods from other extra-EU countries. European producers seem to be more protected from the unfair dumping competition, experiencing a higher employment growth and larger domestic production. At the same time, larger European importers are negatively affected by AD measures, forced to divert their imports to other extra-EU countries at higher prices, and losing productivity with a consequent negative impact on total employment, export performance and survival rate. The aggregate impact of EU anti-dumping measures against Chinese products on European import-dependent and import-competing firms is mixed, definitely bringing a temporary benefit for domestic producers, but with a negative effect on importers and the overall productivity of European firms. This highlights the large degree of politicization in the management of this trade defence instrument.

Secondly, we investigated the impact of innovating activities on firms export performance to evaluate the role played by R&D and knowledge-based strategies in improving the international competitiveness of firms from mature economies. First, we have established at the firm level whether innovation activities improve exporter performance creating new trade links, enriching the firms product mix and opening new export markets, or if they support the intensification of existing flows. In addition, we assessed the effect of different forms of innovation on export performance, by simultaneously taking into account both innovation input and output measures.

We found a positive and significant effect of R&D activities on exports. Innovation increases the probability of firms to participate in international markets, helping them to face the pressure of foreign competitors and experiencing a steady growth of total exports. R&D activities positively affect firms international trade performance, mainly exporting new products to new foreign markets and marginally improving the average value of exports. Dissecting the impact on the trade margins we found that the growth in total exports related to R&D activity seems to be mainly driven by a growth in the number of products exported and of foreign markets served. Innovation plays an essential role in improving the export performance of medium-sized and domestic-owned firms, in particular increasing the likelihood of their participation in international markets and by increasing the number of products exported and of foreign markets served in respect to non-innovators.

Overall, we have shown that innovation plays a key role in developed and mature economies, preparing firms to face international competition, upgrading their knowledge of foreign markets and introducing tailor-made goods designed to penetrate distant and difficult countries. However, we also found some evidence that innovation is a dynamic, time-consuming and resources-intensive process, with a "creative destruction" effect of new innovations on firm performance, leading to an initial insignificant or even negative impact of R&D on exports due to the costs of adaptation, production shift and the time needed in order to commercially exploit new technologies especially in foreign markets. Nevertheless, although a negative or zero impact in the short-run, returns to R&D investment seem to pay back in the long-run with a twofold impact on economic growth, both as a mean of developing new technologies but also boosting export performance with potential welfare gains in terms of production and employment.

Finally, we investigated the relationship between external R&D activities and firms export performance, to analyse the increasing degree of R&D specialisation of mature economies and the impact on their comparative advantages in the global markets. We tested several theoretical predictions about the different and contrasting effects that outsourced R&D might have on trade performance, looking at the value of exports and at the destinations served, conditional on firms strategy, the benefits and costs of R&D internationalisation.

Our results demonstrated the two-way causality linking externalised innovation and export performance, in particular when analysing R&D activities offshored abroad. We have shown that complementarity between internal and external R&D significantly affects firms export performance, highlighting the key role played by internal capabilities in internalising the positive spillovers deriving from external innovating activities outsourced in France or abroad. Moreover, we have found that market-driven activities, such as R&D offshored abroad to extra-group firms, are the major strategies that improve firms export performance, in particular helping exporters to access more difficult and less attractive markets and increasing the total value of exports. R&D activities outsourced domestically instead seem to negatively affect firms total exports in general, but helping French companies to target high-income markets such as the nearby EU single market and other OECD members, probably upgrading exports quality and the technological intensity.

In addition, R&D activities externalised at the arm's-length seem to be particularly beneficial in terms of export performance, suggesting a market-driven factor behind these strategies, while outsourcing within the group boundaries appears to be mainly dictated by rationalisation and supply-driven purposes, with an overall negative impact on exports. Moreover, as expected, foreign-owned companies profit the most from offshored R&D, while domestic firms export performance is mainly affected by innovating activities outsourced to other French intra and extra-group firms. Finally, we have found a diametrically opposed effect of outsourced R&D on the export performance of firms in high-tech or low-tech industries. On the one hand, companies in low-tech industries are able to improve their export performance thanks to R&D activities offshored at the arm's-length, in particular by exporting to more difficult and distant markets. On the other hand, high-tech firms by offshoring R&D abroad tend to reduce their total exports, profiting the most instead from innovating activities outsourced domestically to other French firms and thus exporting to more difficult markets.

Our results show clearly the interdependence between internationalisation strategies and outsourced innovation, highlighting the significant role played by external R&D in improving firms participation in global networks, demonstrating how these strategies are mainly driven by market-demand factors, such as accessing new difficult markets and customizing their exports for foreign markets needs. Our empirical analysis has identified the main factors driving firms to externalize their R&D, evaluating the overall interdependence between externalised innovative strategies and export performance and their effect on the creation of competitive advantage by optimizing firms resources, acquiring specific knowledge and improving the ability of firms to respond to global market needs.

From this economic analysis of the changing patterns of international trade and the impact on firms behaviour we have derived key policy implication on the possible ways to foster the economic growth of mature European countries. European firms should be positively engaged in innovating activities and international markets in order to face and challenge the competitive pressure of developing countries, increasing the investment in human capital and knowledge to boost productivity growth and the creation of new jobs. Only continuously investing in R&D activities and expanding international operations European firms will be able to follow a creatively destructive process, replacing the obsolete products and productive processes and being completely open and integrated in the global value chains of knowledge and production to fully exploit the benefits deriving from globalization.

LIMITATIONS Although the main results presented in this thesis are in line with the theoretical predictions and the empirical evidence has been corroborated by a large number of robustness checks, our analysis could still suffer from a number of potential flaws.

One of the main concerns in the estimation methodology throughout the three chapters is the issue of endogeneity and reverse causality which could potentially affect our results. In particular, in chapter 1 we have discussed the two different sources of bias arising from the selection bias in which the observations affected by anti-dumping duties are endogenously different from those which have not been involved in these procedures, the endogenous political decision of imposing the measures and the lack of a natural counterfactual for a robust analysis.

In the second and third chapters the main endogeneity concern regards the simultaneity between innovation and internationalization strategies, causing a two-way causality between R&D activities and export performance. As stressed in the previous literature, firms investing in R&D activities might improve their export performance by introducing new innovative products and decreasing the cost of production and of exporting thanks to their increased stock of knowledge. At the same time, exporters are more likely to undertake R&D activities given their experience in the international markets, their higher productivity and the connections they might have with external suppliers of innovation inputs. As a result, R&D activities and internationalization strategies are endogenously correlated, resulting in biased estimates of the effect of R&D activities on export performance.

Throughout the thesis we have employed advanced econometric techniques to tackle the different endogeneity issues and we demonstrated the robustness of our results using a range of alternative methods. Nevertheless, our analysis might still be affected by different sources of bias difficult to overcome given the current econometric methods available to us.

Another potential flaw regards the data used to perform the empirical analysis. In particular, five different data issues might create possible concerns of sample bias. First, in chapter

1 the European Commission reports on anti-dumping cases do not provide all the information required for all cases concerning China, due to sensitivity/privacy issues and because of possible retaliation from China. As previously stressed, not all the case reports are publicly available, and not always all the information is disclosed, such as the voting pattern of Member States in the EU Council or data regarding the petitioners of AD measures. Second, in order to carry out a micro analysis at the firm-level on importers and producers of affected products we had to restrict our investigation to French firms for which trade and balance sheet data were available. Given that the anti-dumping policy is decided in Europe at the EU level, an analysis including import-competing and import-dependent firms from all EU countries would be preferable, but the lack of comprehensive, harmonized and coherent data on EU firms is still a major problem hampering micro-level analysis at the EU level.

Another issue related with the French firm-level data regards the composition of these datasets. First, the Custom Agency trade data include only exports and imports of manufacturing products, thus restricting the analysis to trade in goods neglecting the increasingly relevant trade in services, and intra-EU shipments are accounted only if their value exceeds the €250,000 threshold. Second, although the balance sheet dataset is particularly rich, including exhaustive information about firms in the agricultural, manufacturing and service sectors, it includes only firms with more than 20 employees, disregarding micro enterprises which constitute an important part of the business demography in France. Moreover, the rich R&D data used in chapters 2 and 3 is unfortunately available only for a relatively small group of French innovating firms, offering complete coverage of large investors in R&D but only a partial representation of firms investing less than €350,000 which are randomly surveyed every year. Finally, another weakness of the data regards the time period. Despite providing a very large unbalanced panel data for almost 10 years, the sample period of the dataset is relatively outdated, from 1999 to 2007, limiting our analysis to a 10 years old pre-crisis period.

FUTURE RESEARCH The results of this thesis in many respects represent a starting point for a research agenda which can be extended in a number of ways.

First, departing from the analysis of the EU anti-dumping measures against Chinese products, it would be interesting to look at the politicization of the EU anti-dumping mechanism, analysing specifically the role played by lobby groups and national interests in the determination of the trade defence of the EU. Because of its characteristics, the EU anti-dumping procedure is particularly prone to political and discretionary decisions motivated by protectionist pressures rather than technical aspects, especially when considering anti-dumping duties on products imported from emerging countries which increase competitive pressure on domestic industries. For these reasons, it would be extremely interesting to analyse the data on the voting pattern of EU Member States in the EU Council on anti-dumping issues, in order to analyse countries' political strategies and their impact on the industrial performance, taking into account the partisanship of national governments and the industrial lobbies petitioning for or opposing the imposition of anti-dumping measures.

Secondly, the estimation of the effect of R&D activities on firms export performance would not be complete without a comprehensive analysis of the impact of innovation on the quality of exported products. In chapter 2 we have partially addressed this issue, looking at the effect on firms intensive margin of trade. However, a more in-depth analysis might be needed given the importance of quality for the export performance of firms in mature economies, and the complexity of the measurement of products quality, considering prices, added-value, skills, human capital, technology intensity and creativity embedded.

In addition, it might be worth investigating the relationship between R&D activities and other aspects of firms internationalization, such as imports and foreign direct investment. The relationship between firms innovation and imports has been partially analysed by the previous empirical literature, especially looking at the effect of outsourced intermediate inputs on firms innovativeness. The link between R&D and FDI instead has been mostly neglected especially at the firms level, probably because of the lack of extensive data on firms direct investment abroad. Such analysis might be particularly relevant in order to complete our investigation of the relationship between internationalization, R&D activities and outsourced innovation. Moreover, this gap in the literature, together with the results of our analysis in chapter 3, highlights the need of a micro-level theoretical model describing the internationalization and innovation strategies of firms, in particular with regards to the main drivers of outsourced R&D activities and the impact of external sources of knowledge on the performance of firms in the international markets.

Finally, our analysis in chapters 2 and 3 has shown the relevance of publicly funded R&D for improving firms innovativeness and export performance. France devotes significant public resources to research and development activities, ranking at the second place in the EU as total investment in R&D. France provides an open business environment for the development of R&D networks, thanks to its key technology industries, the top quality of public education and research laboratories and the compelling compliance of government policies towards R&D and innovation, effectively sustained by the most generous R&D tax treatment for companies in Europe. Given the relevance of R&D public funds and schemes in France, it would be particularly interesting to evaluate the effectiveness of public support in improving the innovativeness of private firms, looking at the output of R&D activities supported by public authorities and the overall effect on firms productivity and international performance, in order to shed a light on the "entrepreneurial" role played by states in the development of new technologies and economic growth (Mazzucato 2013).

Appendix

AT.1 Total Factor Productivity Estimation

To measure firm-level productivity in chapters 1 and 2 we have estimated firms total factor productivity (TFP) following the De Loecker (2007) approach which is an extension of the standard Olley and Pakes (1996) methodology taking into consideration the heterogeneity in terms of productivity between exporters and domestic firms. In this way, we allow the market structure to be different for exporting firms by introducing exports into the production function, treating the decision to export as endogenous.

In fact, following the standard microeconomic literature and the Olley and Pakes (1996) model, firms are considered to be risk-neutral and will maximize their expected value of profits in function of capital and labour inputs according to the following production function:

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 \omega_{it} + \nu_{it} \tag{AT.1.1}$$

where y_{it} measures firm i total output at time t in terms of added value, while k_{it} and l_{it} represent capital and labour input respectively and ω_{it} is firm productivity. At the beginning of each period t firms will first decide whether to continue their operations or to quit the market, and conditional on this they will decide the level of labour input and investment as a function of firm productivity. Capital is accumulated assuming that investment in the current period t becomes productive in the following period $t+1$, and productivity is assumed to be determined by past productivity shocks and the exit and investment decisions, which in turn change the perception of market structure distribution.

The investment function is usually based on firms capital and productivity. Nevertheless, several studies have found that exporters have on average a higher productivity than domestic firms, mainly related to the ability to access foreign markets and the exposure to international competition which lead to possible "learning-by-exporting" effects (Melitz 2003; Yeaple 2005; Bernard et al. 2006; De Loecker 2007). As a result, exporting firms face different market structures and factor prices when they take decisions on the levels of investment and inputs to be used. For this reason the investment function i_{it}, and conversely the productivity function, should depend on the export status x_{it} of the firm as well:

$$i_{it} = i(k_{it}, \omega_{it}, x_{it}) \tag{AT.1.2}$$

In addition, since data on both investment in tangible and intangible assets are available, we have included all these information in order to consider firms investment in R&D as well, and to account for any simultaneity issue between inputs and productivity shocks, while using a selection equation to correct for the sample-selection bias. Nevertheless, previous studies have highlighted how frequently reported measures of investment in the datasets are equal to zero, given the cost and the time required for the adjustment of capital investment. To tackle this problem of inflated observations with zero investment, Levinsohn and Petrin (2003) suggested an extension of the Olley and Pakes (1996) methodology by using intermediate inputs m_{it}, such as materials and energy consumption, as a proxy to recover the unobserved firm productivity instead of investment, given that intermediate inputs are less costly to adjust and might respond quicker to productivity shocks. The previous investment function (AT.1.2) will then become:

$$m_{it} = m(k_{it}, \omega_{it}, x_{it}) \tag{AT.1.3}$$

By inverting this function to explicitly obtain the productivity shock ω_{it} and then substituting it into the previous production function (AT.1.1) we finally have:

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \omega(k_{it}, m_{it}, x_{it}) + \nu_{it} \tag{AT.1.4}$$

In the first stage, we apply an OLS regression model industry by industry, adding ownership and year dummies to consistently estimate the labour parameter β_2. In a second stage, we estimate the capital coefficient β_1 by correcting the selection bias making the survival decision ψ_{it} depending on firms export status through the productivity shock and the capital accumulation process:

$$Pr(\chi_{it+1} = 1|I_{it}) = Pr(\chi_{it+1} = 1|\omega_{it}, \omega_{it+1}(k_{it+1}, x_{it})) = \psi_{it}(k_{it}, m_{it}, x_{it}) \equiv P_{it} \tag{AT.1.5}$$

Thus, the estimation strategy is similar to Olley and Pakes (1996) except for the fact that both the first stage and the survival equation will now include the export status and all the remaining terms will be interacted with it. This will improve the estimation in the next stage of the capital coefficient, assuming that export status will affect the future productivity distribution through a learning-by-exporting process (De Loecker 2007):

$$y_{it+1} - \beta_2 l_{it+1} = \beta_0 + \beta_1 k_{it+1} + g(P_{it+1}, \omega_{it} - \beta k_{it}) + \xi_{it+1} + \eta_{it} \tag{AT.1.6}$$

A consistent coefficient of capital is obtained estimating the last stage with a non-linear least square regression model, where the coefficient of labour is obtained from the first stage (AT.1.4), the survival probability P_{it} from equation (AT.1.5) and the error term ν_{it} is decomposed into the i.i.d. shock η_{it} and the news term in the Markov process ξ_{it+1}. In addition, by using a semi-parametric method such as the Olley and Pakes (1996) approach, our estimation of TFP will be less sensitive to measurement error and other sources of bias, as shown by Van Biesebroeck (2007) comparing different methods for estimating productivity. Finally, once estimated and logged, we remove the top and bottom percentiles without any significant loss of observations, following the ISGEP (2008) approach in order to mitigate the effect of outliers on our analysis.

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