EXCHANGE RATE MANAGEMENT

IN A RESOURCE-DEPENDENT ECONOMY

By

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Abstract

This thesis investigates issues relating to the predominant culture of fixing the exchange rate in resource-rich economies. The fixed or pegged exchange rate regimes are based on substantial foreign exchange reserve liquidity, accrued almost entirely from natural-resource export earnings. The durability of this policy design, precisely in the context of perpetual recurrence of external shocks, disruptive technological innovations in the global value chain, as well as the potential depletion of natural-resource endowments, forms a central focus of this thesis. The thesis comprises a total of five related chapters, centered around the broad theme of exchange rate regime change, and a concluding sixth chapter, that summarizes the thesis. We explore whether or not there are any countries currently operating pegged regimes amongst the community of resource-dependent economies, with reasonable prospects of transitioning to a floating exchange rate regime in a smooth and orderly manner. A suite of analytical models are employed to this end, and the overarching finding is that the level of foreign exchange market development and financial sector depth, accessibility and efficiency in most of these countries, do not currently augur well for smooth and orderly transitions. By implication therefore, a large pool of resource-dependent economies would most likely face dire macroeconomic consequences if they were to exit their pegs today. Policymakers should thus, fast-track efforts to develop fundamental supportive elements for operating alternative exchange rate regimes, to minimize the risk of crashing-out of the pegs.

Dedication

To Watshipi Mmandala Tebano Molefhe

Acknowledgements

“Some of the materials presented in Chapter One were submitted and assessed as part of my PhD thesis Proposal in June 2021, in the Advanced Research Methods Module (24404)”

First, I thank GOD, for HE wrote every word in this thesis. I would also like to thank my lead supervisor Professor Anindya Banerjee, for he read every word in this thesis. Last but not least, I thank my mother Mareledi Molefhe, my sister Chabo Molefe and the Central Bank of Botswana, for their unwavering support throughout the journey.

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MAIN INTRODUCTION

SUMMARY OF THE CHAPTERS AND KEY FINDINGS

This thesis investigates issues relating to the predominant culture of fixing the exchange rate in resource-rich economies. The fixed exchange rate regimes are based on substantial foreign exchange reserve liquidity, accrued almost entirely from natural-resource export earnings. The durability of this policy design, precisely in the context of perpetual recurrence of external shocks, disruptive technological innovations in the global value chain, as well as the potential depletion of natural-resource endowments, forms a central focus of this thesis. The thesis is segmented into five related chapters, and a concluding sixth chapter that summarizes the thesis, outlines limitations and provides suggestions for future work.

Chapters 1, 2 and 3 explore the macroeconomic implications of transitioning from a fixed exchange rate regime to a floating regime, for a natural resource-dependent economy (RDE) such as Botswana. Simulations from a semi-structural new Keynesian model for a small open economy show that Botswana would most likely face a disorderly transition, if the country's diamond sector were to experience any intense and long-lasting shock. Broadly, Botswana's level of foreign exchange market development and its financial sector depth, accessibility and efficiency, do not currently augur well for a smooth transition. In Chapter 4, we assess whether or not there are any countries currently operating pegged regimes amongst the community of RDEs, with reasonable prospects of transitioning to a floating exchange rate regime in an orderly manner.

To filter-out political noise in our analysis, which is common especially among the so-called resource-cursed countries, we only focus on RDEs with a good track record of both economic and political stability in Sub-Saharan Africa, North Africa and the Gulf region. A number of analytical models are employed for this research problem, these include; a Markov-switching model, logistic model and panel threshold regression model. The overall finding of the study is that, with the exception of only a few countries in the Gulf region, the overall level financial market development and foreign currency risk exposure for most RDEs do not currently portend well for a smooth transition. By implication therefore, a large pool of RDEs would most likely face dire macroeconomic consequences if they were to exit their pegs today.

Chapter 5 deals partially with the so-called *Dutch-disease* phenomenon, which is a common problem amongst the community of RDEs. In particular, the chapter seeks to establish a measurement method of the real exchange rate most relevant for the trade account attributes of RDEs, using Botswana as a case study. We find the import-price based real exchange rate to outperform other alternative measures of the real exchange rate. This identity of the real exchange rate shows a consistent, sensible and economically meaningful association with Botswana's trade flows, both in the short and long run. We thus, recommend Botswana's exchange rate policymakers to start paying considerable attention to the trade competitiveness conditions implied by the import-price real exchange rate, in their policy discussions.

In summary, the overarching recommendation of this thesis is that, policymakers in RDEs should begin to imagine and prepare for a future where pegged regimes (particularly those backed by commodity export earnings) are no longer feasible to effectively implement. As a necessary contingency measure, RDEs should fast-track efforts to develop requisite elements for operating alternative exchange rate regimes. If policymakers find floating regimes appealing, then a detailed guidance on the necessary ingredients for operating these type regimes is provided in chapter 1, 2, 3 and 4 of this thesis.

Chapter One[1]

'BOTSWANA WITHOUT ITS PRECIOUS STONES'

MACROECONOMIC IMPLICATIONS OF TRANSITIONING FROM A PEGGED TO A

FLOATING EXCHANGE RATE REGIME

Abstract

This study explores the macroeconomic implications of transitioning from a fixed exchange rate regime to a floating regime, for the natural resource-dependent economy of Botswana. A semi-structural New Keynesian model is used to assess Botswana's macroeconomic transition profile under different sets of exit conditions, relating mainly to Botswana's level of foreign exchange reserve holdings at the time of the exit and its state of preparedness for exit. The general finding of the study is that, an unplanned policy regime transition in Botswana would most likely be disorderly in nature, characterized by profound macroeconomic instability in the short to medium term. A planned transition on the contrary, would most likely be orderly in nature, characterized by a high degree of public confidence on the stability of key macroeconomic fundamentals. This public confidence however, comes at a hefty price. The Central Bank of Botswana, together with both private and public stakeholders would have to invest a lot of time and effort in establishing some, if not all, the institutional and operational infrastructure necessary for the transition to earn credence. The study is divided into three chapters; the first chapter covers the background of the study and the description of our analytical model. The research questions raised in this study are addressed in the second and third chapters of the thesis.

[1] Some of the materials presented in this chapter were submitted and assessed as part of my PhD thesis Proposal in June 2021; Advanced Research Methods Module (24404).

1. INTRODUCTION

1.1 Background

While there are many remarkable economic success stories across the world, very few stories are as intriguing as the success story of Botswana's economy. This story, extensively documented in a wide range of social and political science literature, begins in 1966 when the country made its debut among the community of independent nations. At the time, there was immense skepticism about the country's survival prospects as an independent state, particularly given its limited economic potential and overwhelming reliance on foreign aid from its colonial master, Britain (Colclough & McCarthy, 1980). With no discernible opportunities for economic development and grossly undeveloped human capital, health care facilities and national infrastructure, the future of the country literally appeared bleak. Indicators of economic and social development placed Botswana among the poorest countries of the world; with a gross domestic product (GDP) of 51.5 million U.S. Dollars (USD) in 1966; a total of 28 health care facilities and 9 secondary schools in a population of approximately 570,000 people (Statistics Botswana, 2016; World Bank, 2019). Almost all the people were rural and agrarian, surviving on subsistence farming in a climate prone to drought and diseases (Colclough & McCarthy, 1980).

A decade later, Botswana began to make wide strides out of its economic hardships, becoming one of the richest economies in Africa (by almost all measures of economic development) and attaining the status of middle-income country in a space of three decades (Statistics Botswana, 2016; World Bank, 2019). At the center of this economic transformation was the discovery of diamond deposits in 1967, the subsequent establishment of the diamond mining trade in the mid-70s and the streams of revenue that accrued to the economy from this trade[2] (Colclough

[2] Diamonds were first discovered in 1967 in Botswana and production began in 1971 at the Orapa mine.

& McCarthy, 1980; World Bank, 1987; Botswana Government, 2008). Until the 2008/09 global economic recession, mineral revenue (more than 90 percent of which is diamond revenue) accounted for almost half of the Government's total budget (Botswana Government, 2008). The revenues have been prudently invested in the development of the country's infrastructure, human capital, health care facilities and building strong public institutions. To this day, Botswana is highly lauded worldwide for the sound management of its diamond wealth which has brought about substantial social and economic development, far above peer countries with comparable values of mineral endowment.

Apart from the contribution of the diamond industry to the country's socio-economic development, the industry also plays a central role in the effective formulation and implementation of Botswana's exchange rate policy framework. Exchange rate policy is an overarching anchor of the country's macroeconomic stability, a role it facilitates by basing both private and consumer confidence on the stability of the value of the domestic currency (Bank of Botswana, 2019). Botswana operates a pegged exchange rate regime supported almost entirely by the foreign exchange reserves accrued from the diamond exports. Under this exchange rate framework, which is operated as a crawling band mechanism, policymakers intervene in the foreign exchange market to influence the nominal value of the domestic currency (pula) against trade partner currencies i.e., the South Africa rand and the International Monetary Fund's (IMF) Special Drawing Rights (SDR)[3] (Bank of Botswana, 2008; Bank of Botswana, 2019). The foreign currency required to facilitate trade in the foreign exchange market at the policy-determined nominal rate of the pula vis-à-vis basket currencies (South African rand and SDR), is sourced from the foreign reserves, which are accumulated

[3] The pula is pegged 45 percent to the South African rand and 55 percent to the SDR (41.73 percent USD, 30.93 percent euro, 10.92 percent Chinese yuan, 8.33 percent Japanese yen, and 8.09 percent British pound sterling) (Bank of Botswana, 2019).

predominately through the sales of diamonds (Bank of Botswana, 2007; Bank of Botswana, 2008).

Botswana's monetary policy framework, which seeks to achieve and maintain a medium-term inflation of 3 to 6 percent, is premised on this crawling band exchange rate mechanism (Bank of Botswana, 2019). The exchange rate serves as the nominal anchor of price stability, and with the objective of low inflation, the nominal exchange rate has been allowed to remain moderately strong, particularly against the South African rand, which is Botswana's dominant trading partner currency (IMF, 2019a). This policy arrangement has been highly effective over the years in maintaining a low and stable inflation environment in Botswana, conducive for mobilising savings, promoting productive investment and contributing towards sustainable economic growth (Phetwe & Molefhe, 2016; Bank of Botswana, 2021).

1.2 Motivation

However, there are major concerns over the long-term sustainability prospects of this exchange rate policy framework, given that it is heavily predicated on the performance of diamond exports (which are susceptible to external shocks and volatile price swings) (IMF, 2019b). Thus, depending on the severity and duration of external shocks that may hit the economy of Botswana, as well as the intensity of drawdowns from the foreign exchange reserves to cushion livelihoods and support day to day government functions during the shocks, the country's foreign exchange reserves may come under severe stress, or at worst, become depleted. Policy interventions in the foreign exchange market to influence or defend the currency peg will become infeasible without sufficient stocks of foreign exchange reserve holdings.

Moreover, in principle, the role of foreign exchange reserves is much broader than just defending the currency peg and cushioning the economy during incidents of adverse shocks[4]. The political will therefore, to completely rundown the reserves in an effort to maintain the stability of the peg and keep the economy afloat, may be progressively diminished as the crisis prolongs. That is, the strategy of using foreign exchange reserves to preserve macroeconomic stability in a crisis, has its own elastic limits, and both private and household agents are privy to this knowledge (Krugman, 1979; Obstfeld & Rogoff, 1995; Dabrowski, 2016). In this regard, investor and consumer confidence in the ability of the country's macroeconomic fundamentals, particularly the stability of the peg to withstand the impact of the shock, may also diminish as the crisis prolongs. This will trigger massive capital outflows by foreign investors and excessive hedging against the perceived imminent collapse of the peg by domestic agents[5] (Krugman, 1979; Obstfeld & Rogoff, 1995; Dabrowski, 2016). At this stage, policymakers will have no choice but to exit the peg and allow the domestic currency to float freely, even before the exhaustive limits of using reserves to defend the peg is reached. This was the experience of most oil export-dependent countries during the 2014 – 2016 commodity price burst (Gillet & Tisseyre, 2017; IMF, 2015a; Dabrowski, 2016), as we discuss below.

Following the deep fall in international oil prices between 2014 and 2016, several oil export-dependent countries with fixed exchange rate frameworks, experienced a rapid fall in their foreign exchange reserves (Gillet & Tisseyre, 2017; IMF, 2015a). Speculative pressures on their currencies mounted, and amidst the pressure, most of them abandoned their currency pegs and switched to floating regimes. In chronological order; Russia switched towards the end of 2014, their reserves were down by roughly 25 percent between 2013 and 2014 (Gillet &

[4] Some of the key roles of foreign reserves include; cushion fluctuations in the government budget, funding national disasters and emergency relief programmes and a source of long-term investment for future generations (Bank of Botswana, 2017).

[5] A speculative attack in essence.

Tisseyre, 2017). Angola, Azerbaijan and Kazakhstan exited in 2015 with substantial loss in their reserves, especially for Angola and Azerbaijan. Egypt gave up the peg in 2016, with reserves equivalent to only 3 months of import cover (IMF, 2017a; Gillet & Tisseyre, 2017; IMF, 2016; IMF, 2018a). Following years of a sustained peg to the US dollar, some of the currencies of these countries lost approximately 50 percent of their nominal value against the USD after the exit (IMF, 2015a). As such, a series of macroeconomic disturbances resulted. Interest rates were hiked aggressively to mitigate the effects of the currency crisis, targeted mainly at dissuading capital flight and moderating rising inflation expectations (IMF, 2017a; Gillet & Tisseyre, 2017; IMF, 2016; IMF, 2018a). The high interest rate environment undermined investment and household consumption, exacerbating the slowdown in economic activity, already suppressed by the subdued performance in the oil-export industry (Gillet & Tisseyre, 2017; IMF, 2018a; Dabrowski, 2016).

Meanwhile, other resource-dependent economies (RDEs) including Botswana, also suffered similar macroeconomic downturns during this period, but not severely as oil-dependent economies. GDP in Botswana contracted by 1.7 percent between 2014 and 2015, mainly on account of the marked decline in diamond export sales (Statistics Botswana, 2016; Bank of Botswana, 2019). Foreign exchange reserves also fell substantially by approximately 15 percent between 2014 and 2016 (Bank of Botswana, 2017). However, the sharp fall in international oil prices dampened headline inflation across many economies[6], and somewhat cushioned the deterioration in the terms of trade, particularly for non-oil exporting countries (IMF, 2017c). At the time, inflationary pressures remained generally muted in the economy of Botswana, and headline inflation fell below the lower bound of Bank of Botswana's medium-

[6] Imported oil inflation was very low globally (IMF, 2017c).

term inflation objective range (Bank of Botswana, 2017). The monetary policy environment in the country therefore, remained relatively accommodative during this period.

1.3 Problem Statement

While Botswana has survived most of the past external shocks with adequate level of foreign reserves to support its exchange rate peg in the short to medium term, diamond sales post the 2014-2016 commodity price shock have however, remained significantly below long-term historical trends, as global demand has weakened (IMF, 2017a; IMF, 2019a). According to the (IMF, 2019a) Article IV Report, the downward pressure on diamond sales continues to intensify due to increased competition from synthetic diamonds and recurrence of adverse external shocks[7]. These external developments generally have negative implications on the long term sustainability prospects of Botswana's foreign exchange buffers and by extension, the country's macroeconomic stability (IMF, 2019a).

1.4 Research Questions

To mitigate this risk and preempt the likelihood of involuntary, abrupt and disorderly shifts in policy frameworks, experienced by some of the oil- export dependent countries during the 2014 -2016 commodity price burst, it is pertinent and necessary for Botswana to consider structural and macroeconomic policy adjustments. In particular, the country should undertake a comprehensive assessment of the prospects and macroeconomic consequences of transitioning from its current pegged regime, to a floating exchange rate regime. As observed in other countries[8] it is generally more prudent to consider the transition much earlier, putting in place some, if not all, the necessary institutional and operational requirements for a durable floating exchange rate regime (Gillet & Tisseyre, 2017; Otker-Robe & Vavra, 2007; IMF, 2004). In addition, and most importantly, acting while the country's foreign exchange reserves are still

[7] Most recently, the outbreak and subsequent global economic impact of the COVID-19 pandemic.
[8] Chile 1984 – 1999, Israel 1985 – 2005 and Poland 1990 – 2000, among other cases.

sufficient enough to manage the resultant exchange rate volatility, should be an important feature of economic policy.

This study undertakes such an assessment. In the first chapter of the study, we explore the fixed-to-float transition experiences (both orderly and disorderly transitions) of other resource-rich economies like Botswana. A semi-structural model adapted for the economy of Botswana is then employed in the second and third chapters, to simulate how Botswana's own transition would most likely look like. The simulations are conducted under different set of exit conditions, outline below;

i. Exit under market pressure with low levels of foreign exchange reserves.
ii. Exit in the absence of market pressure and with adequate foreign exchange reserves to manage immediate short term outcomes.
iii. Exit in the absence of market pressure, with adequate foreign exchange reserves and all the fundamental supportive elements of a durable floating exchange rate system in place.

1.5 Contribution to Literature

To our knowledge, such research has never been undertaken in the specific context described above. Similar studies of this nature however include (Carvalho & Vilela, 2015; Bordo, et al., 2010; Bergvall, 2002; Eitrheim, et al., 2020). (Carvalho & Vilela, 2015) for example, assessed the probable macroeconomic outcomes in Brazil, if the country had not transitioned from a crawling peg to a floating exchange rate and a fully-fledged inflation targeting regime in 1999.[9] The study conducted counterfactual experimental simulations demonstrating first, how macroeconomic fundamentals would have evolved if the crawling peg regime remained in

9 The real (Brazilian currency) as was the case with other emerging market currencies under soft peg regimes at the time, suffered mainly from the contagion of the 1997 Asian financial and currency crises.

place at the time; and secondly, how different the actual trajectory would have been, if the decision to float had been taken much earlier, in a crisis-free environment (Carvalho & Vilela, 2015). Most recently, (Eitrheim, et al., 2020) also carried out counterfactual analysis of alternative exchange rate and monetary policy regimes in the Norwegian economy, over the period 2007 to 2010. The overall goal was to assess how the macroeconomic environment in Norway would have turned out, during the 2008-09 global financial crisis, if the economy had fixed the nominal exchange rate, instead of a free-floating Norwegian krone in place at the time (Eitrheim, et al., 2020).

While this chapter intends to adapt the methodological approaches of some of these studies, the motivation of our study however deviates substantially from what these benchmark studies sought to establish. For a large proportion of these studies, the cardinal motivation was to evaluate, after the actual exchange rate regime transition, whether the right policy decision had been taken, and most importantly, whether it had been taken at the right time. The primary motive of this study is rather to assess, before-hand, potential macroeconomic outcomes Botswana would likely face if it transitions to a floating regime, under different set of exit conditions outlined above. It is highly important for RDEs operating pegged regimes to undertake such forward-looking assessments, in order to determine when and how to exit the peg in a manner that will safeguard both macroeconomic and financial stability, rather than wait for market pressures to dictate policy action at the height of the manifestation of the shock.

Furthermore, there is a paucity of structural-model-based evidence on the exchange rate transition of RDEs. This is understandable since this is an unusual phenomenon for these countries, and has only become relevant in the recent past, more precisely, after the 2014-2016 commodity price burst. Overall, the subject of risk assessment and pre-emptive mechanisms of disorderly exchange rate transitions in RDEs remains grossly unexplored in literature. Accordingly, the contribution of this study is to modify the existing structural models used to analyze exchange rate and monetary policy in RDEs[10], by incorporating features that will link the performance of the export commodity sector to exchange rate stability, macroeconomic outcomes and policy response.

The rest of the chapter is organized as follows; Section 2 surveys the relevant literature on this subject; Section 3 presents stylized facts on exchange rate regime transitions in RDEs; Section 4 maps-out the methodological approach followed in this study and provides a detailed description of our analytical model. Section 5 concludes the chapter.

10 The semi-structural new Keynesian model for a small open economy.

2. LITERATURE REVIEW

This section reviews the literature on different aspects relating to exchange rate regimes and macroeconomic outcomes. It comprises four areas of focus, and is structured as follows. Sub-section 2.1 provides classification and description of exchange rate regimes. Sub-section 2.2 reviews conceptual frameworks on orderly and disorderly exchange rate regime transitions. Sub-section 2.3 presents studies on counterfactual exchange rate regime transitions. Lastly, sub-section 2.4 provides a summary of the literature review, limitations of the existing stock of knowledge on this subject matter and the novel contribution of this study.

2.1 Classification of Exchange Rate Regimes

Classification of exchange rate regimes was first (between 1975 and 1998) based solely on what the government officially declared to be the regime in place, the so-called *de jure* classification (Habermeier, et al., 2009; IMF, 2017a). The de jure classification however, failed to accurately capture the disparities between the officially declared exchange rate framework and the actual prevailing practice on the ground (Habermeier, et al., 2009). Classification evolved in 1998 to include *de facto* exchange rate regime (Habermeier, et al., 2009; IMF, 2017a). This involved classifying exchange rate regimes based on actual prevailing practice and the commitment of policymakers to the exchange rate path, while also taking account of the extent of monetary policy independence (IMF, 2019b; Bubula & Otker-Robe, 2002; Habermeier, et al., 2009). Based on this classification, there are approximately 10 categories of exchange rate regimes employed across the world, ranging from hard pegs to freely floating regimes (Habermeier, et al., 2009; IMF, 2017a). We present under appendix B, the description of these exchange rate regimes and the monetary policy options available under each regime.

2.2 Orderly and Disorderly Exchange Rate Regime Transitions

This section reviews two types of exchange rate regime transitions described by (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004) as *orderly* and *disorderly* exchange rate regime transitions. As implied by the term, an orderly exchange rate regime transition describes an organized and intensively thought-through process involved in shifting from one exchange rate regime to the other (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). (Duttagupta, et al., 2004) use the term in the context of a gradual shift from a fixed or soft peg exchange rate regime to a freely floating regime. According to (Duttagupta, et al., 2004), countries transitioning in an orderly manner adequately prepare for the envisioned change. They work towards building the necessary technical capacity and establishing sound institutional and operational environment to support and enhance the prospects for efficient implementation and durability of the floating regime (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). This entails developing a deep and liquid domestic foreign exchange market for effective price discovery, formulating foreign exchange intervention strategies consistent with the new regime, and in the context of monetary policy, identifying an alternative nominal anchor of price stability (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004).

In addition, there is the need to determine the potential exchange rate risks and build supervisory capacity to manage these risks (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). Above all, there is need for effective and timely communication of the intended transition in order to ensure credibility and financial stability in the economy, during and after the transition. In general, countries whose transition process is characterised by the foregoing attributes rarely experience unpleasant macroeconomic consequences during and after the transition (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). Pegged regime exits under such conditions enjoy high levels of credibility and are associated with negligible fluctuation or persistent downward or upward trend in both the nominal and real exchange rate. As such, macroeconomic disturbances tend to be rare, or marginal if any (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). Cases of orderly transitions include; Chile 1984 – 1999, Israel 1985 – 2005 and Poland 1990 - 2000 (Otker-Robe & Vavra, 2007). Some of these cases are covered in the next section on stylized facts and also under Chapter four of this thesis.

At the opposite extreme of this well-organized and gradual exchange rate regime transition, are disorderly transitions, often undertaken with immense pressure and at a high credibility cost (Gillet & Tisseyre, 2017; IMF, 2019d; IMF, 2015a; Otker-Robe & Vavra, 2007). Disorderly transitions, more often than not, occur under economic environments devoid of the institutional and operational requirements for a successful and durable flexible exchange rate regime outlined above (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004). Evidence shows that this form of transition is common mostly among emerging market and developing economies (Eichengreen, et al., 1998; Gillet & Tisseyre, 2017; Dabrowski, 2016). This evidence includes the massive scale of exchange rate regime transitions observed during the Asian currency crisis in the 1990s and most recently, the 2014-16 commodity price burst (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004; Gillet & Tisseyre, 2017). Given the relevance of the 2014-16 episode to the objectives of this study, a brief review of the crisis and the macroeconomic consequences thereof, specifically in oil-exporting countries (who were the most impacted cohort of RDEs), is presented the next section.

2.3 Counterfactual Studies on the Macroeconomic Impact of Exchange Rate Regime Transitions

The studies reviewed in this subsection assess the variations in macroeconomic outcomes ascribed to changes in exchange rate regimes, using counterfactual experiments (Carvalho & Vilela, 2015; Bordo, et al., 2010; Bergvall, 2002; Eitrheim, et al., 2020). In a retrospective approach, encompassing all the historical shocks that hit the economy under evaluation, the studies explore how key macroeconomic variables would have evolved if the exchange rate regime had not changed. Below is a review of these studies.

(Carvalho & Vilela, 2015) assessed the probable macroeconomic outcomes if Brazil had not transitioned from a crawling peg exchange rate regime to a floating and inflation-targeting regime in 1999. Brazil abandoned the crawling peg regime in June 1999 following a sequence of external currency crises (Asian Crisis in 1997 and Russian Crisis in 1998) and internal political instability (1998 presidential elections) (Carvalho & Vilela, 2015). Prior to the transition, the real (Brazil currency) was devalued by 8 percent in January 1999, inflation rose sharply and the Central Bank of Brazil increased interest rates to over 40 percent to keep inflation expectations unanchored (Carvalho & Vilela, 2015). Interest rates were extremely high for the real sector to survive. On these grounds, the government of Brazil found it more pragmatic to exit the peg and allow the domestic currency to float freely. The decision however remained a subject of debate for a very long time. (Carvalho & Vilela, 2015) sought to contribute to the debate by answering two main questions; (i) what would have been the likely macroeconomic outcomes if Brazil had not taken the decision to float the real in 1999; and (ii) what would have been the likely macroeconomic outcomes if the decision to float the real had been taken much earlier, in a crisis-free environment.

To answer these questions, the study employed a new Keynesian DSGE model for a small open economy, changing the parameters of the monetary policy rule to reflect the primary objective of the monetary authority under each regime. In particular, under the crawling peg exchange rate regime, the monetary authority responds to deviation of the nominal exchange rate from the desired target and to a much smaller degree, deviation of inflation from target and fluctuations in the output gap (Carvalho & Vilela, 2015). For a floating exchange rate and inflation-targeting regime, the monetary authority responds primarily to deviation of inflation from target and output gap fluctuations (Carvalho & Vilela, 2015). Other model parameters are kept constant across the two regimes. The macroeconomic outcomes from each experiment are contrasted against the actual observed outcomes under the floating exchange rate regime between 1999 and 2013.

In the first experiment, the study assumed the crawling peg regime was maintained but with annual devaluations of 8 percent (the same pace of annual devaluations before the 1999 transition) (Carvalho & Vilela, 2015). The key findings were that, maintaining the crawling peg after 1999 would have been extremely detrimental to the macroeconomic well-being of Brazil. Both interest rates and inflation would have remained very high for several quarters, and economic activity substantially subdued relative to its actual trajectory under the floating exchange rate regime (Carvalho & Vilela, 2015). In their assessment, (Carvalho & Vilela, 2015) concluded that maintaining the peg would have been almost impractical after 1999. The second experiment explored the likely outcomes if the transition could have occurred much earlier, in a crisis-free environment and a strong net financial asset position. The counterfactual simulation of this experiment showed that, the transition would have been much smoother, with a slight appreciation in the nominal and real exchange rate, and relatively low fluctuations in the nominal interest rate, real interest rates, inflation and output growth compared to the actual benchmark evolution of the variables after the June 1999 transition (Carvalho & Vilela, 2015).

(Bordo, et al., 2010) explored how the 1950 exchange rate regime transistion in Canada, from the Bretton Woods par-value system to a floating exchange rate regime, would have played-out if the monetary policy focus had not changed in the late-1950s. Canada transitioned from the Bretton Woods par-value system to a floating regime in September 1950, and the economy perfomed quite well until 1957 when domestic monetary policy became too hawkish and incompatible with the expansionary fiscal policy stance at the time (Bordo, et al., 2010). During that time, the central bank maintained high interest rates in an effort to support the strength of the domestic currency and keep inflation at low levels (Bordo, et al., 2010). Aggregate output and employment levels were immensely suppressed as a result, leading to intense political pressure to exit the float (Bordo, et al., 2010). Canada abandoned the float in 1962 and returned to the Bretton Woods par-value system for a period of 8 years, before backtracking to a floating regime again in 1970. (Bordo, et al., 2010) endeavoured to establish how the Canadian economy would have performed between 1950 and 1962, under two hypothetical assumptions; (i) if the monetary policy stance between 1950 and 1956 was maintained until 1962; and (ii) if Canada had not transistioned from a fixed exchange rate regime (Bretton Woods par-value system) to a floating exchange rate regime in 1950.

The counterfactual analysis of the study, conducted in a New Keynesian DSGE model showed that, maintaining an accommodative monetary policy between 1950 and 1962 would have lowered volatility in output and allowed the floating exchange rate to adjust effectively to external shocks (Bordo, et al., 2010). The study showed that inflation would have increased above the actual rates observed between 1957 and 1962, but not substatially so. By contrast, the study found that keeping the fixed exchange rate regime would have resulted in higher volatility in both output, interest rates and inflation, far worse than the actual post-1956 hawkish monetary policy era (Bordo, et al., 2010). In conclusion, (Bordo, et al., 2010) assessed that, although the volatility in the Canadian macroeconomic environment post-1956 was quite high, maintaining the fixed exchange rate regime would not have been an economically viable option.

(Bergvall, 2002) investigated how stable the trajectory of macroeconomic variables in the Swedish economy would have been, if the country could have operated a floating exchange rate regime between 1972 and 1996, rather than the quasi-fixed regime in place at the time. The results of the study showed that while the efficacy of the central bank to stabilise macroeconomic disturbance was relatively high under the hypothetical floating regime, the difference in the volatility of the macroeconomic fundamentals between the float and the actual quasi-fixed regime, was not highly pronounced (Bergvall, 2002). A semi-structural new Keynesian model was employed for this undertaking.

Most recently, (Eitrheim, et al., 2020) conducted counterfactual experiments of alternative exchange rate and monetary policy regimes in the Norwegian economy over the period 2007 to 2010. The study employed the Norges Bank's monetary policy analysis model (a DSGE model, which structure and parameters are in the public domain) to conduct the simulations. The main objective of the study was to establish how macroeconomic fundamentals in Norway would have evolved during the 2008 global financial crisis if the economy had fixed the nominal exchange rate (Eitrheim, et al., 2020). Counterfactual simulation outcomes of the study indicated that, instead of the actual cut in interest rates during the crisis, interest rates would have been hiked to counteract the currency depreciation pressure and maintain the stability of the exchange rate around the pre-crisis level. As such, credit growth, net export, household consumption and aggregate output would have been lower, relative to the actual observed developments over the review period (Eitrheim, et al., 2020).

2.4 Contribution to Literature

The surveyed literature in totality has unexplored areas or gaps which this study endeavors to fill. First, the structural models on exchange rate transitions reviewed in this study, are entirely skewed towards policy evaluation. That is, for a large proportion of studies in this area, the cardinal motivation is to evaluate (after the actual exchange rate transition) whether the right policy decision was taken, and most importantly, at the right time. This study makes few modifications to these models, and applies them for risk assessment purposes instead, as it shall be shown in subsequent discussions. Secondly, the coverage of existing stock of literature on structural models of exchange rate regime transitions completely abstract from the transition cases of RDEs. The model used in this study is however designed specifically to capture the dynamics of these economies, represented by the economy of Botswana.

3. STYLIZED FACTS ON FIXED-FLOAT EXCHANGE RATE REGIME TRANSITIONS: RESOURCE-DEPENDENT COUNTRIES' EXPERIENCES

This section presents the exchange rate regime transition experiences of RDEs. We present first, the transition case of Chile between 1984 and 1999, which according to (Otker-Robe & Vavra, 2007; Duttagupta, et al., 2004) was an orderly transition. The case of Chile is followed by the disorderly transition cases of Kazakhstan, Angola and Egypt during the 2014 - 2016 oil price shock. In general, disorderly transition cases are much more common amongst the community of RDEs than orderly transitions (Dabrowski, 2016; Otker-Robe & Vavra, 2007). The transition case of Chile between 1984 and 1999 is, in fact, the only RDE orderly transition we have identified in literature.

3.1 Orderly Transition Case of Chile (1984 - 1999)

Chile is the leading world exporter of copper, which accounts for almost 50 percent of the country's total merchandise exports and 12 percent of GDP (IMF, 2020). The country exited the peg in September 1999, following the financial and currency crises in Asia-1997 and Russia-1998 (Otker-Robe & Vavra, 2007; Morande, 2001). A floating regime has been in place since then, and has withstood all the regional and global economic crises that have occurred since its adoption (Morande, 2001; Otker-Robe & Vavra, 2007; IMF, 2019b). According to (Otker-Robe & Vavra, 2007), several supportive institutional and operational elements of a durable floating regime, which Chile had established many years before exiting the peg in 1999, facilitated a smooth and orderly transition to a float. At the time of the exit, both foreign exchange market participation, as well as the capacity of the private sector to manage foreign exchange risks prudently, had developed sufficiently over time (Otker-Robe & Vavra, 2007).

Turnover in the foreign exchange derivative market for example, increased from around 0.1 percent of GDP in 1993 to 1.4 percent in 1998 (Ahumada, et al., 2006; De Gregorio & Tokman, 2004). Furthermore, the Central Bank of Chile had already gained reasonable experience in conducting monetary policy in a relatively high exchange rate flexibility environment, under the implicit inflation-targeting framework (Céspedes & Soto, 2005; Otker-Robe & Vavra, 2007). This alternative monetary policy framework, anchored to a preannounced inflation band target, was established in 1989 alongside the crawling band regime (Morande, 2001; Otker-Robe & Vavra, 2007). At the time of the exit in 1999, most of the supportive elements of a fully-fledged inflation-targeting regime were already in place (Céspedes & Soto, 2005; Otker-Robe & Vavra, 2007).

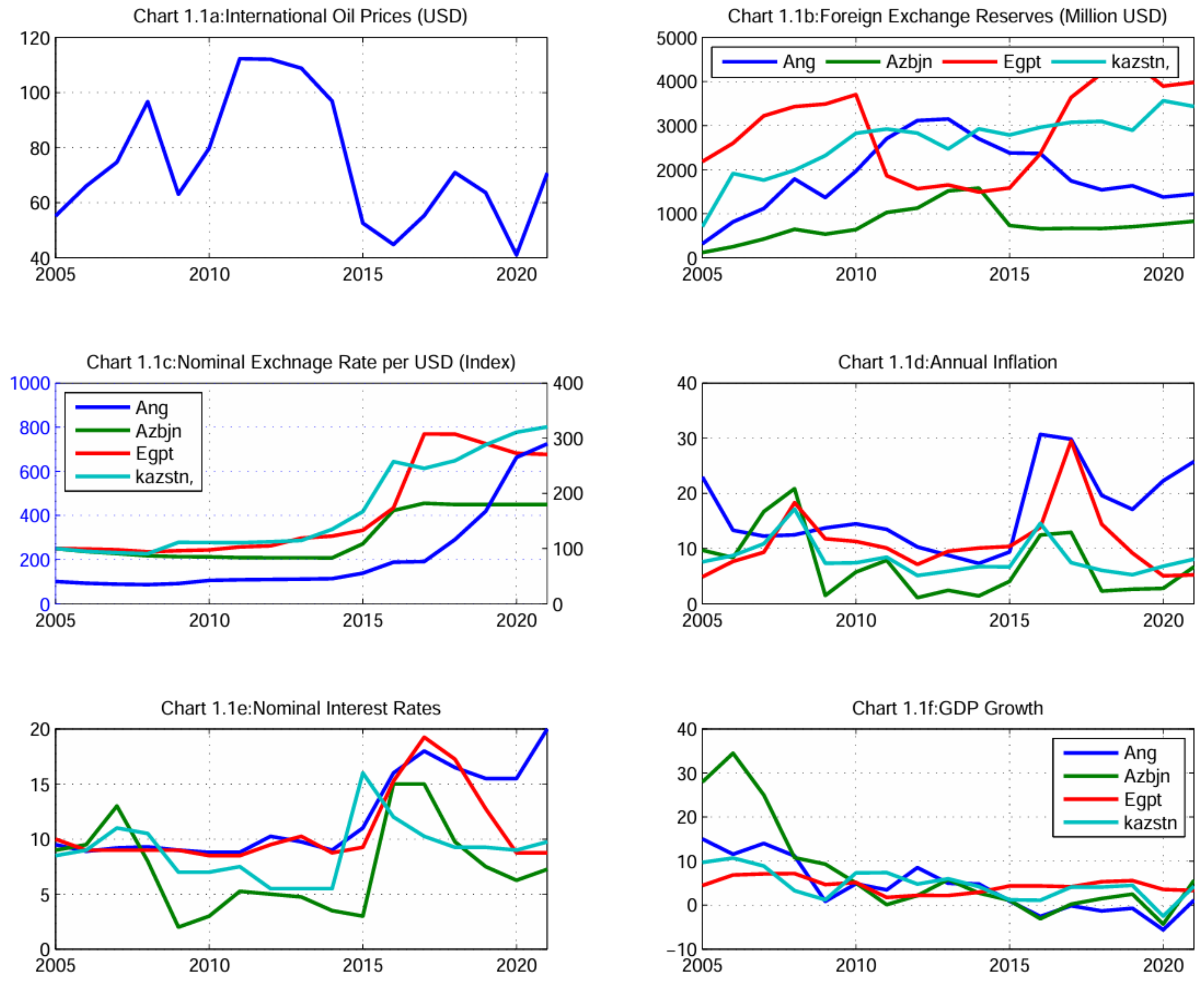
Moreover, the degree of exchange rate pass-through to domestic price was also found to be much lower in 1999 than previously estimated[11] (Morande, 2001). Therefore, fluctuations from the floating peso, were not expected to have much impact on domestic prices (Morande, 2001; Otker-Robe & Vavra, 2007). Last but not least, a new Central Bank foreign exchange intervention strategy under a flexible exchange rate regime was formulated, focused on instilling and promoting credibility through explicit and detailed communication of each intended intervention (Otker-Robe & Vavra, 2007; De Gregorio & Tokman, 2004). According to Morande (2001), the exit was perfect and convinent in timing, with calmness in financial markets and a broadly stable banking system.

[11] Exchange rate pass-through to domestic inflation was estimated at around 0.6 percent pre-1998 and 0.3 percent between 1998 and 2001 (Morande, 2001)

3.2 Disorderly Transition Cases (2015 – 2017)

International oil prices declined sharply from over 100 USD per barrel in mid-2014 to 30 USD per barrel by January 2016 (chart 1.1a below). This led to a deterioration in the foreign exchange buffers of oil-export dependent countries, and it became increasingly difficult and impractical eventually for countries operating hard and soft pegs regimes to sustain their pegs (Dabrowski, 2016; IMF, 2017a; Gillet & Tisseyre, 2017). During the initial phase of the crisis, most countries undertook steep devaluations in their currencies, indicating fears of a potential rundown of foreign exchange reserves, but with optimism nonetheless, that the shock would wither away, and prices would rebound in the near term (Dabrowski, 2016; Gillet & Tisseyre, 2017). The fall in international oil prices however, persisted and by mid- 2015 it had become apparent that the shock would last longer than previously anticipated. Mounting market pressure in the financial system increasingly gave rise to concerns about macroeconomic instability in these countries. Calls arose therefore, for policymakers to consider drastic shifts in some of their policy frameworks, among them, exchange rate policy transition from pegs to free floats (Dabrowski, 2016; IMF, 2017a; Gillet & Tisseyre, 2017).

Figure 1.1: Macroeconomic Outcomes



Note: Ang is Angola, Azbjn is Azerbaijan (which also transitioned during the period under review), Egpt is Egypt and Kazstn is Kazakhstan. Source: (IMF, 2017c; IMF, 2022b).

Kazakhstan exited the peg in December 2015 to a floating exchange regime with an inflation targeting monetary policy framework (IMF, 2016). Two main forces were at play in pushing Kazakhstan out of the peg; first, the diminished capacity to maintain the peg due to the fall in foreign exchange reserves and secondly, the substantial depreciation of the Russian ruble following Russia's exit in December 2014 (Dabrowski, 2016; McKenzie, 2015). With regard to the latter, as a major trading partner of Russia, the Kazakhstan real exchange rate appreciated heavily against the Russian ruble and adversely affected both the internal and external competitiveness of the Kazakhstani's economy. Kazakhstani's current account balances deteriorated from a surplus of 2.8 percent of GDP in 2014 to a deficit of -2.8 percent in 2015 and -6.4 percent in 2016 (IMF, 2017b). Moreover, the decision to exit the peg by the Kazakhstani's government was sudden and against the common practice of public communication prior to major changes in the exchange rate policy positions (McKenzie, 2015). Fundamentally, the exit played-out against the backdrop of underdeveloped foreign exchange markets (mainly forward markets, i.e., to hedge against foreign exchange risk exposure); lack of prudential and supervisory frameworks to regulate financial and corporate institutions' foreign exchange risk exposure and also; limited institutional and technical capacity to operate the newly adopted inflation targeting framework (Dabrowski, 2016; McKenzie, 2015).

Both private and consumer confidence were thus, negatively affected following the government announcement to exit the peg (McKenzie, 2015). The tenge depreciated by over 20 percent against the US dollar as speculation against the currency mounted and dollarized bank deposits increased (chart 1.1c). The tight liquidity conditions induced a substantial increase in market interest rates (chart 1.1e), which somewhat, helped to mitigating the risk of systemic financial instability (IMF, 2015b; Dabrowski, 2016). However, the high interest rate environment further suppressed domestic economic activity, already weakened by the underperforming oil-export sector. Economic growth declined from 6 percent in 2013 to 1.2 percent in 2015 (chart 1.1f). Inflation also increased sharply from 4.8 percent in 2013 to 13.6 percent in 2015 (chart 1.1d), and remained outside the country's medium term-inflation objective range of 6 – 8 percent for some time, largely due to the steep depreciation in the domestic currency and the negative effects thereof, on inflation expectations. Similar phenomena played out in Egypt, Angola and Azerbaijani.

In Angola, where oil exports account for over 90 percent of total exports, years of maintaining a peg of the Angolan Kwacha to the US dollar collapsed in mid-2015 (IMF, 2016). The government succumbed to the pressure presented by the risk of depletion in the foreign exchange reserves, and allowed the Angolan Kwacha to float in June 2015. As was the case with other oil-dependent economies, the transition to a flexible exchange rate regime was undertaken hastily, in an environment devoid of the institutional and operational elements for a smooth float (Dabrowski, 2016). The Kwacha depreciated substantial against the US dollar during this period (chart 1.1c), which led to a sharp rise in inflation from 8.8 percent in 2013 to 41.6 percent in 2016 (chart 1.1d). To contain inflationary pressures, the Central Bank of Angola hiked interest rates, inadvertently dampening economic activity in the process (charts 1.1e and 1.1f).

In Egypt, political instability caused by a series of revolutions across the Arab region in 2011 had already weakened the country's macroeconomic fundamentals before the commodity price crisis ensued in 2014 (IMF, 2018a). Egypt exited the peg in November 2016 and the Egyptian pound instantly depreciated by over 50 percent against the US dollar (chart 1.1c). To mitigate the inflation pressures building up from the currency depreciation, the Central Bank increased the interest rates, a policy position that further undermined economic activity in the country (charts 1.1e and 1.1f). However, the country's current account improved in subsequent years, mainly reflecting the depreciation in the real exchange rate (IMF, 2019c). Egypt's foreign exchange reserves also increased substantially subsequent to the shock (chart 1.1b), on account of a large credit facility the Government of Egypt acquired from the IMF in late 2015 (IMF, 2015a).

In summary, there are three main takeaways from this section. First, RDEs operating fixed exchange rate regimes sustain the framework mainly through foreign exchange reserves earned from commodity export earnings. Secondly, macroeconomic stability in these countries is rigidly anchored to exchange rate stability. Thirdly, exchange rate stability is strongly dependent on the performance of the commodity export sector and as such, external shocks inherently constitute a significant risk to exchange rate stability in these countries, and by extension, macroeconomic stability. Country experiences shows that, RDEs which lack the necessary institutional and operational elements for a smooth float are vulnerable to crashing-out of the peg, with dire consequences to their macro economy.

4. METHODOLOGY

To address the research questions set-out in this study, we employ a semi-structural gap model, called the *New Keynesian (NK) model for a small open economy* or the *Core model*, adapted from (Berg, et al., 2006; Andrle, et al., 2013; Benes, et al., 2017; Amarasekara, et al., 2018; Musil, et al., 2018). Since the target audience of this study is policymakers in Botswana and other RDEs with similar policy frameworks, it is thus, more pertinent to focus on the principal model that is widely used across these countries for forecasting and policy analysis, i.e., the Core model. According to (Pirozhkova, et al., 2023) a vast number of Central Banks in Africa and other developing countries use the Core model as a central component of their forecasting and policy analysis infrastructure. The model design and parameters thereof, for the Central Bank of Ghana, South Africa, Rwanda, Angola, Sri Lanka and many other countries, are in the public domain e.g., central banks' research bulletins and economics journals (Pirozhkova, et al., 2023; Abradu-Otoo, et al., 2022; Amarasekara, et al., 2018; Andrle, et al., 2013).

Most recently, (Abradu-Otoo, et al., 2022; Pirozhkova, et al., 2023) improved this model by adding features that captures central bank credibility and investor sentiments, respectively. Our study therefore, forms part of this on-going innovations to the Core model. This section describes the structure of this model and illustrates its general behavior under different exchange rate and monetary policy regimes (with the help of impulse response functions from a simple canonical prototype). A fully-fledged version of the model adapted for the economy of Botswana, is developed and implemented in the second and third chapters of the thesis to address our research questions.

4.1 New Keynesian Model for a Small Open Economy (Core Model)

The Core model is a widely used forecasting and monetary policy analysis framework across many central banks pursing inflation targeting or quasi-inflation target monetary policy regimes (Berg, et al., 2006; Andrle, et al., 2013; Benes, et al., 2017; Amarasekara, et al., 2018; Musil, et al., 2018; Pirozhkova, et al., 2023). The Core model blends the New Keynesian properties and the theoretical underpinnings of micro-founded DSGE models with stylized facts on macroeconomic fundamentals of interest to monetary policymakers (Berg, et al., 2006). Thus, at its core, the model seeks to organize theory and data in a coherent manner, and most importantly, capture all the key economic features that may be relevant for policy analysis in a given economy. In other words, instead of embracing theory in its entirety, as is the case with micro-founded models, the Core model appeals to theory but without necessarily 'marrying it' (Leeper, 2003; Berg, et al., 2006). That is, some of the equations of the Core model come from micro-foundations and resemble log-linearized version of the DSGE equations[12], but the model however, is not purely derived from 'deep parameters' (Berg, et al., 2006).

Notwithstanding that the Core model is not explicitly derived from micro-foundations, the model however still embodies the core features of micro-founded models. That is; the model is *structural* – all its behavioral equations have a theoretical-informed economic interpretation; the model is *dynamic* because it incorporates both adaptive and rational expectations, the model is *stochastic* in that, random innovations or shocks from all the behavioral equations affect each endogenous variable in the model; and lastly, it is a *general equilibrium* model because the main macroeconomic variables of interest are endogenous and depend on each other (Berg, et al., 2006).

[12] The log-linearized versions of the DSGE equations are supplemented with *ad hoc* elements (e.g foreign demand in the IS equation) under the Core model.

In contrast, parameterization under the Core model follows an eclectic approach, as opposed to purely econometric estimations which are applied in micro-founded DSGE models (Berg, et al., 2006). In general, purely empirically-based structural models are found not to be feasible in practice, particularly for developing economies like Botswana (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018). For most of these countries, data samples are usually very short and highly volatile, with a lot of structural breaks which may grossly undermine the reliability of the estimated parameters (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018; Pirozhkova, et al., 2023). Moreover, most economies (world-wide) generally exhibit a high degree of simultaneity, which makes it even more difficult to reliably estimate model parameters and infer cause-effect relationships, which is critical for identification of the model's behavioral equations (Berg, et al., 2006). In light of these challenges, a common practice therefore under the Core model framework is to use a broad collection of information in assigning parameters to the model equations (the so-called calibration approach). These include economic theory, empirical evidence, stylized facts, econometric estimations and many other tools that many be relevant for this task (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018; Pirozhkova, et al., 2023).

Caveats

One of the challenges of the Core model is that, although it consists of macroeconomic relationships which resemble log-linearized version of the DSGE equations, it is however not purely derived from micro-foundations or 'deep parameters'. The model is thus, vulnerable to the so-called Lucas critique. That is, policy regime changes may also change parameters of the model. Notwithstanding, a vast number of studies have found the model to be highly reliable in tracking both historical records of real time policy adjustments and its associated economic outcomes, as well as predicting future policy path and its prospective economic outcomes (Andrle, et al., 2013; Amarasekara, et al., 2018; Abradu-Otoo, et al., 2022; Pirozhkova, et al., 2023). It can therefore be reasonably argued that, perhaps the large pool of information used to parameterize the model is quite helpful in mitigating the risk contemplated by the Lucas critique.

4.1.1 New Keynesian Properties

The properties discussed below are the premise of the New Keynesian school of thought upon which the Core model is founded. These properties/assumptions are; *imperfect or monopolistic competition market structure*, which implies that, firms set the prices of the commodities they produce. *Nominal rigidities in price adjustments* - firms face constraints on the frequency with which they can adjust prices. More precisely, prices are assumed to be adjusted in accordance with Calvo (1983) staggered price setting mechanism. *Short-term non-neutrality of monetary policy* - which stem from the assumption of nominal rigidities in prices. The assumption implies that, since price changes (inflation) do not move on a one to one basis with changes in nominal interest rates, the monetary policy authority can therefore adjust short term nominal interest at any point, to influence the movements in real interest rates (nominal interest rate minus expected inflation). Fluctuations in the real interest rates will have an effect on consumption-savings decisions by households, aggregate level of investment, employment and output (Gali & Monacelli, 2005; Justiniano & Preston, 2010) .

4.1.2 Micro-Foundations

Micro-foundations form a critical component of the Core model structure in that, they guide and inform the specification of the model's main behavioral equations (Berg, et al., 2006). Accordingly, we present in appendix A, micro-foundations in the context of the dynamics and fundamentals of the economy of Botswana, guided by (Gali & Monacelli, 2005; Justiniano & Preston, 2010).

The log-linearized approximation of the first order conditions of the maximization problems of consumers and firms, under market clearing condition, yields three key behavioral equations of the Core model; *aggregated demand equation (IS curve)*, aggregate *supply equation* (*New Keynesian Phillips curve) and the nominal exchange rate (Uncovered Interest rate Parity-UIP)* equation. The equations are supplemented by the *monetary policy response function (modified Taylor rule)* to constitute the core structure of the Core model, which is described in full in the following discussions.

4.2 Core Model Structure (Canonical Representation)

As alluded above, the Core model comprises 4 main behavioral equations, namely; the *aggregate demand equation, Phillips curve, UIP and the modified Taylor rule.* The framework is a small semi-structural gap model, that is, real variables in the model are measured as gaps or deviations from long-run equilibrium trends. The model however, abstracts from issues relating to how the long-run equilibrium trends of real variables are determined.[13] The trends are simply assumed to evolve through an autoregressive process, centered around the steady state or historical average of each respective real variable (Berg, et al., 2006; Musil, et al., 2018). Policy makers set the desired targets for nominal variables in this model, precisely, the inflation target and the target for the nominal exchange rate, in line with the 'law of one price' or the relative purchasing power parity (PPP) principle (this will be demonstrated in subsequent discussions). Below is a prototype or canonical representation of the Core model, under (i) *a fixed exchange rate and an implicit inflation targeting monetary policy regime* and (ii) *a floating exchange rate and a fully-fledged inflation targeting monetary policy regime.*[14]

13 Long-run equilibrium trends in principle, are determined by structural factors outside the remit of exchange rate and monetary policy. These include, quality of education, strength of public institutions, level of public investment and the efficiency thereof, (IMF, 2004; Berg, et al., 2006).

14 Conceptual overview of these policy regimes is presented under appendix B.

Case 1: Fixed Exchange Rate and an Implicit Inflation Targeting Monetary Policy Regime

Under this framework, the Central bank targets both inflation and the nominal exchange rate movements. This model captures a policy design akin to the current monetary policy framework pursued by the Bank of Botswana, the so-called *intermediate or hybrid monetary and exchange rate policy regime.*

Model Structure

Aggregate Demand Equation (IS Curve)

$$\hat{y}_{D,t} = a_1\hat{y}_{D,t-1} + (1-a_1)\hat{y}_{D,t+1} - a_2 mps_t + a_3(\hat{y}_t^f + \widehat{dim}_t^{price}) + \varepsilon_t^{yD} \quad (1.1)$$

Where: a_1, a_2 *and* a_3 are calibrated parameters, $\hat{y}_{D,t}$ is the domestic output gap expressed as 100*$log(\frac{y_{D,t}}{Y_{D,t}^T})$, $y_{D,t}$ is actual or observed domestic output, $Y_{D,t}^T$ is the trend of domestic output, , $rmci_t$ is the real monetary condition index or policy stance, $\hat{y}_t^f$ is the foreign output gap, $\widehat{dim}_t^{price}$ is diamond price gap and ε_t^y is the demand shock.

The aggregate demand equation relates total output in the economy to its persistence or inertia, expected output, real monetary conditions, foreign output or demand for domestic exports and world diamond prices. The real monetary conditions comprise two components, the real interest rate gap and the real exchange rate gap (equation 1.1.1). The real interest rate gap links monetary policy actions (adjustments in short term nominal interest rates) to fluctuations in aggregate output, while the real exchange rate gap measures both the internal and external competitiveness of the domestic economy, as implied by the strength of the exchange rate, in real terms.

$$mps_t = a_4\hat{r}_t + (1-a_4)(\hat{z}_t) \quad (1.1.1)$$

Where: $\hat{r}_t$ is the real interest rate gap (real interest rates measured as, nominal interest rates minus expected inflation) and $\hat{z}_t$ is the real exchange rate gap

Experience and empirical evidence suggest that, parameter a_2 would be relatively small in many economies, reflecting weak and substantial lags in the transmission of monetary policy signals to the overall economy (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018; Abradu-Otoo, et al., 2022). Parameter a_2 ranges between 0.1 and 0.2 in general (Berg, et al., 2006; Andrle, et al., 2013; Benes, et al., 2017; Amarasekara, et al., 2018). High degree of persistence in aggregate output on the other hand, imply large parameter values for $a_1$and smaller values for the lead parameter (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018). Persistence parameter lies between 0.4 and 0.95 in the literature (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018; Musil, et al., 2018). Foreign output parameter (which captures external demand for domestic exports) typically lies between 0.1 and 0.5, and its calibration is largely based on the country's export-to-GDP ratio (Berg, et al., 2006; Andrle, et al., 2013; Benes, et al., 2017; Amarasekara, et al., 2018).

Domestic Aggregate Supply Equation (New Keynesian Philips Curve)

$$\pi_t = b_1\pi_{t-1} + (1 - b_1)\, E(\pi_{t+n}) + b_2 rmc_t + \varepsilon_t^{\pi} \tag{1.2}$$

Where: b_1 and b_2, are calibrated parameters, π_t is headline inflation, rmc_t is the real marginal costs and ε_t^{π} is the supply shock

The Phillips curve describes the evolution of consumer price inflation in the economy, as a function of past and expected future inflation, as well as real marginal cost. Real marginal cost comprises two components; the output gap, which represents marginal cost associated with domestic output, and the real exchange rate gap, which represent marginal cost of imported commodities (equation 1.2.1). The fundamental restrictions of the Phillips curve are that, (i) parameter on past and expected inflation should sum up to one (ii) the parameter values for expected inflation and real marginal cost should be greater than zero (Berg, et al., 2006). The former ensures that the role of monetary policy in providing a nominal anchor for inflation is embodied in the equation (expected inflation is usually set as the actual inflation target set by the central bank). The latter restriction provides a link between monetary policy actions (adjustments in the policy rate) and the nominal target (inflation). This link is necessary to close the model or bring the system to its equilibrium state when exposed to a shock (Berg, et al., 2006).

$$rmc_t = b_{21}\hat{y}_t - (1 - b_{21})(\hat{z}_t) \tag{1.2.1}$$

Parameter on expected inflation also serves as measure of the credibility of the central bank in meeting its inflation target. Thus, parameter $(1 - b_1)$ will tend to be high for developed countries (where central banks are much more credible) and relatively low in developing countries, where most central banks do not enjoy a considerable level of public trust (Berg, et al., 2006; Andrle, et al., 2013; Amarasekara, et al., 2018; Musil, et al., 2018; Abradu-Otoo, et al., 2022; Pirozhkova, et al., 2023). The value of $(1 - b_1)$ generally lies between 0.1 and 0.4 for less credible central banks (Berg, et al., 2006; Andrle, et al., 2013; Musil, et al., 2018). The output gap to inflation pass-through parameter (b_{21}), typically ranges between 0.05 and 0.4 (Berg, et al., 2006; Amarasekara, et al., 2018; Musil, et al., 2018). This parameter is also a measure of the sacrifice ratio of growth for low inflation. The lower the parameter, the higher the sacrifice, and the reverse is true (Musil, et al., 2018). The exchange rate pass-through parameter on the other hand, depends largely on the country's degree of openness to imports. The parameter ranges between 0 and 0.9, and tends to be relatively high for countries with a large proportion of imported commodities in their consumer price baskets (Berg, et al., 2006; Andrle, et al., 2013; Benes, et al., 2017; Musil, et al., 2018).

Nominal Exchange Rate Equation (Modified UIP)

$$S_t = g_1 S_t^{Tar} + (1 - g_1)\left(S_t^e + \left(i_t - i_t^f - prem_t\right)/4\right) + \varepsilon_t^s \quad (1.3)$$

Where: g_1 is a calibrated parameter, S_t is log of the nominal exchange rate, S_t^{Tar} is the nominal exchange rate target, i_t and i_t^f are domestic and foreign nominal interest rates respectively, $prem_t$ is the country's risk premium and ε_t^s is the exchange rate shock

The UIP equation above describes the path of the nominal exchange rate under the hybrid or intermediate monetary policy regime, where the central bank seeks to target both the movements in the nominal exchange rate and inflation (Carvalho & Vilela, 2015; Andrle, et al., 2013). The equation comprises two components; the exchange rate target and the conventional UIP under a freely floating exchange rate regime. Parameter g_1, reflects the degree of central bank's commitment to a desired nominal exchange rate target. g_1 would range between 0.75 and 1, 1 being under a full commitment arrangement (Carvalho & Vilela, 2015; Andrle, et al., 2013). On the contrary, g_1 would be zero under a freely floating exchange regime, and the movements in the nominal exchange rate in this case, would be determined almost entirely by the conventional UIP.[15]

The nominal exchange rate in this study, is expressed as foreign currency per unit of domestic currency, consistent with the measurement used by the country of interest, Botswana. With this exchange rate measurement or quotation, upward movements in the exchange rate reflect an appreciation, and downward movements reflect depreciation. The real exchange rate is also defined (and its movements interpreted) in a similar manner.[16] Meanwhile, the expected nominal exchange rate (S_t^e) evolves through a process captured by equation (1.3.1) below, and the country's risk premium, which captures the risk associated with investing in the domestic financial markets, evolves through equation (1.3.2).

15 The interest rate differential and the risk premium in the UIP are divided by 4 because they are measured in annual terms (Berg, et al., 2006). The core model itself it's a quarterly projection framework.

16 The real exchange rate, is the nominal exchange rate adjusted for the differential between domestic and foreign inflation.

$$S_t^e = \delta E_t(S_{t+1}) + (1-\delta)(S_{t-1}) \quad (1.3.1)$$

Where; δ is an estimated parameter, S_t^e is expectation formed at time t, $E_t S_{t+1}$ is the model-consistent expectations, produced by the forward iteration of the UIP equation one period ahead and S_{t-1} is the previous period nominal exchange rate.

$$prem_t = \Delta\overline{z}_{t+1} + \overline{r}_t - \overline{r}_t^{\,f} + shock\_prem_t \quad (1.3.2)$$

Where: $\Delta\overline{z_{t}}_{+1}$ is the expected change in the real exchange rate trend, $\overline{r_t}$ and $\overline{r_t}^f$ are domestic and foreign real interest rates trend respectively, and $shock\_prem_t$ is risk premium shock. Premium equation is simply the real version of the UIP.

Under this monetary policy regime, the choice of the nominal exchange rate target imposes an implicit restriction on the choice of the inflation target. In particular, the desired exchange rate target and the inflation target must adhere to the relative purchasing power parity principle, specified below (Benes, et al., 2017; Musil, et al., 2018).

$$\Delta\overline{z_{ss}} = \Delta S_t^{Tar} + {\pi_D}^{Tar} - {\pi_F}^{Tar} \quad (1.3.3)$$

Where: $\Delta\overline{z_{ss}}$ is the real exchange rate trend appreciation/depreciation equilibrium, ΔS_t^{Tar} target of the nominal exchange rate appreciation/depreciation, ${\pi_D}^{Tar}$ *and* ${\pi_F}^{Tar}$ are domestic and foreign inflation targets respectively.

Thus, since the real exchange rate trend and foreign inflation target[17] are exogenous in equation (1.3.3), it therefore follows that, domestic inflation target is implicitly determined by the choice of the nominal exchange rate target under this regime. By implication therefore, the monetary authority can only set an inflation target of its choice if and only if, the nominal exchange rate is freely floating. In such a case, the implied target or equilibrium appreciation/depreciation of

[17] Foreign inflation target is the weighted average inflation targets of Botswana's trading partner countries (South Africa and SDR countries).

the nominal exchange rate will be determined by exogenous variables (real exchange rate trend and foreign inflation) and of course, the monetary authority's inflation target of choice.

Monetary Policy Response Function

$$i_t = h_1 i_{t-1} + (1 - h_1) * \left(h_2\left[-4(E_t(S_{t+1}) - S_t) + \left(i_t^f + prem_t\right)\right] + (1 - h_2)\left[i_t^n + m_1(E_t\pi_{t+n} - \pi_D^{Tar}) + m_2\hat{y}_{D,t}\right]\right) + \varepsilon_t^i \quad (1.4)$$

Where: h_1, h_2 m_1, m_2, are calibrated parameters, i_t is the policy rate, π_D^{Tar} is the domestic inflation target, $E_t\pi_{t+n}$ is forecast inflation, $\hat{y}_{D,t}$ is domestic output gap, i_t^n is the policy neutral rate, defined as $i_t^n = \overline{r_t} + \pi_D^{Tar}$, $\overline{r_t}$ is the real interest rate trend and ε_t^i is the monetary policy shock

The policy rate under this monetary policy framework responds to three main fundamentals, namely; (i) *expected movements in the nominal exchange rate from the desired target*.[18] Thus, consistent with our definition of the nominal exchange rate, expectations of a depreciation (downward movement in the nominal exchange rate) will trigger a hike in the policy rate. Likewise, expected appreciation in the exchange rate will lead to a reduction in the policy rate. (ii) *Deviation of forecast inflation from its target*[19]*, and (iii) fluctuations in the output gap*. The policy rule also comprises two other important components, that is, *persistence in the policy rate* and *the policy neutral rate.* Policy persistence captures the frequency with which the central bank adjusts the interest rates, and the policy neutral rate is the level of interest rate that will prevail when inflation is on its target and the output gap is closed.

Parameter h_1, which is commonly referred to as the 'wait and see' parameter in literature, would tend to be high if the policy rate exhibits high degree of persistence, implying infrequent adjustments in the interest rates by the central bank. h_1 generally lies between 0 and 0.8 (Berg,

18 This part of the monetary policy rule is simply the modified UIP (equation 1.3) expressed in terms of the evolution of domestic nominal interest rates.

19 $E_t\pi_{t+n} - \pi_D^{Tar}$ implies that policymakers should adjust the policy rate at time t, if forecast inflation at period $t + n$ is not on its set target π_D^{Tar}.

et al., 2006; Amarasekara, et al., 2018; Musil, et al., 2018). Parameter h_2 depends largely on the most predominant instrument used by the central bank in influencing movements in the exchange rate. If interest rates is the predominant instrument, then h_2 will be relatively high, but if the central bank's main instrument is foreign exchange reserves (which is the case for most resource-rich countries) then h_2 will be low (Carvalho & Vilela, 2015; Amarasekara, et al., 2018; Musil, et al., 2018). The main restriction in the policy rule is the so-called Taylor principle, which requires that m_1 must be greater than zero. The restriction ensures that, policy responses to deviation of inflation from its target are aggressive enough to stir real interest rates in the desired direction (Berg, et al., 2006; Benes, et al., 2017; Amarasekara, et al., 2018).

Foreign Block

Our country of interest in this study (Botswana) is a small open economy, meaning that, though it participates in international trade, it is however too small to influence global market forces. Global output, inflation and interest rates are therefore in this model, assumed to evolve exogenously through autoregressive processes specified below (Benes, et al., 2017; Musil, et al., 2018; Amarasekara, et al., 2018).

$$\hat{y}_t^f = f_1 \hat{y}_{t-1}^f + \varepsilon_t^{fy} \tag{1.5.1}$$

$$\widehat{dim}_t^{price} = f_2 \widehat{dim}_{t-1}^{price} + \varepsilon_t^{\text{dim}\_price} \tag{1.5.2}$$

$$\pi_t^f = f_3\pi_{t-1}^f + (1 - f_3)\pi_F^{Tar} + \varepsilon_t^{f\pi} \tag{1.6}$$

$$i_t^f = f_4 i_{t-1}^f + (1 - f_3) i_F^{SS} + \varepsilon_t^{fi} \tag{1.7}$$

Where: f_1, f_2, f_3 , f_4 are calibrated parameters, $\hat{y}_t^f$ is foreign output gap, π_t^f and π_F^{Tar} is foreign inflation and its target respectively, i_t^f and i_F^{SS} are foreign nominal interest rates and their steady state respectively, ε_t^{fy}, $\varepsilon_t^{f\pi}$, ε_t^{fi} are shocks of each respective AR process.

Case 2: Floating exchange rate and a fully-fledged inflation targeting monetary policy regime

Under this monetary policy framework, the central bank only targets inflation, the nominal exchange rate is freely floating and its behavior is determined by the conventional UIP. The aggregate demand equation and the Phillips curve in this framework are exactly the same as in case 1 above, the difference only emanates from the specification of the UIP and the monetary policy response function. In particular, we drop the nominal exchange rate target in the modified UIP from equation (1.3), and monetary policy cease to respond to exchange rate movements as is the case in equation (1.4). Below are the modifications to equation 1.3 and 1.4 necessary to transition to a *floating exchange rate and a fully-fledged inflation targeting monetary policy regime* model.

Nominal Exchange Rate Equation (UIP)

$$S_t = E_t(S_{t+1}) + \left(i_t - i_t^f - prem_t\right)/4 + \varepsilon_t^s \tag{1.8}$$

Equation (1.8) is the conversional version of the UIP describing the evolution of the nominal exchange rate under a free-floating exchange rate regime. We assume parameter one for all the components of the UIP. This is mainly because of the inherent simultaneity between interest rates and the exchange rate, which generally makes it very difficult to estimate or calibrate the UIP coefficients (Berg, et al., 2006). Furthermore, the risk premium is exogenously determined under this regime, evolving through an AR process below;

$$prem_t = q_1 prem_{t-1} + (1 - q_1) prem_{ss} + \varepsilon_t^{prem} \tag{1.8.1}$$

Monetary Policy Response Function

$$i_t = h_1 i_{t-1} + (1 - h_1)\big(i_t^n + m_1(E_t\pi_{t+n} - \pi_D^{Tar}) + m_2\hat{y}_{D,t}\big) + \varepsilon_t^i \qquad (1.9)$$

As alluded above, we drop the modified UIP from the policy rule, nominal interest rates therefore in this case, responds only to deviations of forecast inflation from target and fluctuations in the output gap. Parameters in this equation would also change to reflect the central bank's primary commitments under this framework. More precisely, m_1 and m_2 would be relatively higher than in case 1.

4.3 Model Calibration and Properties

In this subsection, we describe the calibration and model performance evaluation procedures for the two canonical models discussed above. All the model parameters are calibrated to reflect stylized facts and the general policy transmission mechanism under each monetary and exchange rate policy regime. Calibration is based on quarterly data for the economy of Botswana and its trading partner economies (South Africa and SDR countries) from 2000Q1 to 2020Q1. Table 1.1 below provides a list of variables used in this process, their definitions and where they are sourced.

Table 1.1: Model Variables

Variable Names	Definition	Primary source	Frequency
ZAR/BWP	Nominal South African Rand/Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
USD/BWP	Nominal US Dollar /Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
GBP/BWP	Nominal British pound sterling /Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
JPY/BWP	Nominal Japanese yen /Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
EURO/BWP	Nominal Euro/Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
CNH/BWP	Nominal Yuan Renminbi /Pula exchange rate	Bank of Botswana-Financial Statistics	3 Months Average

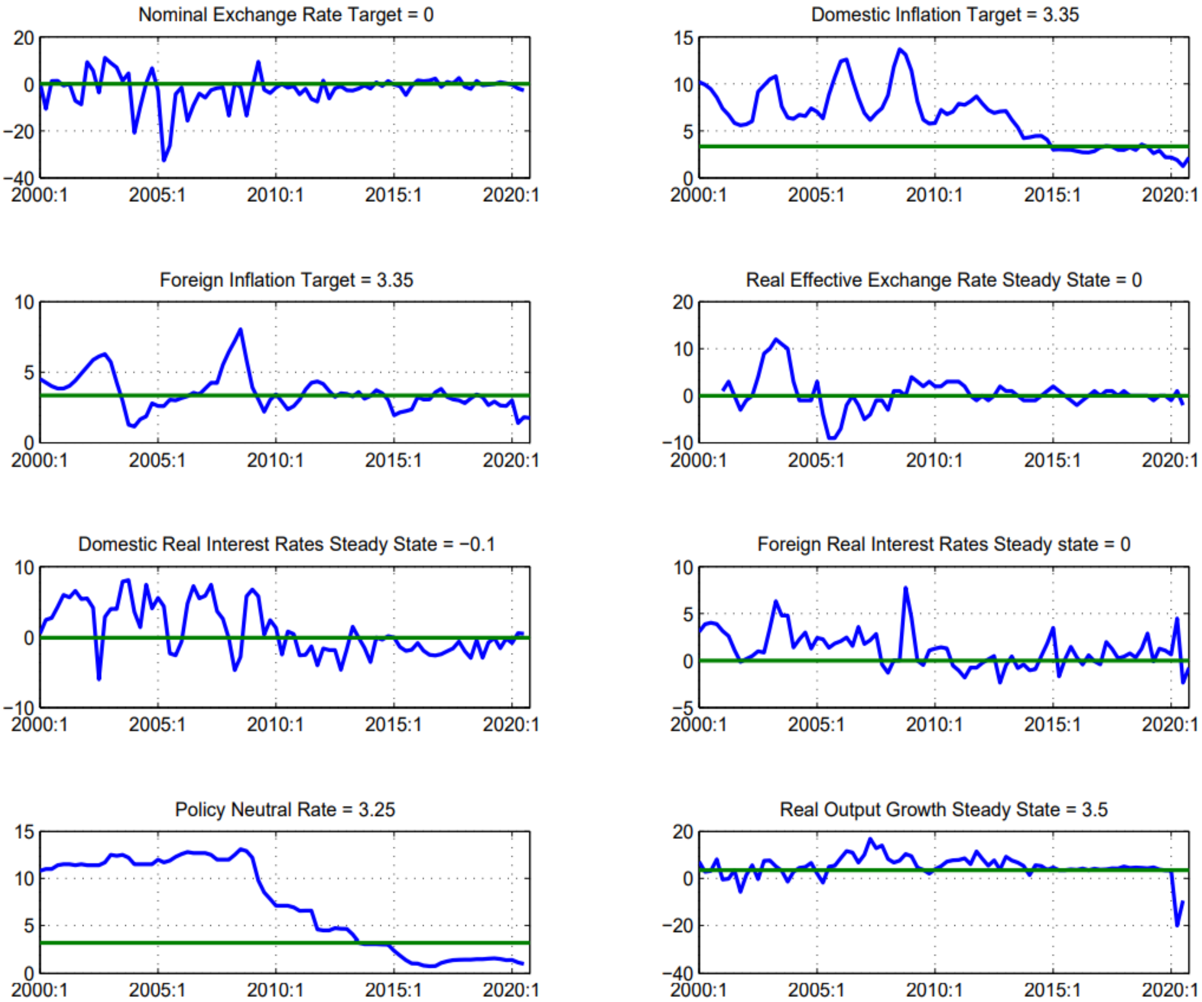
GBP/USD	Nominal GBP/USD exchange rate	Bank of Botswana-Financial Statistics	3 Months Average
JPY/USD	Nominal JPY /USD exchange rate	Bloomberg	3 Months Average
ZAR/USD	Nominal ZAR/USD exchange rate	Bloomberg	3 Months Average
EURO/USD	Nominal EURO /USD exchange rate	Bloomberg	3 Months Average
CNH/USD	Nominal CNH /USD exchange rate	Bloomberg	3 Months Average
Botswana Interest Rates	Bank of Botswana 7 day Certificate rate	Bank of Botswana-Financial Statistics	3 Months Average
South Africa Interest Rates	Safe South Africa Johannesburg Interbank Agreed Rate 3 Month (RSA)	Bloomberg	3 Months Average
Japan Interest Rates	ICE Libor JPY 3 Month (Japan)	Bloomberg	3 Months Average
United Kingdom Interest Rates	ICE Libor GBP (UK)	Bloomberg	3 Months Average
United States Interest Rates	ICE Libor USD 3 Months (US)	Bloomberg	3 Months Average
China Interest Rates	China 1-year Benchmark Lending Rate (China)	Bloomberg	3 Months Average
Euro Interest Rates	Euribor 3 Months (Eurozone)	Bloomberg	3 Months Average
World Food Price	Food and Agriculture Organisation of the United Nations (FAO) Food price Index	Bloomberg	3 Months Average
World Oil Price	Brent Oil Price (USD)	Bloomberg	3 Months Average
Diamond Price	Diamond prices (USD)	Bloomberg	3 Months Average
Botswana CPI	Headline Consumer Price Index Botswana	Statistics Botswana	3 Months Average
South Africa CPI	Headline Consumer Price Index South Africa	Bloomberg	3 Months Average
Japan CPI	Headline Consumer Price Index Japan	Bloomberg	3 Months Average
United Kingdom CPI	Headline Consumer Price Index UK	Bloomberg	3 Months Average
United States CPI	Headline Consumer Price Index US	Bloomberg	3 Months Average
China CPI	Headline Consumer Price Index China	Bloomberg	3 Months Average
Euro CPI	Headline Consumer Price Index Euro	Bloomberg	3 Months Average

Botswana GDP	Total Real Domestic Product Botswana	Statistics Botswana	Quarterly
Botswana Mining GDP	Real Output Value Mining Sector Botswana	Statistics Botswana	Quarterly
South Africa GDP	Real Domestic Product South Africa	Bloomberg	Quarterly
Japan GDP	Real Domestic Product Japan	Bloomberg	Quarterly
United Kingdom GDP	Real Domestic Product UK	Bloomberg	Quarterly
United States GDP	Real Domestic Product US	Bloomberg	Quarterly
China GDP	Real Domestic Product China	Bloomberg	Quarterly
Euro GDP	Real Domestic Product Euro	Bloomberg	Quarterly

Case 1: Calibration of the Fixed Exchange Rate and an Implicit Inflation Targeting Monetary Policy Regime model

The model comprises two categories of parameters, these are; (i) parameters for targets of nominal variables and steady states for long- run trends of real variables; (ii) coefficients of behavioral equations and dynamics of long-run trends of real variables. Targets of nominal variables are chosen by the authorities, and in this model, there are two nominal targets; the nominal exchange rate target and the inflation target. We assume the nominal exchange rate target takes precedence over the inflation target, and as such, the target for inflation is implied by the relative purchasing power parity principle (equation 1.3.3). The steady states for long-run trends of real variables on the other hand, are simply based on historical averages. Figure 1.2 below shows the nominal targets and steady states of key variables in this model.

Figure 1.2: Nominal Targets and Steady State of Real Variables (Percentage change)



With regard to coefficients of behavioral equations, calibration of this category of parameters is based on a number of tools, which include, economic principle, empirical evidence, stylized facts, autoregressive models (to assess persistence in the economy) and structural VARs. Table 1.2 summaries the calibration procedures used to determine the coefficients of our four main behavioral equations. Meanwhile, coefficients of long-run trends of real variables are calibrated to match actual observed trends (derived from the Hodrick-Prescott filter) as well as to ensure smoothness. Calibrated parameters of trends of real variables are presented in appendix C.

Table 1.2: Calibration of Behavioral Equation Parameters

Parameter	Calibration Procedure	Calibrated Value	Calibrated Values in Literature[1]
Aggregate Demand Equation (Output gap)			
a_1	**Output gap persistence**; range between (0,1) in principle (linear homogeneity condition). A regression of log of output gap on its lagged value was used to calibrate this parameter, with judgement based on empirical evidence and stylized facts.	0.6	Angola 0.65 Ghana 0.4 Kenya 0.6 WAEMU 0.9 Average 0.64
a_2	**Real interest rates and exchange rate gaps (real monetary conditions) in the output gap equation;** The linear homogeneity condition (0.1, 0.9). Calibration based on impulse-response function in a structural VAR, and judgement.	0.3 real interest rate gap 0.2 real exchange rate gap	Angola 0.1, 0.05 Ghana 0.08, 0.02 Kenya 0.09, 0.01 WAEMU 0.06, 0.04 Average 0.08,0.03
a_3	**Impact of foreign demand and diamond prices on the output gap;** Calibration based on the ratio of export-to-GDP.	0.35	Angola 0.05 Ghana 0.1 Kenya 0.2 WAEMU 0.3 Average 0.2
New Keynesian Phillips Curve (Inflation Equation)			
b_1	**Inflation persistence:** The linear homogeneity condition (0,1). Calibration based on a regression of inflation (quarter-on-quarter) on its lagged value, with judgement.	0.4	Angola 0.55 Ghana 0.7 Kenya 0.55 WAEMU 0.8 Average 0.65

$b_2 * b_{21}$	**Pass-through from output gap to inflation (marginal cost of domestic producers)**. Calibration involved running a regression of inflation on output gap, with judgement.	0.1	Angola 0.2 Ghana 0.28 Kenya 0.1 WAEMU 0.12 Average 0.18
$b_2 * (1 - b_{21})$	**Pass-through from imported inflation to domestic inflation (real exchange rate gap).** The parameter is calibrated by running a regression of inflation on the real exchange rate gap, complemented with an assessment of the share of imported inflation in Botswana's CPI basket.	0.25	Angola 0.15 Ghana 0.12 Kenya 0.1 WAEMU 0.08 Average 0.11
Nominal Exchange Rate Equation (UIP)			
g_1	**Speed of exchange rate adjustment to target**. Parameter value ranges between (0,1). Calibration based on the degree of rigidity of the nominal exchange rate of the Pula against trading partner currencies.	0.75	Angola N/A Ghana N/A Kenya N/A WAEMU 0.5 Average 0.5
Monetary Policy Response Function (Taylor Rule)			
h_1	**Policy rate persistence in the Taylor rule**. The linear homogeneity condition (0, 1). The parameter is calibrated by running a regression of the policy rate on its lagged value, with judgement.	0.5	Angola N/A Ghana 0.75 Kenya 0.8 WAEMU 0.2 Average 0.58
h_2	**UIP in the Taylor rule** Parameter value ranges between (0,1). Calibration based on the availability of	0.1	Angola N/A Ghana N/A

	exchange rate stabilizing instruments (e.g. foreign exchange reserves in the case of Botswana).		Kenya 0.25 WAEMU 0.4 Average 0.32
m_1	**Weight put by the policy maker on deviations of inflation from the target in the policy rule**. The linear homogeneity condition, $m_2 > 0$ (Taylor principle). Calibrated by running a regression of inflation on the policy rate, with judgement.	1	Angola N/A Ghana 1.3 Kenya 1.4 WAEMU 0.2 Average 0.97
m_2	**Weight put by the policy maker on output gap in the policy rule**. The linear homogeneity condition $m_3 > 0$. Calibrated by running a regression of the output gap on the policy rate, with judgement.	0.5	Angola N/A Ghana 0.1 Kenya 0 WAEMU 0.2 AVR 0.15
$lambda^2$	Output gap	0.5	N/A
$lambda$	Real Exchange Rate Gap	0.45	N/A
$lambda$	Real Interest Rate Gap	0.5	N/A (Not available)

Note *1: The table also provides calibrated parameters found in RDE studies and developing countries which share similar economic attributes observed across RDEs. The countries covered are Angola, Ghana, Kenya, West African Economic and Monetary Union (WAEMU) and their respective parameter average* (Zedginidze, et al., 2024; De Resende, et al., 2020; Abradu-Otoo, et al., 2022; Andrle, et al., 2013).

2 Values of lambda are discretionary, and largely based on the aim to obtain smooth trends (Berg, et al., 2006).

Case 2: Calibration of the Floating exchange rate and a fully-fledged inflation targeting monetary policy regime model

Parameter values in this model are closely similar to those presented in case 1 above. There are only three differences in particular, that is; (i) the central bank explicitly chooses the target for inflation under this framework, which we have set at 3.35 (the same as in case 1). The nominal exchange rate equilibrium implied by the relative purchasing power parity rule is therefore zero, holding other variables in the PPP rule unchanged from case 1. (ii) We drop the nominal exchange rate target in the modified UIP and its associated parameter (g_1). (iii) The policy rate no longer responds to exchange rate movements. Thus, parameter h_2 and the modified UIP are dropped from the Taylor rule. We have deliberately kept parameters values in these two canonical models almost the same. This is to ensure that, variations in the impulse response functions from these two models (which are discussed below) are mainly accounted for by the differences in the policy design under the two frameworks, rather than parameterization.

4.4 Solving the Model

There exist a number of software packages that automatically solves these structural models, this include, Troll, Dynare and IRIS (used in this study). The process, which is largely based on the so-called Blanchard and Kahn (1980) approach, involves the following steps. First, we find the model's steady-state solution by substituting all the lags and leads of each endogenous variables in the model with current period values, and then solving these transformed system of equations (Berg, et al., 2006). A unique solution is established if and only if, all the gaps in the model are closed, all the nominal variables are on their targets and all real variables converge to their exogenously determined steady-states (Berg, et al., 2006).

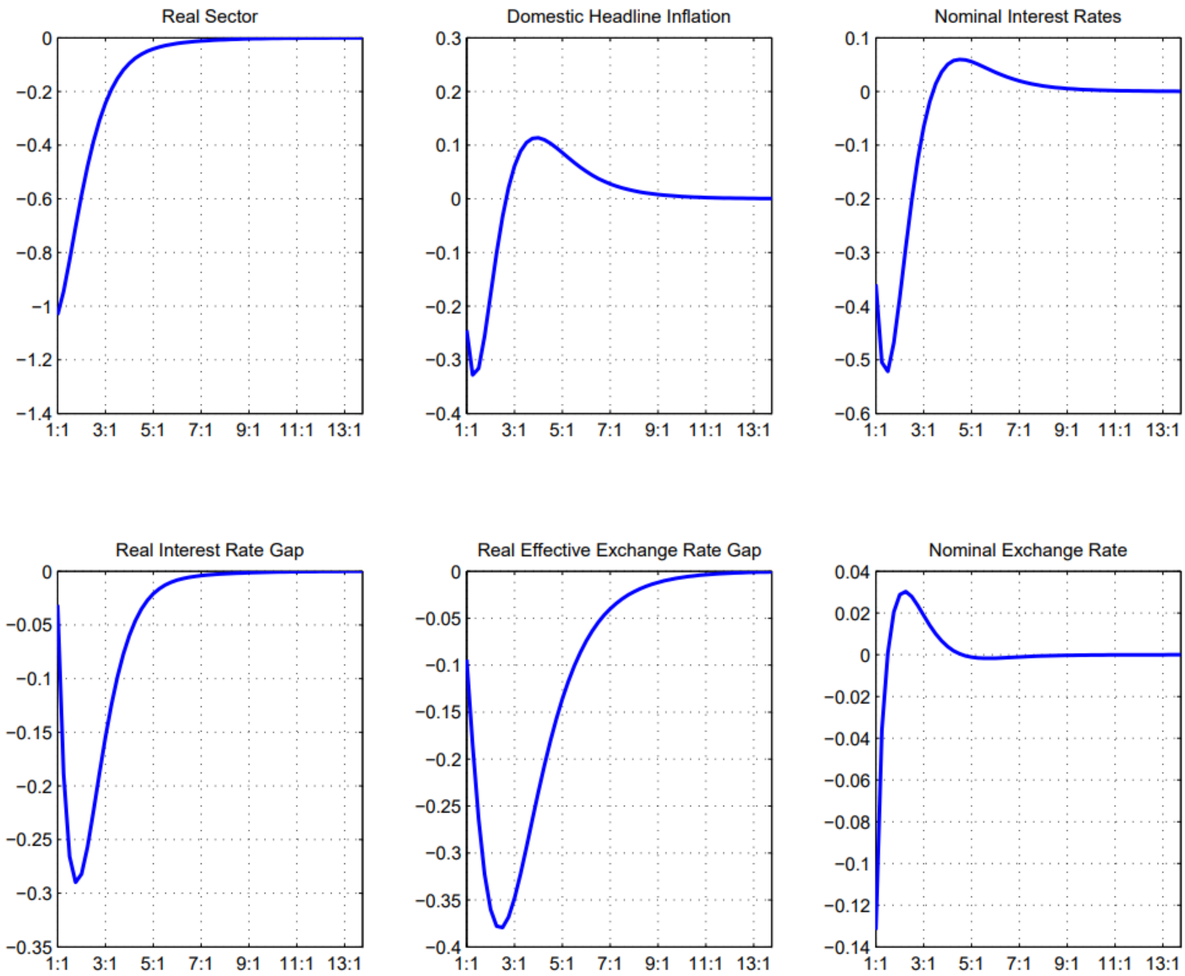
Secondly, a two-point boundary approach is used to trace the dynamic properties of these models (Berg, et al., 2006). With this approach, we assess the effects of an exogenous shock on the model by setting a two-end point condition which the model solution should satisfy. Thus, we assume that, the model start-off at some long-run equilibrium state (before the shock is instituted) and end up at the same equilibrium state, at a future period, after the effects of the shock has fully dissipated (Berg, et al., 2006). For a given set of parameter values, the model solution is the path of endogenous variables that meet these two-end point condition (Berg, et al., 2006). The same technique is also used to derive the model's impulse response functions.

4.5 Impulse Response Functions (IRFs)

IRFs serve as a useful diagnostic tool for understanding the dynamic properties of these models. To derive the IRFs, all the shocks in the model are set at zero, except for the shock whose impact on the model we want to trace. After the specific shock of interest is instituted, the model is solved in a two-point boundary approach described above (Berg, et al., 2006). We derive IRFs for the two canonical models presented in this section to study their distinct behavior and the general policy transmission mechanism under each case. Two exogenous shocks are considered, that is, aggregate demand shock and the nominal exchange rate shock.

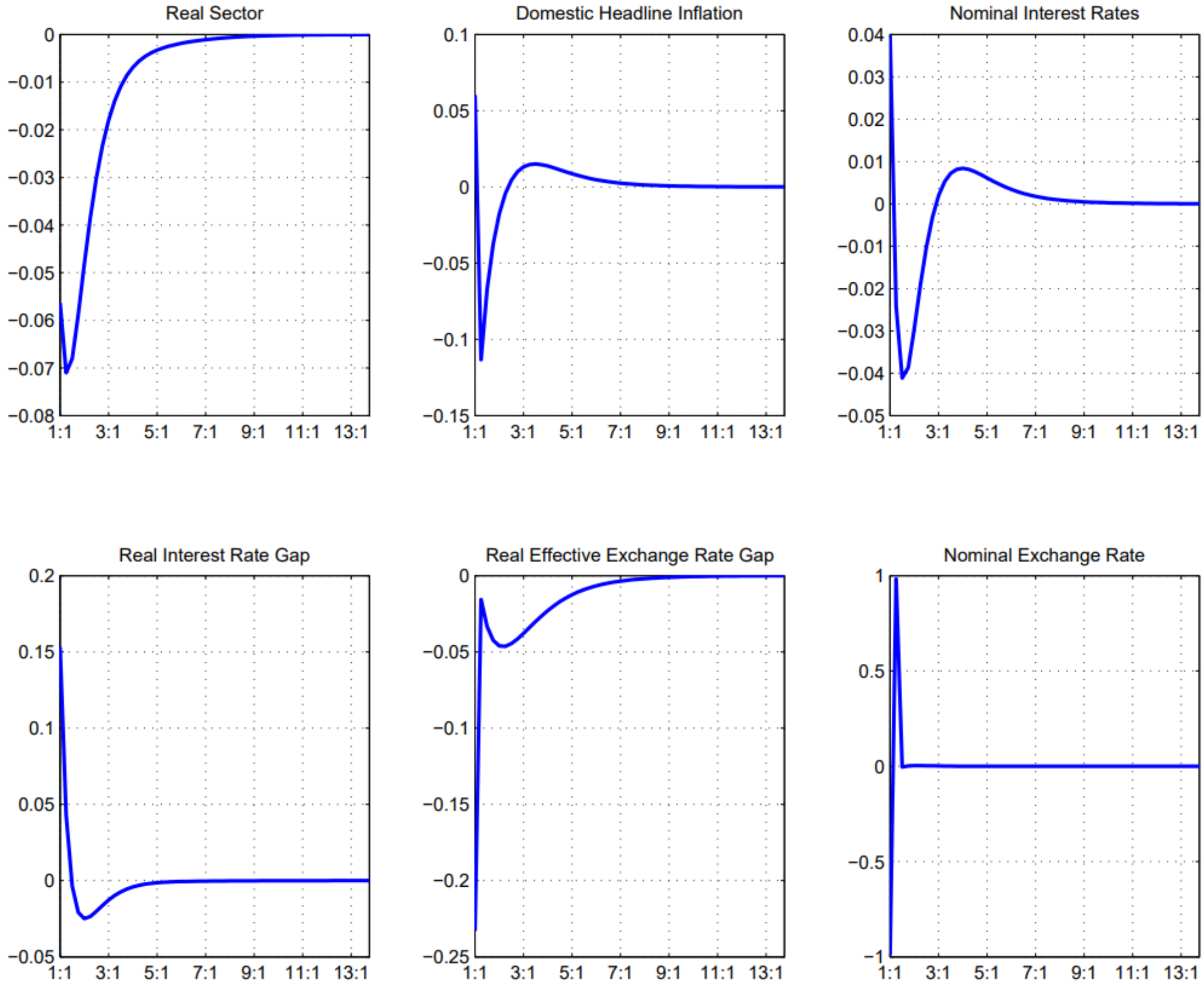
Case 1: IRFs from the Fixed Exchange Rate and an Implicit Inflation Targeting Monetary Policy Regime Model

Figure 1.3: Aggregate Demand Shock



A negative 1 percent shock to aggregated demand (output gap), leads to a fall in headline inflation below its target. The monetary authority responds to the fall in both aggregate demand and inflation by cutting the nominal interest rates, and the real interest rate gap becomes loose (negative). Meanwhile, the nominal exchange rate takes a knock and depreciates slightly, on account of the fall in the nominal interest rates. The real exchange rate also depreciates, and the combined impact of the negative real interest rate and real exchange rate gaps (accommodative real monetary conditions) drives the economy back to equilibrium. Nonetheless, equilibrium takes quite some time to be restored under this policy framework.

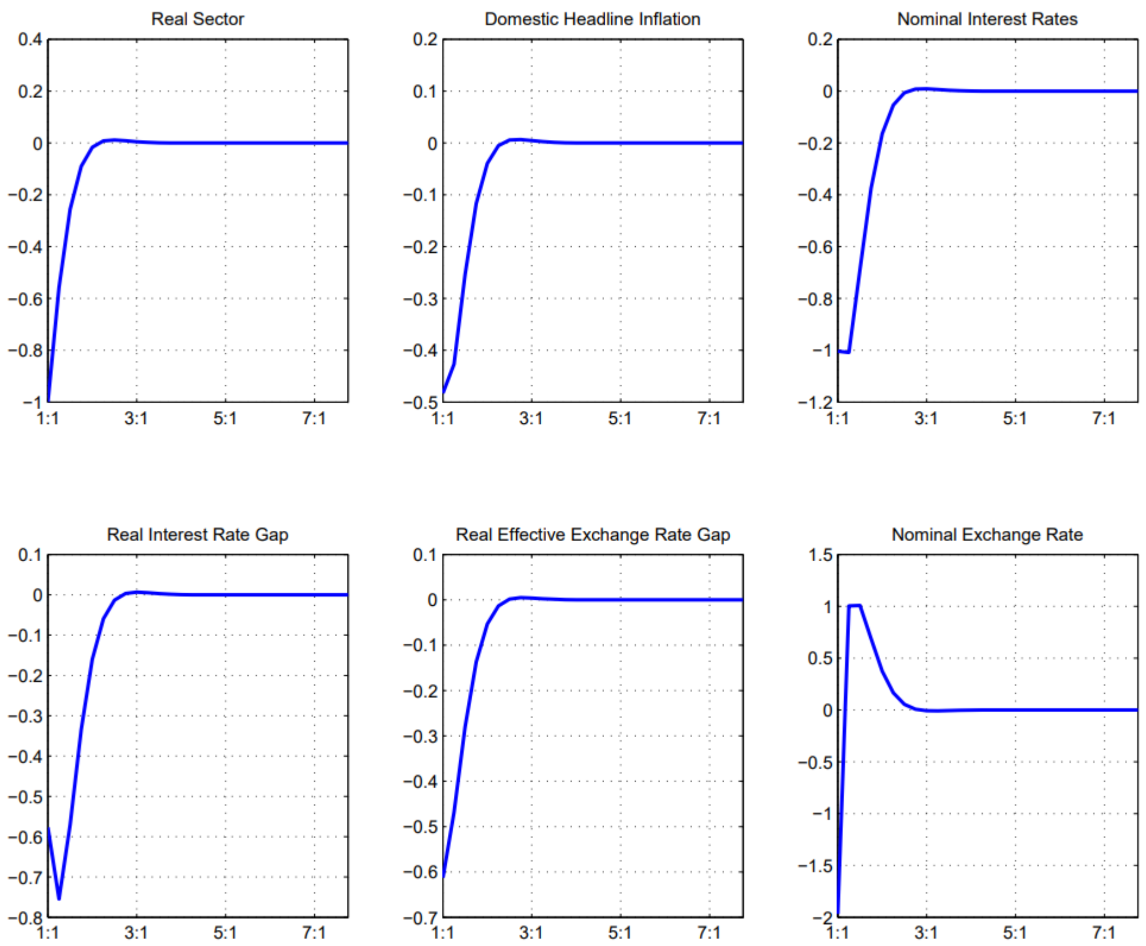
Figure 1.4: Exchange Rate Shock



A negative shock to the nominal exchange rate triggers an increase in the policy rate. The policy rate rises primarily for two reasons. First, to defend the stability of the exchange rate, an objective which is achieved in the next immediate year after the shock. The speed of adjustment of the exchange rate to its target main reflects our model calibration, wherein, the parameter of the speed of exchange rate adjustment in the modified UIP, is assigned a relatively high value of 0.75. The second reason for the rise in policy rate is to stir inflation back to target, which rose above target from the initial exchange rate depreciation shock. The increase in the policy rate leads to a positive real interest rate gap, and given our calibration of the real monetary conditions (a higher weight is given to real interest rate gap), real monetary conditions will become restrictive, and hence dampen aggregate output. The fall in aggregate output will exert downward inflationary pressure necessary to stir inflation to target and the general economy back to equilibrium.

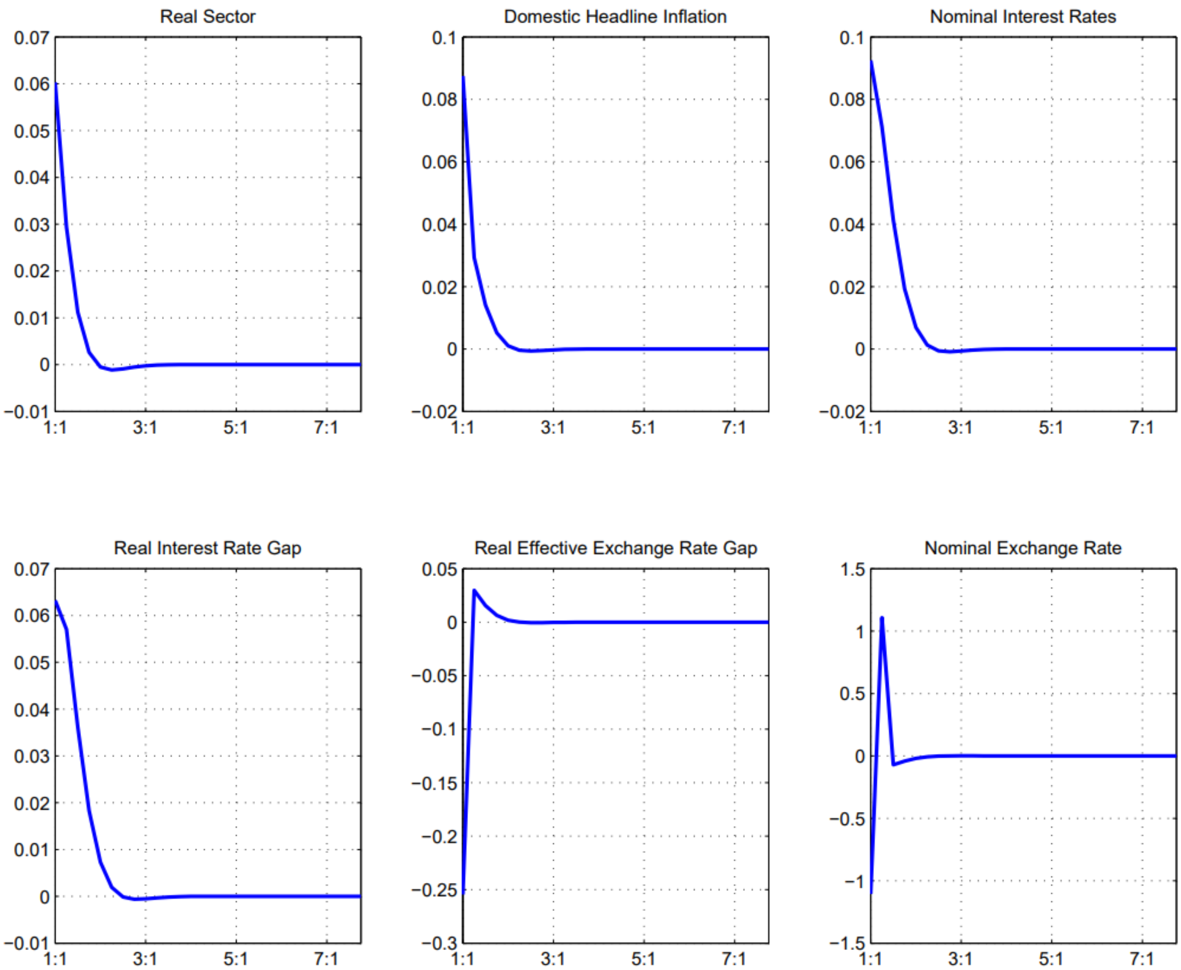
Case 2: IRFs from the Floating Exchange Rate and a Fully-Fledged Inflation Targeting Monetary Policy Regime Model

Figure 1.5: Aggregate Demand Shock



The transmission of the aggregate demand shock under this policy framework is similar to the one presented in the counterpart framework above. However, the trajectory and speed of convergence to equilibrium is quite different between the two frameworks. In particular, economic variables in this framework follow a smooth path (characterized by benign volatility) to equilibrium, and the speed of convergence of the economy to nominal targets and steady states is fairly high. This is mainly because movements in the nominal exchange rate are unrestrained under this framework. For example, the nominal exchange rate depreciation, from a negative 1 percent shock in aggregate demand in this framework, is around 2 percent compared to only 0.12 percent under the fixed regime. Thus, under this regime, both the interest rate and exchange rate transmission channels are fully and perfectly functioning, without any policy-induced constraint. The combined force of these two channels therefore helps to restore equilibrium in the economy much quicker and with limited noise or volatility.

Figure 1.6: Exchange Rate Shock



The propagation of the exchange rate shock in this framework is similar to the one under the hybrid policy framework case above. There are two main fundamental differences nonetheless. First, the nominal exchange rate under this policy framework takes a relatively longer duration to revert back to its implied target or long-run equilibrium position, approximately 2 years.

This is because the monetary authority does not carry the burden of stabilizing the exchange under this regime, hence convergence of the nominal exchange rate to equilibrium takes a bit of time. The second difference relates to the impact of the shock on economic activity or the output gap. Thus, relative to the hybrid model, a depreciation shock under this model, leads to a small or marginal increase in the real interest rate gap, the impact of which (on the output gap) is outweighed by the depreciation in the real exchange rate gap. In other words, real monetary conditions become loose (on account of the accommodative real exchange rate gap) under this framework, leading to a rise in the economic activity. Therefore, to restore equilibrium in the system, the exchange rate gap must appreciate and overshoot its balanced position (become positive or overvalued), in order to slow economic activity and drive inflation to its target. This overvaluation in the real exchange rate is reflected by the positive spike in the second year of the IRF horizon.

Overall, the general observation from the IRFs of these two monetary policy frameworks is that, variables in the hybrid framework overshoot their targets and take quite some time to converge to equilibrium. This is mainly because there is only one transmission channel that restores equilibrium when the model is hit by a shock, which is the interest rate channel. However, in the case of a floating and a fully-fledged inflation-targeting regime, where both the interest rate and exchange rate move together to restore equilibrium, variables exhibit benign volatility and the speed of convergent to nominal targets and steady states is relatively high.

5. SUMMARY

In summary, this chapter covered all the background materials pertinent to the subject matter under investigation, that is; the motivation of the study, research questions, survey of the relevant stock of literature, and a detailed description of our analytical model. The upcoming chapter is therefore entirely circumscribed to developing a more detailed and richer version of the Core model, which will comprehensively capture the structure and fundamentals of the economy of Botswana. The model is then implemented to answer the research questions set-out in this study.

Chapter Two

'BOTSWANA WITHOUT ITS PRECIOUS STONES'

MACROECONOMIC IMPLICATIONS OF TRANSITIONING FROM A PEGGED TO A

FLOATING EXCHANGE RATE REGIME

1. INTRODUCTION

So far, the study has covered sufficient materials to form an inference on the general monetary and exchange rate policy design in resource-dependent economies (RDEs). Evidence abound to the effect that, monetary and exchange rate policy design in RDEs is centered predominantly on foreign exchange reserve holdings, accrued from commodity-export earnings. Macroeconomic stability in these countries is in turn, entrenched on this policy design, which is commonly a mix of a fixed exchange rate system and a quasi-inflation targeting framework. Case study evidence presented under section 3 of the preceding chapter shows that, this policy design performs generally well as an anchor of macroeconomic stability, as long as there are no substantial disruptions to the country's stock of foreign exchange reserves. Such disruption, which often emanates from intense and long-lasting external shocks, renders this policy design profoundly difficult to operate. In extreme cases, the disruptions may even precipitate transitions to alternative policy regimes, which are much more 'cheaper' to run[20]. Popular amongst these alternative regimes, is a flexible exchange rate system and a fully-fledged inflation targeting monetary policy framework.

In general, policy regime transitions under circumstances described above, are more often than not disorderly in nature and characterized by immense macroeconomic disturbances. This is attested to by the transition experience of a vast number of oil-dependent economies during the 2014-2016 commodity price shock, presented under section 3 of the preceding chapter. Nonetheless, not all exchange rate policy regime transitions of resource-rich economies assume a disorderly profile. Some of these countries (although rarely so) transition in an orderly fashion. These are countries which work towards establishing some, if not all, the necessary institutional and operational requirements for a durable flexible exchange rate regime, many

[20] Cheaper in the sense that, in principle, these alternative regimes can be operated with limited foreign exchange liquidity.

years before exiting the peg. The transition case of Chile between 1984 and 1999 is a good example in this regard. Meanwhile, there is a subset of resource-rich countries which have never in their lifetime faced compelling risks to transition to alternative regimes, nor confronted by circumstances pressing enough to impel them to even contemplate on the matter. Botswana is one such country.

However, in view of the perpetual recurrence of external shocks, as well as disruptive technological inventions in the global diamond market (invention of artificial diamonds for example), it is almost given that Botswana will exit the peg at some point in time, and most likely transition to a floating exchange rate regime. What remains uncertain at this point, is when and how. This chapter presents a number of counterfactual scenarios of how Botswana's transition profile would most likely look like under different set of exit conditions. To the extent that this prophesy (that Botswana will exit the peg at some point in time) is indeed plausible and probable, it becomes imperative therefore, for policymakers to be aware beforehand, of the macroeconomic outcomes that awaits them with each exit door they may consciously or otherwise choose to take. It is almost inconceivable that policymakers would manage to effectively and prudently handle any transition case in manner that will safeguard the country's macroeconomic stability, without preconception of the dynamics of such a transition. In other words, by undertaking these policy regime transition scenarios, these paper accords policymakers an opportunity to study how each transition is likely to play-out, and therefore, prepare and device measures necessary to preserve macroeconomic stability in the eventuality of any of the transitions materializing.

As already alluded in the previous chapter, the existing stock of literature on exchange rate policy regime transitions provides limited methodological guidance to analyze the transition cases of RDEs. First, there is a paucity of structural-model-based evidence on the policy regime transition of RDEs. Secondly, structural models in this strand of literature are entirely skewed towards policy evaluation after the fact. That is, for a large proportion of studies in this area, the cardinal motivation is to evaluate (after the actual regime transition) whether the right policy decision was taken, and most importantly, at the right time (Carvalho & Vilela, 2015; Bordo, et al., 2010; Bergvall, 2002; Eitrheim, et al., 2020). To bridge these gaps, this chapter makes few modifications to the semi-structural new Keynesian model for a small open economy presented under section 4 of chapter 1, to capture the specific features and dynamics of RDEs, represented by the economy of Botswana. The modifications, which are discussed in detail in section 3 of this chapter, are the noble contributions of our study in this field of research. The models are then applied in a forward-looking fashion, to analyze policy regime transition scenarios of interest.[21]

The rest of the chapter is organized as follows; Section 2 provides a brief description of the transition scenarios considered in this study and section 3 construct the baseline model and presents tools used to diagnose its performance.

[21] A forward-looking approach is perceived at least in the context of this study, to be the most relevant approach to take given that the overarching motive herein, is to assess the macroeconomic outlook prospects, for a country faced with the likelihood of a fundamental change in its policy frameworks. A backward-looking analysis, which is a common approach in the literature on this matter, would simply be illogical in our case.

2. TRANSITION SCENARIOS

There are three main exchange rate policy regime transition scenarios conducted in this study. In the first scenario, we assume Botswana transitions from its current peg regime to a flexible and a fully-fledged inflation targeting regime under immense market pressure, with very low levels of foreign exchange reserve holdings. The scenario assumes transition under a crisis-environment, more precisely. In the second scenario, the transition is assumed to occur under a crisis-free environment, with adequate level of foreign exchange reserves to manage immediate short term outcomes. The third scenario assumes a perfect and well-planned policy regime transition, preceded by establishment of most of the fundamental supportive elements of a durable flexible exchange rate and a fully-fledged inflation targeting regime. The projection profiles of key macroeconomic variables under each scenario are contrasted against the baseline projection. The baseline projection is simply the forecast profile of macroeconomic variables under the current policy regime pursued by Botswana; a crawling-peg exchange rate and an implicit inflation targeting monetary policy regime.

3. BASELINE MODEL CALIBRATION AND PROPERTIES

This section begins with a brief overview of the current exchange rate and monetary policy frameworks in the economy of Botswana, and their associated macroeconomic outcomes. The analysis forms a necessary prelude to the calibration of the baseline model. That is, parameterization of our baseline model is to a large extent informed by the observed historical evolution of economic developments presented herein.

The section is organized as follows; first, we provide a brief description of the two key policy frameworks of interest, focusing mainly on the overall objectives of each policy framework, intermediate targets and the money market operations involved in the central bank's implementation of the policies, under subsection 3.1. This is followed by a comprehensive analysis of how the economy has generally responded to these policies overtime. Subsection 3.2 presents the baseline model structure consistent with the analysis of stylized facts in subsection 3.1. Diagnostic tools on the properties of the baseline model are presented in subsection 3.3.

3.1 Botswana's Exchange Rate and Monetary Policy Frameworks and their Associated Macroeconomic Outcomes overtime (2000-2020)

Exchange Rate and Monetary Policy Frameworks

Botswana has maintained a peg to the South African rand and SDR currencies from as far back as the early 80's. Prior to 2005, the exchange rate policy had two main objectives; that is, controlling inflation and promoting competitiveness of domestic tradeable output (Bank of Botswana, 2007). During this period, the domestic currency underwent intermittent discrete adjustments (in the form of revaluations and devaluations) aimed at achieving either one of the two objectives. It had become obvious nonetheless, by the mid-2000's to the authorities that, maintaining a stable inflation environment while promoting competitiveness at the same time is almost impractical to achieve under this framework. Thus, in May 2005, the Government adopted a new exchange policy framework (the current crawling peg mechanism) in which the role of the exchange rate policy was limited to the sole mission of promoting competitiveness through maintenance of a stable real exchange rate (Bank of Botswana, 2007).

Under this framework, the nominal exchange rate of the pula against the weighted average of trading partner currencies[22] is periodically and gradually adjusted (hence the term 'crawling') to offset the forecast inflation differential between Botswana and trading partner countries. The formulation of this policy is based on the so-called 'law of one price' or the relative purchasing power parity principle; where the projected inflation differential (intermediate target),

[22] Interchanged with the term 'basket currencies' henceforth.

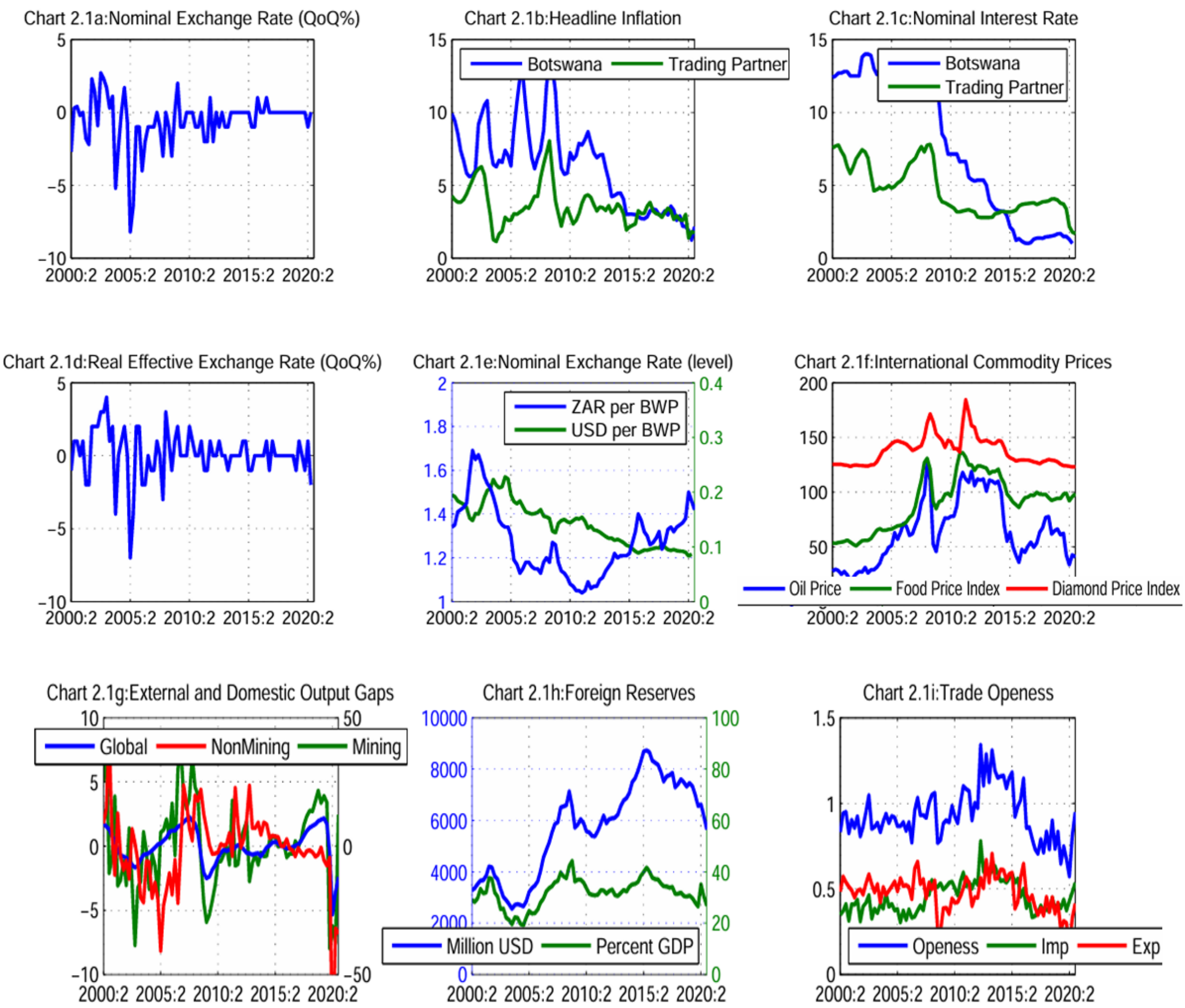
measures the magnitude of the misalignment in the real exchange, and the rate of crawl (policy instrument), is the magnitude of the adjustment in the nominal exchange rate required to correct for the real exchange rate misalignment. The authorities follow a two-step approach in implementing this policy. In the first step, the authorities set an annual rate of crawl at the beginning of the year (which is subject to mid-year reviews). Daily adjustments to the nominal value of the pula (determined by cross-rates of basket currencies) are then conducted such that, at the end of the year, the cumulative daily changes in the nominal exchange rate equal the annual rate of crawl (Bank of Botswana, 2007). The second step involves provision of liquidity or foreign currency required to facilitate trade in foreign exchange market at the policy-determined nominal rate of the pula vis-à-vis basket currencies. Such liquidity is sourced from the foreign exchange reserves, which as already emphasized, are accumulated predominantly through the sales of diamonds.

The exchange rate policy is complemented by a quasi-inflation-targeting monetary policy framework (Bank of Botswana, 2008). The framework seeks to achieve and maintain a medium term inflation within the range of 3 to 6 percent, through the use of short term interest rates, which are, the bank rate (benchmark rate) and the 7-day Bank of Botswana Certificate rates[23] (actual policy rate). A decision-making body of the central bank, called the Monetary Policy Committee (MPC), convenes bimonthly to decide on the direction and magnitude of the change in the policy rate consistent with stirring forecast inflation (intermediate target) towards the objective range. In principle nonetheless, precisely given the co-existence of the exchange rate and inflation targets, the short interest rates should ideally play a dual role of stabilizing the nominal exchange rate around the desired target and at the same time, stirring inflation towards the objective range (Fischer, 2001). This phenomenon is however not playing-out in the

[23] The 7-day Bank of Botswana Certificates are used in open market operations (Bank of Botswana, 2020)

economy of Botswana, short term interest rates are largely used to control inflation, and the exchange rate is managed through the use of foreign exchange reserves (Bank of Botswana, 2008). These features of the exchange rate and monetary policy operations will become much clearer in the following descriptive analysis on Botswana's macroeconomic developments overtime.

Figure 2.1: Analysis of Botswana's Macroeconomic Developments Overtime (2000-2020)



Source: Botswana Financial Statistics and Bloomberg

Business Cycles (Gaps) – Author's own computations

Important Note: Upward exchange rate movements reflect appreciation of the pula against trading partner currencies and downward movements are depreciations. This is consistent with the Bank of Botswana's measurement of the exchange rate.

Botswana's macroeconomic policy environment and its associated outcomes in the past 20 years can be best described by three transition phases, which for simplicity, we shall classify as Phase I, II and III. Phase I is the period before 2005, a period characterized by erratic and uncoordinated conduct of the exchange rate and monetary policy. During this period, the intermittent and discretionary adjustments in the nominal exchange rate (Chart 2.1a) led to a lot of noise or volatility across a number of key macroeconomic fundamentals, notably, inflation (Chart 2.1b) and the real exchange rate (Chart 2.1d). The pass-through of the exchange rate to the real sector was however moderate during this period. That is, the fluctuations in both the nominal and real exchange rate did not have any perceivable impact on the composition and volume of trade (Chart 2.1i). The level of imports and exports remained relatively steady between 2000 and 2005. Meanwhile, given the exorbitantly high and unstable inflation at the time, nominal interest rates were kept very high (Chart 2.1c). Global demand was also subdued during this phase, which led to a fall in mining output or diamond exports more precisely (Chart 2.1g). The combined impact of high interest rates and low mining output, suppressed economic activity in the non-mining sector (Chart 2.1g).[24]

Phase II covers the period from 2005 until the 2008-09 global financial crisis. This is a period of order and coordination in the conduct of both the exchange rate and monetary policy. Volatility in the nominal and real exchange rate began to subside during this period, following adoption of the new exchange rate policy framework, the crawling peg regime. Domestic inflation however, remained unstable and very high on account of the persistent rise in international commodity prices between 2005 and 2009 (Chart 2.1f) and to some extent, the depreciation of the bilateral nominal exchange rate of the pula, particularly against the South African rand[25] (Chart 2.1e). The high domestic inflation implied an overvaluation of the pula (appreciation of the real exchange rate). To counteract this overvaluation, the authorities, consistent with the guidelines of the new exchange rate policy framework, pursued a gradual

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24 Economic activity in the non-mining sector is to a considerable degree, driven by the performance of the mining sector. This is mainly due to the significant role played by the Government of Botswana in the broader economy, through diamond revenues; which constitute about 30 percent of the total government budget (Ministry of Finance & Economic Development, 2021).

25 South Africa is Botswana's major trading partner. Over 5 billion USD worth of South African imports flow into the economy of Botswana on annual basis, and this constitute over 50 percent of Botswana's total imports (Statistics Botswana, 2020). Thus, a weaker pula against the rand, inherently leads to a rise in both imported and headline inflation.

but relatively steep path of downward annual rates of crawl, for about four consecutive years (Chart 2.1a).

The overvaluation moderated towards the end of 2010 as international commodity prices declined sharply and domestic inflation began to trend downwards. The magnitude of the downward rates of crawl was thus reduced substantially and kept very close to zero thereafter. The nominal interest rates also began to fall, consistent with the relatively low domestic inflation environment (Chart 2.1c). Meanwhile, developments in the real sector were predominantly driven by external developments during this phase, precisely the 2003-2008 global commodity price boom (led by the rapid urbanisation and industrialisation in the Chinese economy). Mining output (diamond exports) increased substantially in this period, and domestic economic activity (i.e., non-mining sector) expanded rapidly until the outbreak of the global financial crisis in 2008 (Chart 2.1g; *right hand side scale plots mining output*). The country's stock of foreign exchange reserves also increased markedly between 2003 and 2008, on account of the rise in diamond exports earnings (Chart 2.1h).

Phase III runs from 2010 to 2020. This is the period between the two major global crises, the 2008-09 global financial crisis and the outbreak of the COVID-19 pandemic in 2019. This phase is characterized by a widespread convergence of key macroeconomic variables in the economy of Botswana. Domestic inflation converged to the weighted average of the inflation target of trading partner countries in 2016, and annual adjustments in the rate of crawl were kept close to zero as the real exchange rate remained fairly stable from thereon. The fall in domestic inflation was largely driven by the persistent appreciation in the bilateral exchange rate of the pula against the South African rand, especially after the global financial crisis (Chart 2.1e), as well as the sharp decline in international oil prices during the 2014 – 2016 global commodity price shock (Chart 2.1f). The nominal interest rates were therefore kept very low in response to the low inflation environment and the muted developments in the real sector.

Both the mining and non-mining output gaps were closed for a larger part of this phase, as external demand remained relatively mild (Chart 2.1g). The stock of foreign exchange reserves on the other hand, began to fall sharply between 2015 and 2020, following the 2014 - 2016 commodity price burst[26] and the subsequent outbreak of the COVID-19 pandemic in 2019 (Chart 2.1h).

In summary, the following key takeaways are in order. First, the economy of Botswana experienced three major structural changes in the past 20 years, which we have labeled, *Transition Phase I, II and III.* Secondly, the current exchange rate and monetary policy regime in Botswana, which has brought about macroeconomic convergence in the past decade, is heavily premised on the country's foreign exchange reserve holdings. This is largely demonstrated by the high degree of independence enjoyed by Bank of Botswana in its monetary policy formulation. The analysis shows that, Bank of Botswana sets the path of its nominal interest rates independently from the movements in the interest rates of trading partner countries, a phenomenon that is in complete defiance of the trilemma.[27] Bank of Botswana is able to defy this principle largely on account of the country's substantial stock of foreign exchange reserve holdings, part of which is utilized as an exchange rate stabilizing instrument[28].

Nonetheless, Botswana's foreign exchange reserves have been persistently falling with each external shock that ensued in the past 5 years; i.e. the 2014-2016 commodity price burst and most recently, the COVID-19 pandemic. This persistent fall in foreign exchange reserves indicates that, Botswana has been heavily drawing down on its reserves without sufficient

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26 Diamond prices fell during this period, but not as deeply as oil prices.

27 According to the principle of trilemma, under a fixed exchange rate regime, the central bank should maintain interest rate parity with trading partner countries, to keep the exchange rate on the desired target (Fischer, 2001).

28 Foreign portfolio investment as a proportion of GDP is also generally quite low in the economy of Botswana, at 0.3 percent (World Bank, 2022). So broadly, the economy does no attract substantial volume of capital inflow that could potentially undermine exchange rate stability.

replenishment. In view of these developments, it is without doubt that any intense and long-lasting external shock that may ensue from now on, will further dampen Botswana's stock of foreign exchange reserves. In fact, it is highly probably that the reserves may fall and reach a point where it would no longer be feasible for the country to continue operating its current exchange rate and monetary policy regime effectively.

If policymakers are willing to acknowledge this risk, then it becomes pertinent at this time for the country to consider the prospects of transition to alternative policy regimes. A policy regime transition, will undoubtedly bring about substantive changes to the economy yet again, a new *Transition Phase IV* in essence. Using the knowledge we have gained thus far on the basic features of the economy of Botswana, the following sections employ a semi-structural New Keynesian model for a small open economy to simulate how macroeconomic fundamentals are likely to evolve in the short to medium term, under this envisioned transition Phase IV. The simulations assume different exit conditions which pertain mainly to the country's level of foreign exchange reserves holdings and its state of preparedness for the alternative choice.

3.2 Baseline Model Structure

This section outlines the calibration process of the baseline model, and presents its performance evaluation analysis. The baseline model captures the transmission mechanism under the current exchange rate and monetary policy regime pursued by Bank of Botswana. The model is used to produce baseline or benchmark forecasts against which the projections from the three transition scenarios are contrasted. The structure of the model is closely similar to the canonical model structure under the hybrid regime, which is presented in subsection 4.2 of chapter one. The baseline model comprises the four main behavioral equations of the New Keynesian model for a small open economy or the Core model, namely; the *aggregate demand equation, Phillips curve, UIP and the Taylor rule*. The equations are modified nonetheless, to reflect stylized facts discussed in subsection 3.1 above. The following discussions describe these modifications and their underlying motivations, for each of the four behavioral equation of the model.

Aggregate Demand Equation (IS Curve)

A common practice when measuring aggregate demand in a resource-dependent economy is to remove the resource–output component (mining output in this case) from total output (Vlcek, et al., 2020; Andrle, et al., 2013). Non-mining output (which is total GDP less mining output), is therefore the most appropriate measurement of domestic economic activity or aggregate demand, in the case of Botswana. With this measurement, we are able to avoid excessive volatility emanating from mining output (Chart 2.1g) in modelling aggregate demand. Moreover, this measurement of domestic aggregate demand captures the actual component of total output amenable to exchange rate and monetary policy actions, which is the non-mining output.[29] Under this definition of aggregate demand, the influence of the performance of the diamond exports on the non-mining sector (through government spending, for example), is

[29] Mining output (which is predominantly diamond mining) is almost entirely driven by global demand (Chart 2.1g).

implicitly captured by the foreign demand variable in the IS curve (Andrle, et al., 2013). We present below, the IS curve with the above modifications.

$$\hat{y}_{D,t} = a_1 \hat{y}_{D,t-1} + (1 - a_1)\hat{y}_{D,t+1} - a_2 mps_t + a_3(\hat{y}_t^f + \widehat{dim}_t^{price}) + \varepsilon_t^{yD} \tag{2.1}$$

Where: $\hat{y}_{D,t}$ is the non-mining output gap, other variables are as defined in chapter one.

The same calibration approach adopted under the canonical model in chapter one is followed to assign parameter values for all the behavioral equations in this chapter. Thus, parameterization follows an eclectic approach, informed by announced policy targets, historical averages, regression model estimates, economic intuition and extant empirical evidence, among other things. Accordingly, parameter a_1 is assigned the value 0.6, based on a regression of log of output gap on its lagged value, and empirical evidence. The parameter ranges between 0.4 and 0.7 in developing countries on average (Andrle, et al., 2013; Amarasekara, et al., 2018; Vlcek, et al., 2020). Given the relatively mild pass-through of monetary and exchange rate policy actions to the real sector, highlighted in subsection 3.1, parameter a_2 is assigned the value 0.2, and the composite variables of the real monetary condition index (MPS) i.e., the real interest rate and exchange rate gaps, share the same weight. In general, the parameter for the RMCI assumes a relatively small value in developing economies, mainly on account of the weak policy transmission channels in these countries (Berg, et al., 2006; Andrle, et al., 2013; Vlcek, et al., 2020). Calibration of the foreign demand variable is based on the ratio of export-to-GDP, which is estimated at 0.35. However, given that the variable in the context of Botswana's IS curve, captures the indirect influence of external developments on the non-mining sector (through diamond exports), the valued is lowered slightly, to 0.25.

Domestic Aggregate Supply Equation (New Keynesian Philips Curve)

The analysis in subsection 3.1 reveals a number of factors which are critical to consider in constructing a Philips curve that embodies a fair share of the special features and dynamics of the economy of Botswana. First, chart 2.1i shows that, Botswana is widely open to external trade, both on the export and import side. Imports, which constitute an important component of the Phillips curve, are almost half the entire size of the economy by value. Secondly, the country's headline inflation is positively and highly correlated with movements in foreign inflation and international commodity prices. Another important aspect stemming from the analysis, pertains to the role of the exchange rate in explaining movements in headline inflation. Chart 2.1b and1e shows a considerable negative correlation between Botswana's headline inflation and the nominal exchange rate, precisely the rand/pula exchange rate.

With these features, a reasonable conjecture can be made that, Botswana is a net importer of most of its consumer goods and services, and as such, relative prices of imported commodities become crucial to incorporate in the Phillips curve (Andrle, et al., 2013; Vlcek, et al., 2020). For this reason, we decompose headline inflation into three components, which are; oil inflation, food inflation and core inflation (measured as headline inflation excluding oil and food inflation). Each of these components is modelled with its own separate Philips curve, capturing the movements in relative prices and other explanatory variables specific to the component. This disaggregation of the Phillips curve also serves to isolate components of headline inflation predominantly driven by supply side factors (oil and food inflation) from those driven by demand factors (core inflation). It is quite important to set-out this distinction because in principle, it is primarily the demand-driven component of headline inflation which monetary policy actions target or seek to influence (Berg, et al., 2006; Andrle, et al., 2013).

The evolution of supply-side driven components is generally of limited policy concern, but important to track nonetheless[30]. Below are the three Phillips curves outlined above.

Oil Inflation

$$\pi_t^{oil} = b_{11}\pi_{t-1}^{oil} + b_{12}\left(\pi_t^{worldoil} - \Delta S_t + \Delta z_t^{oil}\right) + (1 - b_{11} - b_{12})\, E\left(\pi_{t+n}^{oil}\right) + b_{13} rmc_t^{oil} + \varepsilon_t^{\pi oil} \qquad (2.2.1)$$

Where: b_{11}, b_{21} and b_{31}, are calibrated parameters, π_t^{oil} is oil inflation, rmc_t^{oil} is the real marginal costs for retailers of oil products, $\left(\pi_t^{worldoil} - \Delta S_t + \Delta\overline{z_t^{oil}}\right)$ is the relative oil price inflation, which captures the difference between world price inflation of oil in local currency $\left(\pi_t^{worldoil} - \Delta S_t\right)$ and the domestic oil price inflation (π_t^{oil}) , adjusted by the temporary deviations between the two ($\Delta\overline{z_t^{oil}}$) and $\varepsilon_t^{\pi oil}$ is the oil inflation shock.

Food Inflation

$$\pi_t^{food} = b_{21}\pi_{t-1}^{food} + b_{22}\left(\pi_t^{worldfood} - \Delta S_t + \Delta z_t^{food}\right) + (1 - b_{21} - b_{22})\, E\left(\pi_{t+n}^{food}\right) + b_{23} rmc_t^{food} + \varepsilon_t^{\pi food} \qquad (2.2.2)$$

Where: b_{21}, b_{22} and b_{23}, are calibrated parameters, π_t^{food} is food inflation, rmc_t^{food} is the real marginal costs for retailers/producers of food products, $\left(\pi_t^{worldfood} - \Delta S_t + \Delta\overline{z_t^{food}}\right)$ is the relative food price inflation and $\varepsilon_t^{\pi food}$ is the food inflation shock.

Core Inflation

$$\pi_t^{core} = b_{31}\pi_{t-1}^{core} + b_{32}\left(\pi_t^{f} - \Delta S_t + \Delta z_t^{core}\right) + (1 - b_{31} - b_{32})\, E(\pi_{t+n}^{core}) + b_{33} rmc_t^{core} + \varepsilon_t^{\pi core} \qquad (2.2.3)$$

Where: b_{31}, b_{32} and b_{33}, are calibrated parameters, π_t^{core} is core inflation, rmc_t^{core} is the real marginal costs for retailers/producers of all CPI basket commodities excluding oil and food products , $\left(\pi_t^{f} - \Delta S_t + \Delta\overline{z_t^{core}}\right)$ is the relative prices of core inflation, which captures the difference between foreign inflation in local currency and

30 Policymakers are largely concerned about the spill-over effects of these supply-drive components on core inflation (Wynne, 1999).

domestic core inflation, adjusted by the temporary deviations between the two and $\varepsilon_t^{\pi core}$ is the core inflation shock.

Headline Inflation

Headline inflation is simply the weighted average of these three inflation components, and the weights of the components are taken as given in Botswana's CPI basket. Thus, oil inflation has a weight of 0.1003, food inflation 0.1355 and core inflation 0.7642 (Statistics Botswana, 2020).

$$\pi_t = w_{oil}\pi_t^{oil} + w_{food}\pi_t^{food} + (1 - w_{oil} - w_{food})\pi_t^{core} + \varepsilon_t^{\pi} \quad (2.2.4)$$

Where: w_{oil} , w_{food} and $(1 - w_{oil} - w_{food})$ are the weights for oil, food and core inflation, respectively.

Based on the Bayesian vector error correction model (BVECM) estimates of the long-run relationship of domestic oil and food prices against their corresponding world prices in domestic currency (world oil and food prices), as well as a simple bivariate OLS estimate of imported foreign inflation on domestic core inflation, parameter values b_{12}, b_{22}, b_{32} are assigned the values 0.25, 0.2 and 0.15, respectively. This approach is adopted from (Botha, et al., 2017; Abradu-Otoo, et al., 2022). With regard to inflation expectations, the analysis in subsection 3.1 shows that, Botswana's headline inflation converged and remained on target for a considerable period of time (over 5 years). By implication therefore, public expectations on price stability, are generally well-anchored. As such, parameters on expected inflation are assigned relative high values across all the three inflation equations. Oil inflation expectation parameter is assigned the value 0.3, food inflation expectation 0.35 and core inflation expectation 0.4. The parameters for these inflation expectations are in line with the values observed in other developing countries with similar macroeconomic attributes as the economy of Botswana (Botha, et al., 2017; Benes, et al., 2017; Abradu-Otoo, et al., 2022).

The parameter value on real marginal cost (RMC) under the oil inflation equation is assigned a relatively low value of 0.05. The rationale is that, Botswana imports all of its petroleum products, and therefore, inclusion of the relative price variable in the oil Philips curve (which largely serves as a measure of imported inflation), moderates the importance of RMC in the oil inflation equation. Moreover, oil prices in Botswana are regulated or administered by the government, which further undermines the importance of marginal costs faced by oil retailers, who are merely price takers under this price administration scheme.[31] Similarly, the share of the import component in food inflation is fairly large. Therefore, the parameter value on RMC under the food inflation equation also assumes a low value of 0.05, for reasons relating to the inclusion of the relative price variable. On the contrary, RMC under the core inflation equation is of high significance and importance, as it provides a critical link between monetary policy actions and the movements in the demand-driven component of headline inflation. As already alluded, it is this component of headline inflation (core inflation) which is of primary interest to policymakers. A regression model of RMC on core inflation yields an estimate of 0.25.

Overall, our Philips curves meet the fundamental equilibrium condition. That is, all the three components of headline inflation grow at the same rate in equilibrium. This condition ensures that headline inflation converges to its medium-term target set by policymakers. The condition is that, in equilibrium, $\pi_t^{oil} = \pi_t^{food} = \pi_t^{core} = \pi_t = \pi^{Tar}$.

Modified Uncovered Interest Rates Parity (UIP) Equation

The UIP equation presented herein, forms an integral part of this study. The equation is modified to reflect two important aspects relating to the subject matter under investigation in this study, that is; a currency crisis-induced policy regime transition. The first modification, which also happens to be the major contribution of this study in this field of research, deals with modelling public expectations or confidence on the domestic currency of a resource-

31 Pump prices of all petroleum products in Botswana's CPI basket are administered by a government regulatory body called Botswana Energy Regulatory Authority (BERA), (BERA, 2016). These petroleum products are petrol, diesel and paraffin, which together constitute what we call the oil inflation component of headline inflation.

dependent economy. The second modification captures our transition assumptions, precisely the level of financial market and institutional development assumed across the three transition models. Below is the UIP for the economy of Botswana and all the modification thereto.

$$S_t = g_1 S_t^{Tar} + (1 - g_1)\left(S_t^e + \left(i_t - i_t^f - prem_t\right)/4\right) + \varepsilon_t^s \qquad (2.3)$$

Where: g_1 is a calibrated parameter, S_t is log of the nominal exchange rate, S_t^{Tar} is the nominal exchange rate target, S_t^e is the nominal exchange rate expectation, i_t and i_t^f are domestic and foreign nominal interest rates respectively, $prem_t$ is the country's risk premium and ε_t^s is the exchange rate shock

Equation 2.3 is the modified UIP for the economy of Botswana.[32] According to this equation, the nominal exchange rate of the pula against trading partner currencies follows the policy desired path or target set by the central bank, public expectations and the differential between domestic and foreign nominal interest rates adjusted by the risk premium. Calibration of parameter g_1 largely depends on the degree of divergence of the nominal exchange rate from the policy desired path, as well as availability of exchange rate-stabilization instruments (foreign exchange reserves in this case). Chart 2.1a in subsection 3.1 shows that, the nominal exchange rate promptly follows the policy desired path, and the country holds sufficient stock of foreign reserves (chart 2.1h) to support the exchange rate, at least in the short to medium term, holding all other things constant. For these reasons, and consistent with literature, parameter g_1 is assigned a high value of 0.95 (Carvalho & Vilela, 2015; Andrle, et al., 2013; Vlcek, et al., 2020). What remains from here on, is to model public expectations (S_t^e) and the country's risk premium ($prem$).

[32] See Appendix F for derivation.

Public Expectations

Public expectations form a critical aspect of this study. By its very definition, a currency crisis (which is the primary focus of this study), arise from a sudden loss in public confidence on the stability of the domestic currency (Fischer, 2001; Dabrowski, 2016). This loss in public confidence leads to speculative attacks, substantial depreciation in the currency, and in the worst-case scenario, the collapse of the exchange rate peg (Dabrowski, 2016). Modelling public expectation formation is therefore of paramount importance, and literature provides a lot of guidance in this matter. There are about four generations of models developed after major currency crises across the world, which sought to explain the role of public expectations behind these crises. The first-generation models followed a series of currency crises between 1970 and the early 80 across Latin America countries, and are ascribed to (Flood & Garber, 1984; Krugman, 1979), among others. The second-generation models were developed by (Obstfeld, 1994; Drazen, 1999) following speculative attacks against a number of European currencies in 1992 and the Mexican peso in 1994. A third generation of models followed the Asian crises in the late 90s, and was developed by (McKinnon & Phil, 1996; Krugman, 1999; Corsetti, et al., 1999).

The fourth- generation model was developed by Dabrowski (2016), after the currency crises experienced by a number of oil-dependent economies during the 2014 - 2016 commodity price shock. Given the relevance of this model to the subject matter under investigation in this study, a considerable share of the innovations we make herein are therefore, to a large extent informed by the propositions of this model. According to the model, public trust will sustain the stability of the pegged exchange rate regime in a resource-dependent economy, in so far as, the country holds adequate stock of foreign exchange reserves and there are no intense shocks to the global commodity market. Any adverse external shock with considerable impact on the country's foreign exchange liquidity, may trigger speculative attacks on the domestic currency.

The model further asserts that, the threshold level of foreign exchange reserves below which speculative attacks are likely to ensue, depends largely on past experiences economic agents endured under similar episodes of currency crises. A phenomenon the model refers to as '*Ghost of the past'* (Dabrowski, 2016). According to the model, economic agents with very bad experiences of previous episodes of currency crises such as, loss of savings from hyperinflation, imposition of foreign exchange controls and other administrative restrictions on currency use; hold these bad memories for all their entire lives (Dabrowski, 2016). Thus, even a slight fall in foreign exchange reserves which happens to occur concurrently with a slowdown in commodity exports is enough to cause unnecessary panic and large-scale speculative attacks (Dabrowski, 2016). The general implication we draw is therefore that, the precise threshold or adequate level of foreign exchange reserves necessary to sustain a peg is ambiguous, and this chapter makes no attempt to estimate it.

Nevertheless, we make the following innovations to the public expectation equation of the UIP, in line with other propositions of the model. First, we modify the equation to reflect dynamics of a resources-dependent economy. Thus, contrary to conventional practice under this class of models, where UIP expectations are casually modelled as model-forecast consistent expectations (which is simply the forward iteration of equation 2.3 one period ahead) and adaptive expectations in some cases,[33] we infuse economic intuition to the equation. More precisely, public expectations in this paper, equation 2.3.1, entail both forward-looking expectations and the performance of the commodity export sector. The latter serves primarily as an indicator of the movements in the foreign exchange reserves balances, which in the case of Botswana as indicated before, are accrued predominantly from diamond exports. Secondly, we assume that agents have full knowledge of Bank of Botswana's foreign exchange intervention strategy, depicted by equation 2.3.2. Thus, equation 2.3.1 and 2.3.2 as well as the

33 (Berg, et al., 2006; Andrle, et al., 2013; Abradu-Otoo, et al., 2022; Pirozhkova, et al., 2023)

thought process behind their calibration (discussed below), forms the noble contribution of this study in this area of research.

$$S_t^e = g_2 E_t S_{t+1} + (1 - g_2)\hat{y}_{m,t} \qquad (2.3.1)$$

Where: g_2 is a calibrated parameter, $E_t S_{t+1}$ expected nominal exchange rate, one period ahead (model-consistent forecast), $\hat{y}_{m,t}$ is the mining output gap.

$$\hat{y}_{m,t} = g_3 \hat{y}_{m,t-1} + (1 - g_3)E(\hat{y}_{m,t+1}) + g_4(\hat{y}_t^f + \widehat{dim}_t^{price}) + \varepsilon_t^{ym} \qquad (2.3.2)$$

Where: g_3 and g_4 are calibrated parameters, $\hat{y}_t^f$ is foreign output gap, $\widehat{dim}_t^{price}$ is diamond price gap and ε_t^{ym} is the mining output shock.

And furthermore,

$$E_t S_{t+1} - S_t = \Delta S_t = \Delta S_t^{Tar} \qquad (2.3.3)$$

$E_t S_{t+1}$, which is simply a one period forward iteration of equation 2.3, is almost always on target as reflected by equation 2.3.3, under Botswana's current exchange rate and monetary policy regime, which is characterized by sufficient stock of foreign exchange reserve holdings. Parameter g_2 under the current regime therefore, assumes a high value of 0.9. In other words, when the country holds sufficient stock of foreign exchange reserves to supports its pegged exchange rate regime, economic agents are less concerned about the cyclical movements in the commodity export sector (mining output gap). Furthermore, public expectations on price stability, which are largely anchored on the stability of the exchange rate under this regime, have relatively high parameters in the Philips curves as already modelled in equations 2.2.1 to 2.2.3. However, during episodes of negative external shocks, agents become more concerned about domestic economic fundamentals or the movements in the primary source of foreign exchange reserves (mining output gap). The magnitude of the parameter on the mining output gap will therefore increase relative to g_2, and the size of expectation parameters in the Philips curve falls. This would be the primary features of the model under transition case 1 and 2, presented in the next subsection. Overall, the modifications to the public expectation equation adhere to the equilibrium conditions of the model. That is, the mining output gap converge to zero in equilibrium and hence; $E_t S_{t+1}$ = S_t = S^{Tar} in equilibrium, given that $\Delta S^{Tar} = 0$ in this model, as it shall be discussed in the latter part of the chapter.

Furthermore, under this model, public confidence on the stability of the exchange rate is also entrenched by the central bank's transparency with respect to its foreign exchange intervention strategy or rule, specified below. The rule therefore, partly informs the value for parameter g_1.

$$F_x = z_1 \, (\Delta S_t - \Delta S_t^{Tar}) \tag{2.3.4}$$

Where:z_1 is a calibrated parameter, F_x are foreign exchange interventions and $\Delta S_t = S_t - S_{t-1}$, $\Delta S_t^{Tar}$is the fixed nominal exchange rate target or steady state rate of appreciation or depreciation

Parameter z_1 ranges between 0 and 1, values close to one signify high degree of commitment by the central bank to defending its exchange rate target. Bank of Botswana publishes monthly balances of the tranche of foreign exchange reserves set aside for the sole purpose of defending the exchange rate peg; the Transaction Balance Tranche (TBT). The correlation between the TBT and the cumulative movements in the country's stock of foreign exchange reserves is around 0.55, which is the value assigned to parameter z_1. Loosely interpreted, Bank of Botswana is prepared at all material times, to lose over half of its foreign exchange reserves to keep the exchange rate on target. It is important to note that, the Central Bank is constrained to commit all the reserves to defending the peg. As previously indicated in chapter one, the reserves have other equally important purposes to serve, such as cushion fluctuations in the government budget, funding national disasters and emergencies, etc. The level of commitment pledged by Bank of Botswana thus far, is nonetheless sufficient to entrench trust, as is observed in the fairly stable and policy-aligned movements of the nominal exchange rate overtime (chart 2.1a and 2.1e).

Country Risk Premium

The risk premium is a mark-up or adjustment in the nominal interest rate to reflect the risk associated with holding domestic currency or pula denominated financial assets (Berg, et al., 2006). Under a fixed exchange regime model, the risk premium is simply captured by the real version of the UIP, equation 2.3.5 (Musil, et al., 2018). The equation is however modified in this study by incorporating a variable which accounts for the difference in the level of financial market and institutional development between Botswana and its trading partner countries (rfd). The variable assumes a binary parameter g_4, which takes the value 1 under all transition models and 0 under the baseline model. This modification is yet again, another ingenious contribution of our study to the existing stock of literature on this subject. The modification also forms part of the cardinal assumptions we employ to transition from the baseline model to alternative policy regime models, as it shall be shown in subsequent discussions.

$$prem_t = \Delta\overline{z_t} + \overline{r_t} - \overline{r_t}^f + g_4 rfd \qquad (2.3.5)$$

Where: g_4 is a binary parameter that assumes the value 0 under the baseline model and 1 under all transition models, $prem_t$ is the country's risk premium, $\Delta\overline{z_t}$ is the expected change in the real exchange rate trend, $\overline{r_t}$ and $\overline{r_t}^f$ are domestic and foreign real interest rates trend respectively, rfd is a wedge between the composite index of financial market and institutional development between Botswana and its trading partner countries (the index is developed by the IMF), and $shock\_prem_t$ is risk premium shock

The average of Botswana's nominal interest rate in the past five years was 1.5 percent, and 3 percent for trading partner countries (Chart 2.1c). This imply a spread of around -1.5 percent, which at face value seems to suggest that, it is much riskier to hold trading partner securities or currencies (US dollar, Euro, Chinese yuan, Japanese yen, British pound sterling and the

South African rand) compared to holding the pula or securities denominated in pula. Financial development indicators however, show that Botswana lags far behind its trading partner countries in virtually all measures of financial market and institutional development. According to the rfd estimates, financial development in trading partner countries is almost three times higher than the current level in the economy of Botswana. A reasonable inference that can be drawn from the current interest rate disparity and its implied currency risk premium is therefore that, Botswana's large stock of foreign exchange reserves have entrenched both public and investor confidence on the stability of the pula so strongly that, the actual reality on the ground with respect to country's level of financial market depth, accessibility and efficiency is grossly overlooked in asset pricing.

This oversight however, would not prevail if Botswana was to transition to a flexible exchange rate regime, where the country would offer no commitment to stabilizing the nominal exchange rate around any explicitly defined target. As already highlighted in the discussion on '*fundamental requisite elements for a durable flexible exchange rate regime*', under a floating regime, public and investor confidence on the pula would become a strong function of the country's relative level of financial market development, which is an implicit indicator of the risk associated with holding the domestic currency or assets denominated therein. Accordingly, we use the following assumptions to reflect this policy regime change dynamics;

(i) Under the baseline model (current regime) parameter g_4 assumes the value 0, for the obvious reasons outlined above. That is, Botswana's substantial stock of foreign exchange reserves have trivialized the need by investors to care about the currency risk implied by the country's current relative level of financial market development.[34]

[34] The stock of foreign exchange reserve holdings is quite high in the economy of Botswana, at an average of 30 percent of GDP (chart 2.1h).

(ii) Under the transition models parameter g_4 assumes the value 1, to reflect the importance of the relative level of financial market development in the assessment of the risks associated with holding the pula, in a regime where the central bank has relinquished its commitment to stabilizing the exchange rate around a specific target.

Monetary Policy Response Function (Modified Taylor Rule)

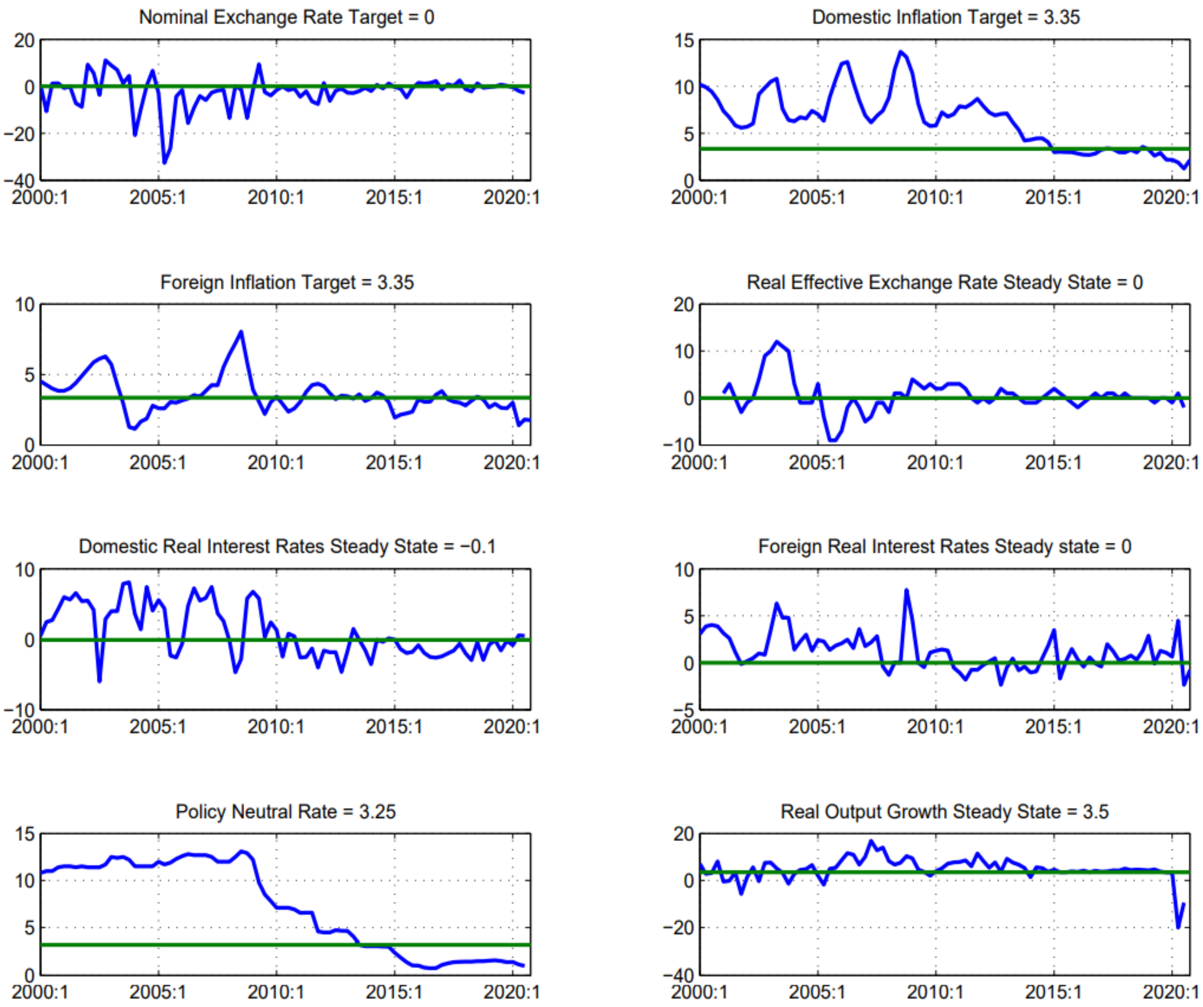
The Taylor rule under the baseline model is closely similar to the one presented and discussed in chapter one, under the hybrid policy regime model. Thus, monetary policy under the current regime responds to three main fundamentals, namely; exchange rate movements, deviation of forecast inflation from its medium term target and fluctuations in the output gap. The equation is presented below.

$$i_t = h_1 i_{t-1} + (1-h_1) * \left(h_2\left[-4(E_t(S_{t+1}) - S_t) + \left(i_t^f + prem_t\right)\right] + (1-h_2)\left[i_t^n + m_1(E_t\pi_{t+n} - \pi_D^{Tar}) + m_2\hat{y}_{D,t}\right]\right) + \varepsilon_t^i \quad (2.4)$$

As pointed out in the analysis of Botswana's current exchange rate and monetary policy dynamics in subsection 3.1, short term interest rates are predominantly used for the purpose of influencing inflation and output gap movements. The exchange rate is managed through the use of foreign exchange reserves. As such, parameter h_2 is assigned a relatively low value of 0.1. Inflation deviation parameter m_1 and output gap parameter m_2 are assigned the values 1.5 and 0.5, respectively. Policy persistence parameter h_1 is assigned the value 0.5, based on the regression of the policy rate on its lagged value, with judgement.

Figure 2.2 below, shows the nominal targets and steady state values of real variables in the baseline model. The list of all baseline model parameters is presented in appendix C.

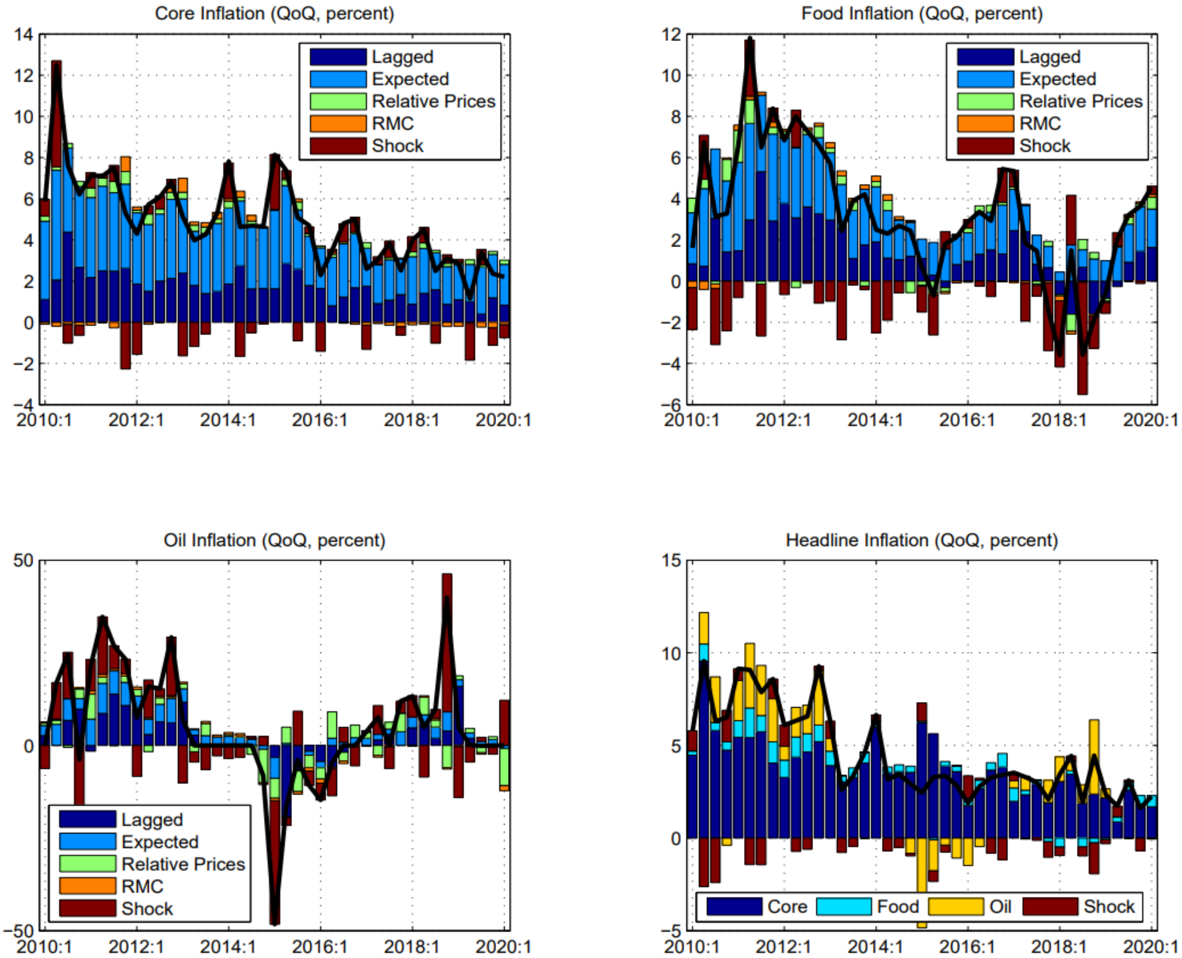
Figure 2.2: Nominal Targets and Steady State of Real Variables (Percentage Change)



Baseline Model Performance Evaluation

Two techniques are used to evaluate the prediction power and the general dynamic properties of the baseline model, which are; variance decompositions of key model variables[35] and impulse response functions.

Figure 2.3: Variance Decomposition



The decomposition above, shows how much of the variation in the observed data on the three components of inflation is explained by our calibrated Philips curves. In general, unexplained variations (shocks) are low[36] across all the inflation components, except for oil inflation. Oil

35 In this case (the current policy regime), the main variable of interest to the monetary policy authority is inflation; so, the variance decomposition analysis focuses on the three components of inflation (oil, food and core inflation).

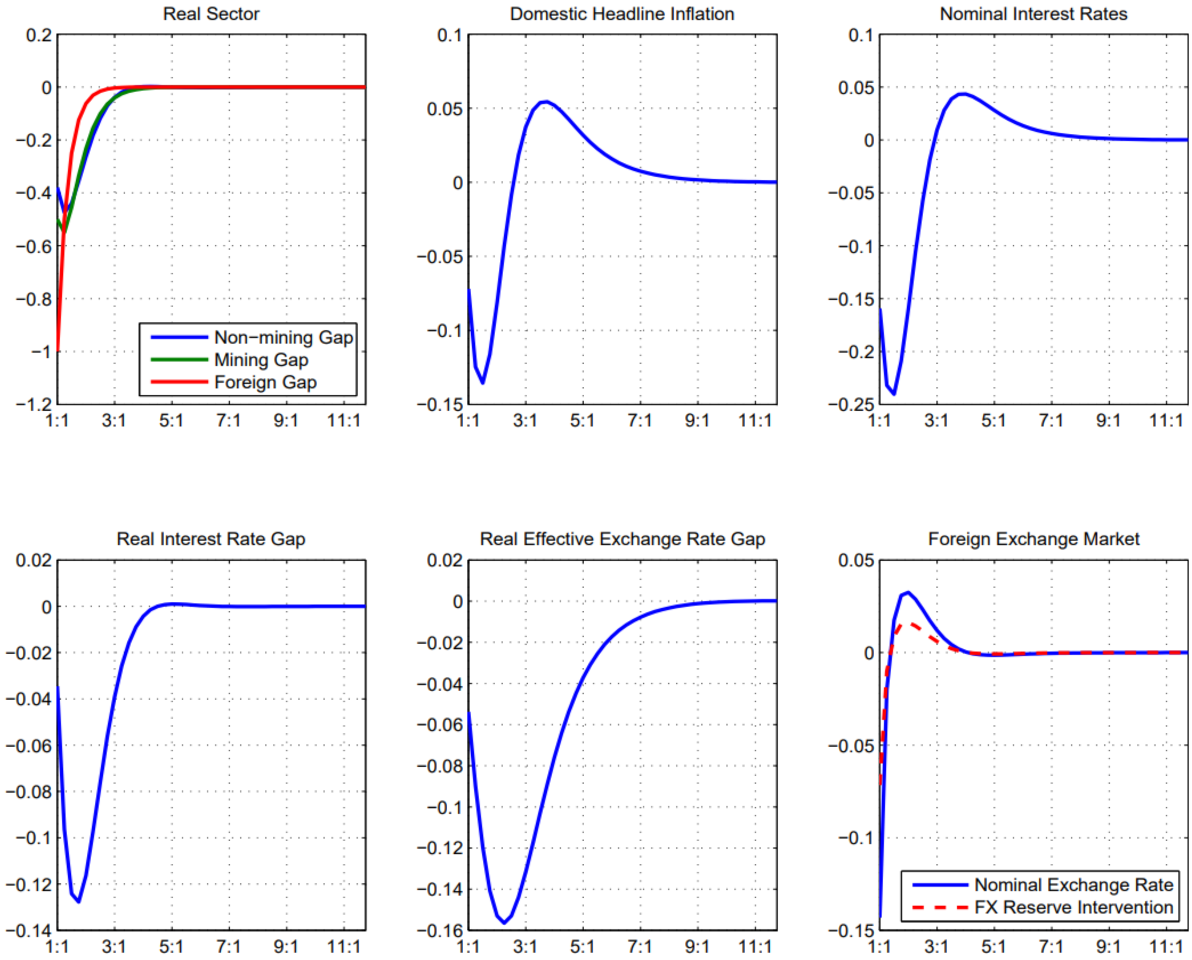
36 Particularly in view of the high-volatility data frequency under consideration, quarter-on-quarter (Q-on-Q) changes.

prices, as highlighted before, are entirely controlled by the government through BERA, and their adjustments may, in certain instances, be misaligned to the fundamentals specified under our oil inflation equation. For example, the substantial increase in oil inflation in the fourth quarter of 2018 was an attempt by the government to replenish the national petroleum fund, after it was almost depleted, allegedly, by corrupt activities (Bank of Botswana, 2018). International oil prices were fairly low at the time, at around 60 USD per barrel (Chart 2.1f). The model prediction of oil inflation (for 2018 quarter 4) is thus, consistent with the prevailing international price conditions during this period. The shocks under core and food inflation (although marginal) are also to some degree a reflection of the model's blind-sight to intermittent adjustments in government-controlled prices. These include adjustments in public transport fares, electricity and water tariffs, value added taxes, etc (Bank of Botswana, 2018). Nonetheless, the overall performance of the baseline model seems to be satisfactory, at least based on the small magnitude of its errors under the Philips curves.

Impulse Response Functions

The impulse response functions (IRFs) are used to assess the general response of the baseline model to both external and domestic shocks. The shocks applied herein are; (i) negative 1 percent shock to foreign output (signifies a fall in external demand) and (ii) negative 1 percent shock to the nominal exchange rate (signifies a currency attack).

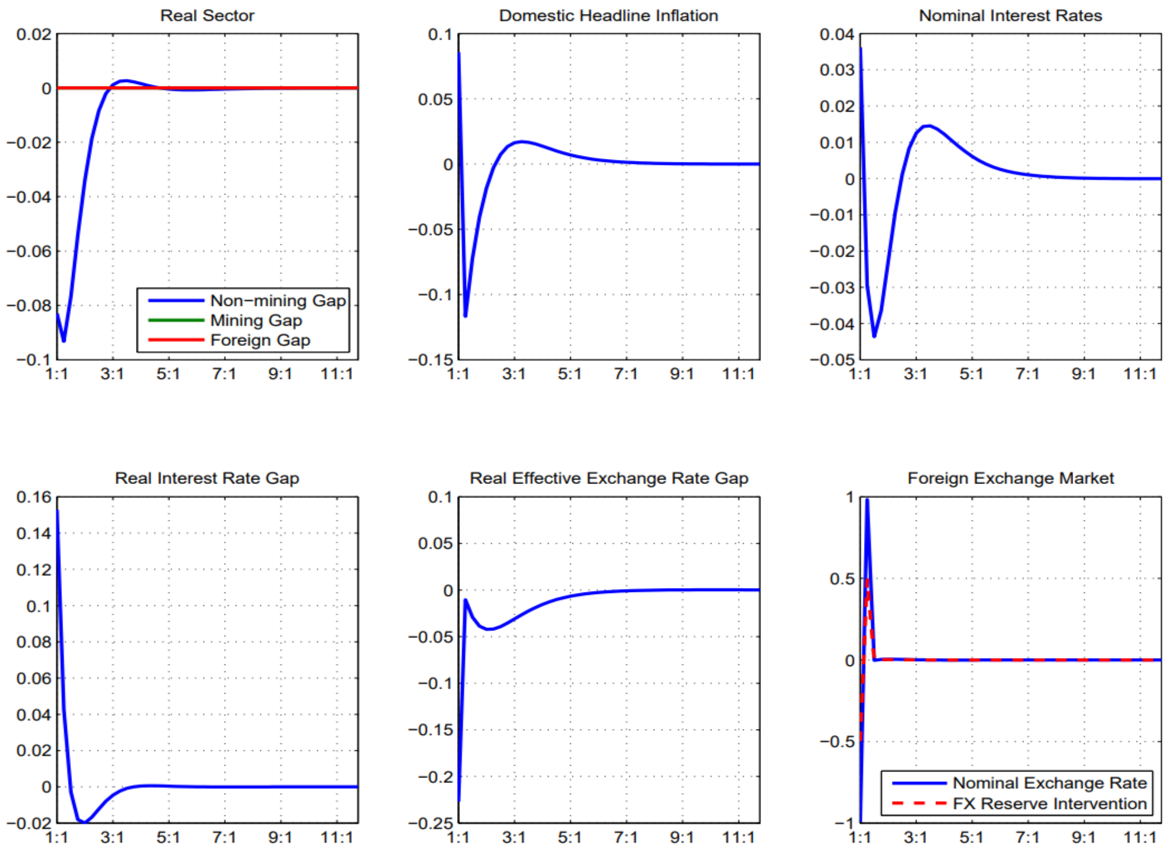
Figure 2.4: Foreign Demand Shock



A negative 1 percent shock to foreign output or external demand, leads to a fall in mining output (diamond exports). Domestic economic activity (captured by the non-mining output gap) declines as a result of the fall in mining output, given the importance of the diamond revenue on the broader economy. The fall in non-mining output gap dampens headline inflation. The monetary authority responds to the fall in inflation by cutting the nominal interest rates, real interest rates become loose and the economy begins to revert back to equilibrium. Meanwhile, credibility on the stability of the exchange rate takes a slight knock from the fall in diamond exports. Skepticism in the foreign exchange market therefore, leads to a slight depreciation in the nominal exchange rate. However, given the abundance of foreign exchange reserves holding assumed under this model, the authorities immediately intervene in the foreign exchange market (by selling foreign currency) to restore confidence on the stability of the pula.

Overall, the economy as a whole, takes quite some time to converge to equilibrium under this model.

Figure 2.5: Exchange Rate Shock



A negative 1 percent depreciation in the exchange rate leads to a lot of volatility in the entire economy. The initial impact of the depreciation is on headline inflation, which increases sharply above its target, reflecting the strong exchange rate-to-inflation pass-through in the economy of Botswana, captured by the relative prices of the three inflation components in the Philips curve. The monetary authority responds by hiking nominal interest rates to counteract the rise in inflation, and to some small extent, the depreciation in the exchange rate. Intervention in the foreign exchange market in response to the shock, is so aggressive that the nominal exchange rate considerably overshoots its target. This leads to a sharp fall in inflation, followed by a reduction in the nominal interest rates, and the economy begins to converge back to equilibrium. The volatility in the nominal exchange rate also spills over to the real exchange rate, which oscillates for some time before converging to equilibrium. The observed decline in domestic economic activity on the other hand, reflects the initial increase in the nominal and real interest rates. Mining output, which is mainly driven by external demand, is not affected by this shock. Overall, the dynamic properties under these two shocks are closely similar to those observed under the canonical model of the hybrid regime case, in chapter 1.

Chapter Three

'BOTSWANA WITHOUT ITS PRECIOUS STONES'

MACROECONOMIC IMPLICATIONS OF TRANSITIONING FROM A PEGGED TO A FLOATING EXCHANGE RATE REGIME

1. INTRODUCTION

Chapter 3 focuses primarily on developing transition models, and implementing these models to simulate our policy regime transition scenarios. This is the final lap of the three chapters on this subject matter, and it is organized as follows. Section 2 describes the transition models, in particular, the adjustments we make to the baseline model to reflect policy formulation under each transition case. Section 3 simulate and analyzes the transition scenarios as well as their associated social welfare loss functions. Lastly, Section 4 concludes the three chapters and provides recommendations.

2. POLICY REGIME TRANSITION MODELS: CALIBRATION AND PROPERTIES

This section presents modifications to the baseline model undertaken to reflect the basic economic features and policy transmission mechanisms under our three transition cases. Below are hypothetical triggers and exit conditions we assume to be behind Botswana's decision to transition to a floating exchange rate regime. The hypothetical scenarios are informed largely by the transition experiences of RDEs presented in chapter 1. Accordingly, our hypothetical triggers are centered around an assumption of a strong external shock to the diamond export market, which results in the following exit conditions.

1. *Exit in a crisis environment under immense market pressure*- for this case, the study assumes that, the negative impact of the shock on Botswana's diamond exports and the dampen effects thereof on the country's level of foreign exchange reserves prolongs to the point where the Central Bank of Botswana loses public credibility on its ability to sustain the peg. The diminished confidence on the pula ignites speculative attacks, which pushes the country out of the peg to a floating exchange rate regime.

2. *Exit in a crisis free-environment*- for this case, the study assumes that, the negative impact of the shock on Botswana's diamond exports and its level of foreign exchange reserves, persist for some time. However, Bank of Botswana at some point, is able to anticipate potential build-up in market pressures and decides to exit the peg with adequate stock of foreign exchange reserve holdings. It should be noted that, *a crisis free-environment* only implies the absence of market pressures or speculative attacks.

3. *Exit in a gradual and orderly manner*- for this case, the study assumes that, the external shock eventually subsides; Botswana's diamond exports increase and Bank of Botswana is able to build-up its foreign exchange buffers to pre-shock level. The threat to exchange rate instability posed by the shock however, remains a matter of concern for policymakers, which impel them to think of alternative future anchors of macroeconomic stability in the unfortunate event of the collapse in Botswana's diamond business. As such, policymakers embark on a planned and intensively thought-through mission to exit the peg, and begin to gradually establish supportive operational and institutional elements for a durable floating exchange rate regime outlined in (Duttagupta, et al., 2004; Otker-Robe & Vavra, 2007). We further assume that, prior to the exit, the Central Bank engages on an extensive public communication campaign to entrench public confidence on the stability of the exchange rate, during and after the transition, and it succeeds in this mission

We present below, model designs for these three transition cases.

2.1. Transition Model 1

The fundamental force precipitating the fixed-to-float transition is the same under transition case 1 and 2. That is, transition in these two cases is triggered by occurrence of an external shock with dire effects on the diamond export performance. The only difference is the actual timing of the transitions. Thus, in transition case 1, the Central Bank is pushed out of the peg at height of the manifestation of the shock. In the second transition case, the Central Bank jumps out of the peg to avoid the unpleasant eventuality of being pushed-out if it waits too long and face the full-scale effects of the shock (depletion of foreign reserves). The two transition cases therefore, share the same model design, but different simulation shocks nonetheless. We discuss below, the basic features of this model and its dynamic properties.

In this model, the output gap equation, Phillips curves and the Taylor rule, assume the same specifications presented under the baseline model. The parameter values of the equations are however, different. The only block of equations which undergo major changes is the UIP, consistent with the exchange rate policy formulation under this new regime. First, the Central Bank ceases to target the movements in the nominal exchange rate, so the exchange rate target S_t^{Tar} is dropped from the UIP equation. Secondly, we assume that the Central Bank pledges no commitment to any form of foreign exchange intervention strategy. Therefore, the Central Bank's foreign exchange intervention rule, equation (2.3.4), is dropped from this model. It is worth noting that, even if the Central Bank was to pledge commitment to a particular intervention strategy, it is highly unlikely that such a commitment would enjoy any credibility, particularly given circumstances around which the regime transition is carried-out. Below are modifications we make to the UIP block.

$$S_t = E_t(S_{t+1}) + \left(i_t - i_t^f - prem_t\right)/4 + \varepsilon_t^s \qquad (3.1)$$

All variables and parameters are as defined before.

Furthermore, the country risk premium, as outlined in the previous chapter, is modified to reflect the relative level of financial market and institutional development between Botswana and its trading partner countries, as shown below.

$$prem_t = p_1 prem_{t-1} + (1 - p_1) prem_{ss} + \varepsilon_t^{prem} \qquad (3.2)$$

Where: p_1 is a calibrated parameter and $prem_{ss}$ is the steady state or equilibrium risk premium

The risk premium is exogenously determined, which is a technical requirement of the Core model under a floating exchange rate regime. The premium follows an AR process centered around a steady state, defined below.

$$prem_{ss} = \Delta\overline{z_{ss}} + \overline{r_{ss}} - \overline{r_{ss}}^f + g_4 rfd \qquad (3.2.1)$$

Where: $= \Delta\overline{z_{ss}},\ \overline{r_{ss}}\ and\ \overline{r_{ss}}^f$ are steady states values of the real exchange rate, domestic and foreign real interest rates, respectively.

In the absence of an explicit target for the nominal exchange rate, economic agents will begin to care more about the cyclical movements in the diamond sector and the implications thereof, on foreign exchange liquidity (Dabrowski, 2016).[37] The parameter for the mining output gap in equation 2.3.1 is therefore higher in this model relative to the baseline model. Furthermore, public expectations on price stability will be unanchored if Bank of Botswana relinquish its over 30 years commitment to a stable pula, under circumstances assumed for both transition case 1 and 2. Inflation expectations parameters in all the three Philips curves are therefore, lower in this model compared to the baseline model. Low inflation expectations, particularly for core inflation, imply a relatively high sacrifice ratio. That is, under this model, where credibility on price stability is low, the central bank would need to shed or sacrifice a substantial amount of output to bring inflation to target (Clarida, et al., 1999). In other words, the social

[37] It is worth noting that, foreign exchange liquidity is still important even under a float, to facilitate trade in FX market, and to beat down depreciation pressures.

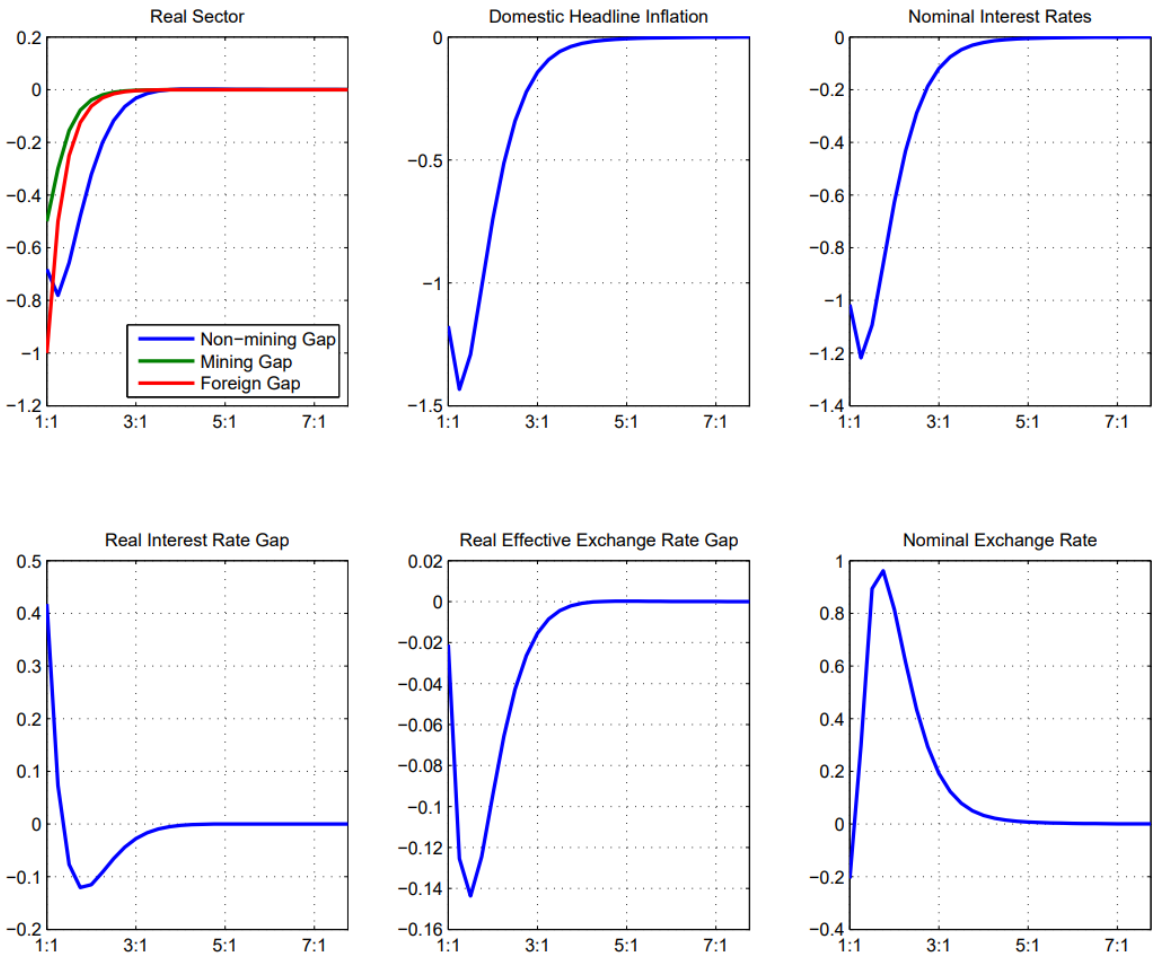
welfare cost of maintain price stability is very high under this model, and this is reflected by a low parameter for the real marginal cost under the core inflation equation.

In addition, the equilibrium level of interest rates is relatively high under this framework, in line with our assumption on the evolution of the risk premium. Furthermore, the exchange rate parameter in the modified Taylor rule assumes a higher value relative to the baseline model, signifying the dual role of the interest rates in stabilizing both the nominal exchange rate and inflation, under these transition cases. A list of all the parameters under this model, is presented in appendix D.

Impulse Response Functions

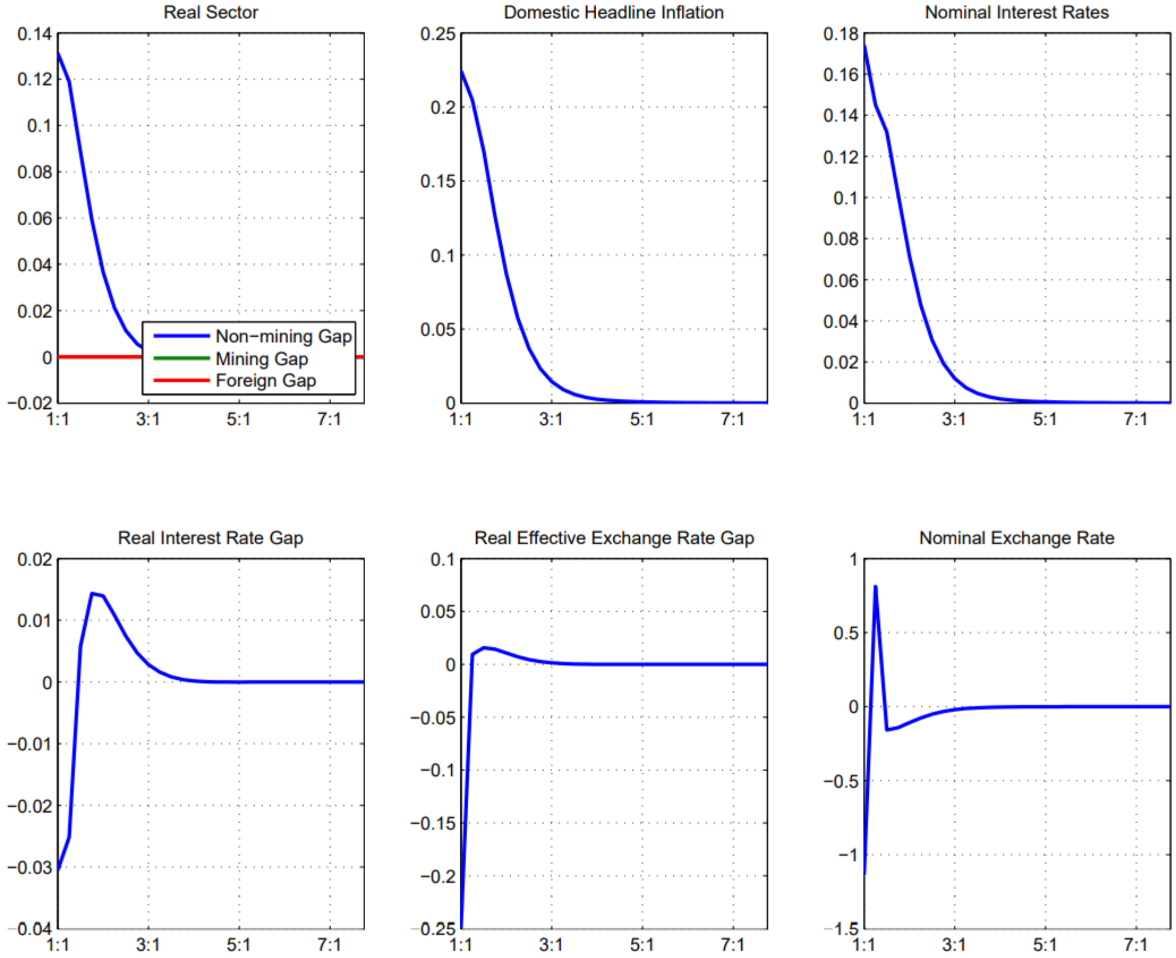
We apply the same shocks used under the baseline model, that is; (i) negative 1 percent shock to foreign output (signifies a fall in external demand) and (ii) negative 1 percent shock to the nominal exchange rate (signifies a currency attack).

Figure 3.1: Foreign Demand Shock



The transmission of the foreign output shock in this model is similar to what we observed under the baseline model in chapter 2, except for one peculiar attribute, which is specific to this model design. Under this model, the Taylor principle tends to be violated, because of the dual role of the nominal interest rates in stabilizing both the exchange rate and inflation movements. Under this shock for example, both the non-mining output gap and headline inflation falls, but the nominal interest rate response is not aggressive enough to cause a fall in the real interest rates, as the Taylor principle would dictate should be the case. This is mainly because, an aggressive nominal interest rate response would exert excessive depreciation pressure on the nominal exchange rate, which is against the desires of policymakers. Equilibrium under this shock is therefore, restored by the real exchange rate gap.

Figure 3.2: Exchange Rate Shock



The Taylor principle is still violated under this shock to avoid excessive appreciation rebound in the nominal exchange rate. More precisely, the rise in the nominal interest rate from the initial exchange rate depreciation shock, is not high enough to tighten the real interest rate gap. The loose real interest rates gap therefore, exacerbates the upward pressure on both inflation and the output gap from the initial exchange rate shock. The appreciation in both the nominal and real exchange rate in the immediate period after the shock, creates the contractionary impetus necessary to bring the model to equilibrium.

2.2. Transition Model 2

Transition model 2 captures the third policy regime transition scenario. In this model, we assume that at the point of exiting the peg, the country's efforts (over an extensive period of time) to establish fundamental requisite elements for a durable flexible exchange rate regime, would have gained considerable traction. In particular, financial market depth, accessibility and efficiency would have improved markedly. Furthermore, Bank of Botswana would still be enjoying a high degree of public trust (as is the case under the baseline model), on account of its impressive track record of maintaining both price and exchange rate stability overtime. The exit is also assumed to occur in a crisis-free environment, with calmness in the global diamond and foreign exchange markets. The country's stock of foreign exchange reserves is thus, assumed to be in adequate levels at time of the exit. Foreign exchange reserve adequacy in this model nonetheless, only serves to reinforce public trust.[38] The central bank offers no commitment to a specific nominal exchange rate path under this model. That is, the pula is freely floating and its movements are determined entirely by the perfect version of the UIP. Accordingly, we make the following adjustments to the baseline model structure.

First, we drop the exchange rate target S_t^{Tar} from the UIP, the UIP under this model therefore becomes,

$$S_t = E_t(S_{t+1}) + \left(i_t - i_t^f - prem_t\right)/4 + \varepsilon_t^s \quad (3.3)$$

Since no assumption is made on Botswana's trade patterns at the time of the exit, diamond exports therefore still remain the main source of foreign exchange reserves under this model. Thus, developments in the global commodity market are still important somewhat, in

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38 It is generally more comforting to the public and investors when the country holds adequate levels of foreign exchange reserves, even under a floating exchange rate regime. Availability of adequate stock of foreign exchange reserves is a signal to economic agents that, the central bank is able to intervene (even when no explicit commitment is made) in the foreign exchange market when such a need arise. This signal helps to enhance and reinforce credence on the regime (Otker-Robe & Vavra, 2007).

entrenching public confidence on the pula. Public expectation formation under the UIP therefore, still evolves through equation 2.3.1 and 2.3.2 from the baseline model.

Secondly, we drop the exchange rate from the Taylor rule, the monetary policy response function under this model therefore becomes,

$$i_t = h_1 i_{t-1} + (1 - h_1)\left(i_t^n + m_1(E_t\pi_{t+n} - \pi_D^{Tar}) + m_2\hat{y}_{D,t}\right) + \varepsilon_t^i \tag{3.4}$$

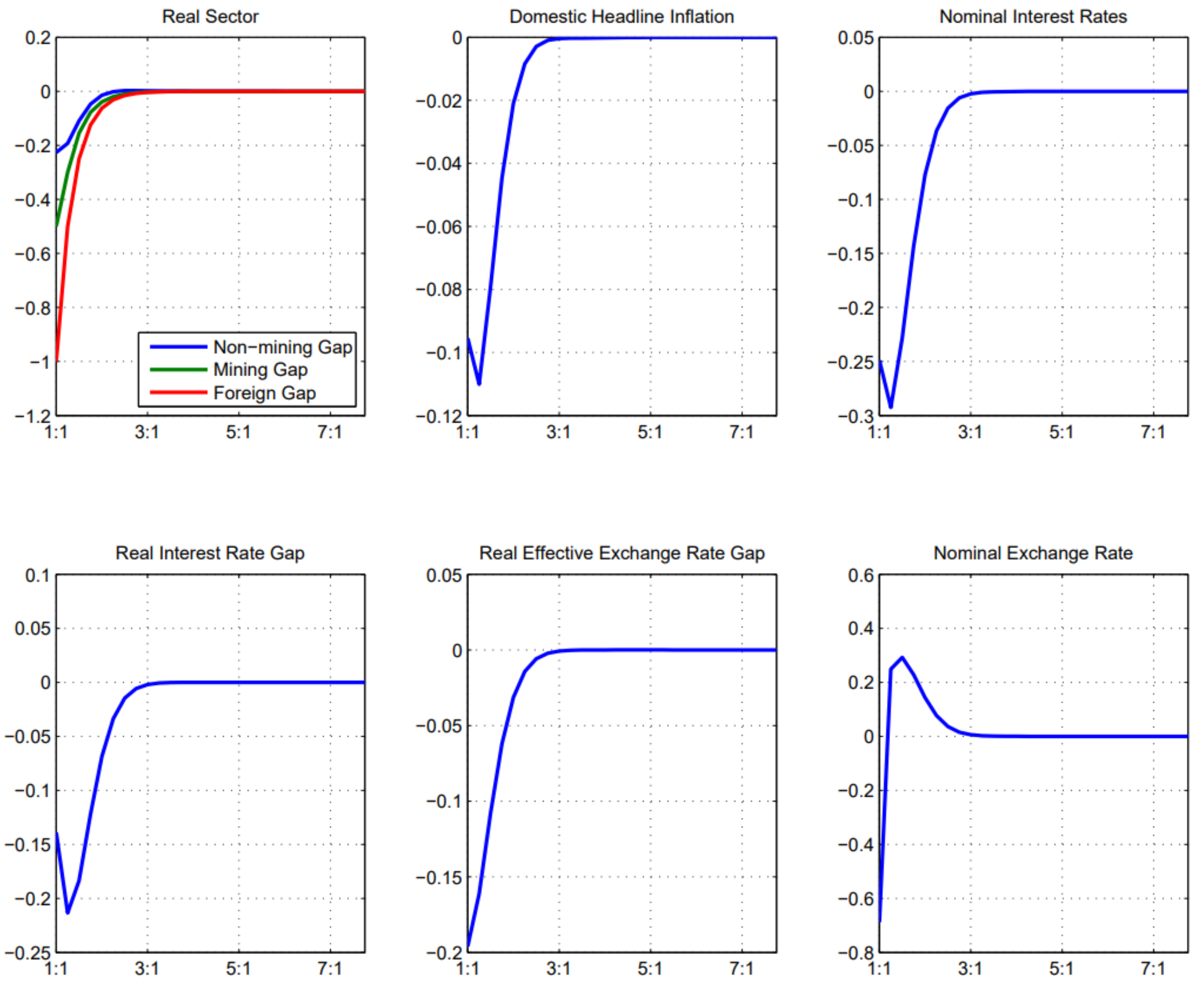
Under this model, public confidence on the pula is largely entrenched on existence of fundamental requisite elements for a durable flexible exchange rate regime. Thus, Foreign exchange reserve balances are important but not crucial, in this model. As such, the parameter for the mining output gap in equation 2.3.2 is kept at par with the value assigned under the baseline model. Moreover, Bank of Botswana's good track record in maintaining price stability, its improved technical capacity in forecasting inflation (based on the assumption of institutional development), improvement in financial market depth, access and efficiency, as well as, public confidence on the pula, helps to enhance the Bank's credibility in meeting its inflation target. Inflation expectations parameters in all the three Philips curves are therefore, higher under this model compared to the baseline model. High inflation expectations imply a low sacrifice ratio in the core inflation equation, and by extension, low social welfare cost.

Furthermore, the equilibrium level of interest rates is low under this framework (close to the level under the baseline model), consistent with the low risk premium implied by the improvements in financial markets and institutional development. A list of all the parameters under this model, is presented in appendix E.

Impulse Response Functions

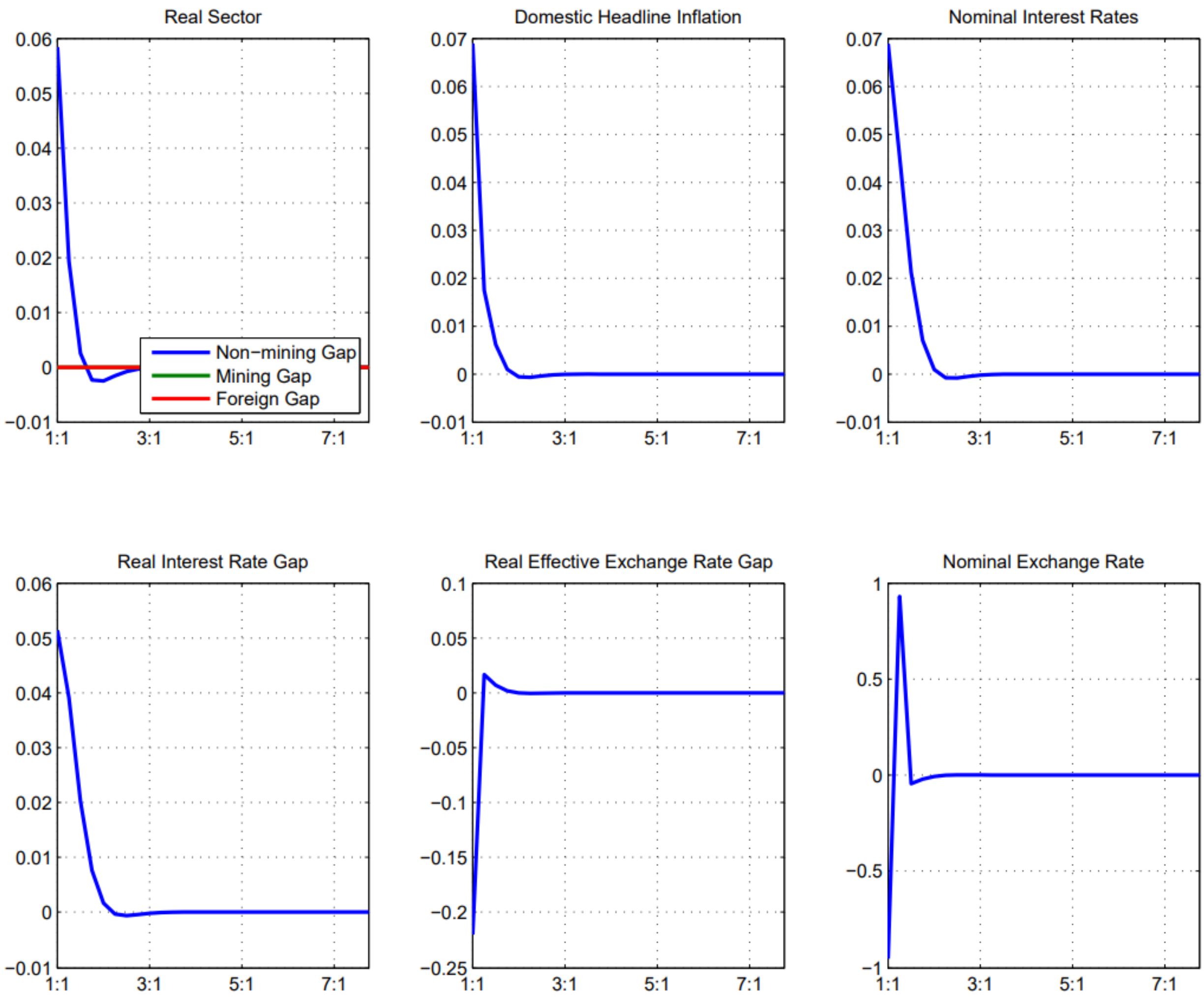
We apply the same shocks used under the baseline model, that is; (i) negative 1 percent shock to foreign output (signifies a fall in external demand) and (ii) negative 1 percent shock to the nominal exchange rate (signifies a currency attack).

Figure 3.3: Foreign Demand Shock



The transmission of the foreign demand shock under this policy framework is similar to the one presented in the baseline model. However, the trajectory and speed of convergence to equilibrium is quite different between the two frameworks. In particular, economic variables in this framework follow a smooth path to equilibrium, and the speed of convergence of the economy to nominal targets and steady states is relatively fast. This is mainly because both the interest rate and exchange rate transmission channels are fully and perfectly functioning, without any policy-induced restriction. The combined force of these two channels therefore helps to restore equilibrium in the economy much quicker and with benign volatility.

Figure 3.4: Exchange Rate Shock

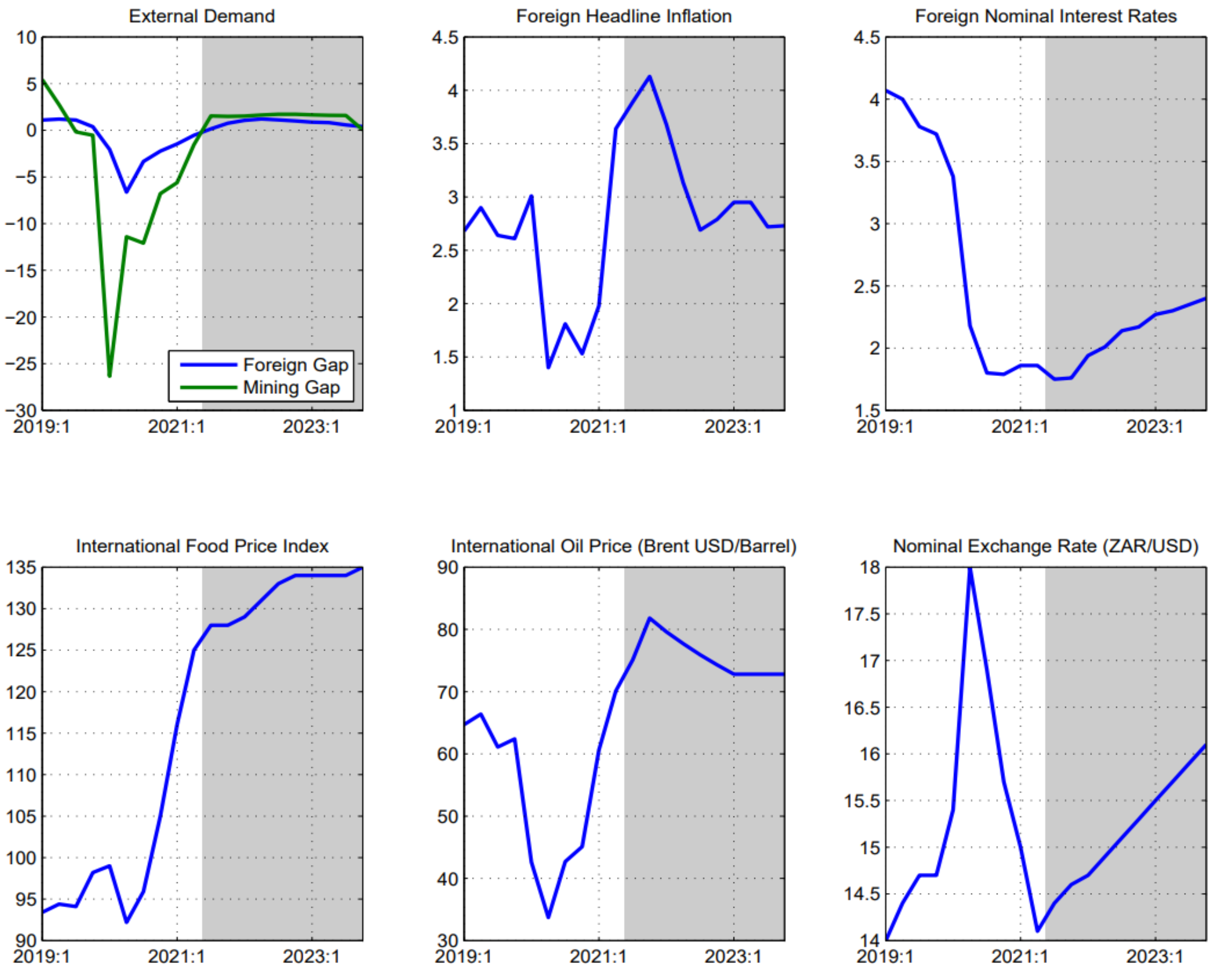


The propagation of the exchange rate shock in this model is also similar to the one under the baseline model. There are two main fundamental differences nonetheless. First, the nominal exchange rate under this policy regime takes a relatively longer duration to revert back to its implied target or long-run equilibrium position. This is because the monetary authority does not carry the burden of stabilizing the exchange in this regime, hence convergence of the nominal exchange rate to equilibrium takes a bit of time. The second difference relates to the impact of the shock on economic activity or the non-mining output gap. Thus, relative to the baseline model, a depreciation shock under this model, leads to a small or marginal increase in the real interest rate gap, the impact of which (on the output gap) is outweighed by the depreciation in the real exchange rate gap. In other words, real monetary conditions become loose (on account of the accommodative real exchange rate gap) under this model, leading to a rise in economic activity. Therefore, to restore equilibrium in the system, the exchange rate gap must appreciate and overshoot its balanced position (become positive or overvalued), in order to slow economic activity and drive inflation to its target. This overvaluation in the real exchange rate is reflected by the positive spike in the second period of the IRF horizon.

3. POLICY TRANSITION SCENARIOS

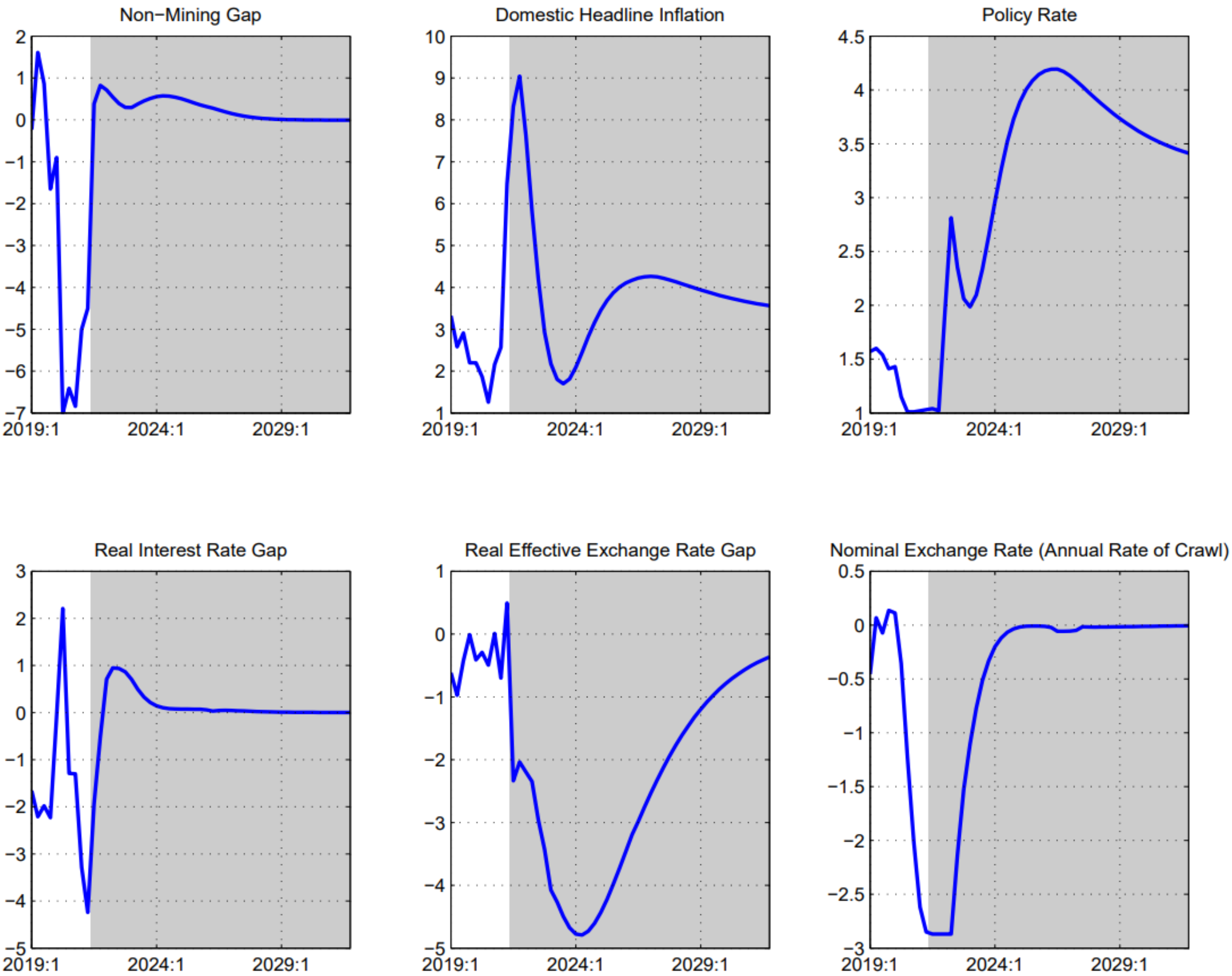
This section presents the three policy regime transition simulations conducted in this study. The section is organized in the following order. First, the section provides a brief overview of the external assumptions used in the simulations. This is followed by a discussion of the baseline forecasts, and lastly, we simulate and discuss our three transition scenarios.

Figure 3.5: Foreign Variables Forecasts (Post-Global Shutdown External Assumptions)



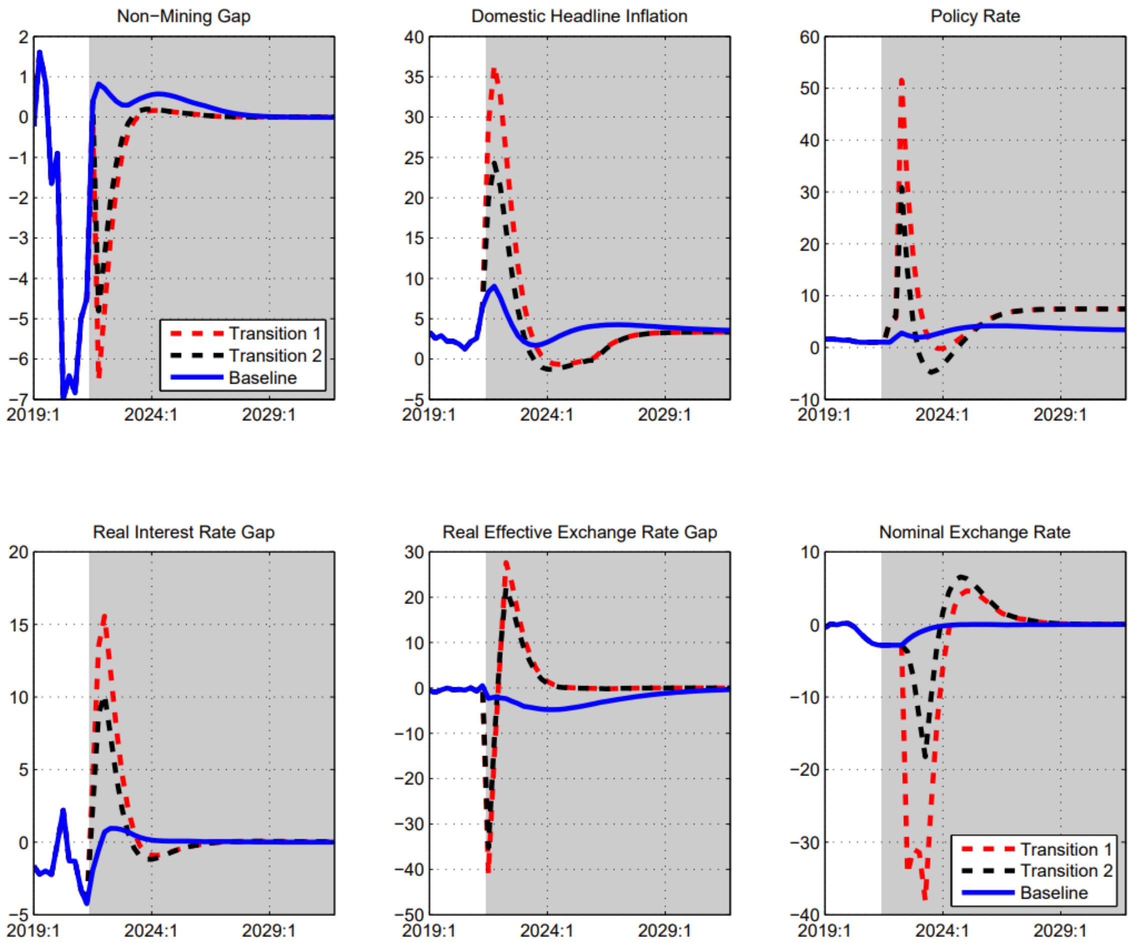
The baseline forecasts and transition simulations conducted in this study, are conditional on external assumptions presented above. These external assumptions are simply consensus forecasts of key foreign variable of interest, produced by independent analysts in the Bloomberg data portal. The assumptions which runs from 2021 to 2023, shows the outlook of the global economy post the 2020 COVID-19 induced global lockdowns. At the time, global output was projected to recover from the negative impact of the COVID-19 pandemic in the first quarter of 2021, and remain stable thereafter (the unshaded part is actual observed data). Domestic mining output was therefore, expected to improve markedly, from the recovery in global demand. At the same time, international commodity prices (oil and food prices) were projected to increase, and exert pressure on global inflation. Monetary policy across the world was therefore, expected to be relatively tight, in response to the rise in inflation. Meanwhile, the nominal exchange rate between the US dollar and the South African rand (which are major trading partner currencies of the pula) was forecast to trend upwards, implying an appreciation of the dollar against the rand. Overall, the general sentiments at the time were that, the global economy will recover from the negative impact of the COVID-19 pandemic, but with immense inflationary pressures nonetheless. We present below, the baseline forecasts and transition simulations conditional on these external assumptions.

Figure 3.6: Baseline Forecasts



Projections from all the three transition scenarios are contrasted against the baseline forecasts presented above. The baseline forecasts (which are produced from our baseline model), show the outlook of the domestic economic in the absence of unanticipated intense shocks or major changes in the current policy regime. In general, the trajectory of the baseline forecasts is in line with external assumptions, particularly in the short term. That is, in the first three years of the forecast horizon, economic activity in the non-mining sector is improving, supported by the recovery in external demand for diamonds. Domestic headline inflation is rising, largely on account of the surge in international commodity prices. Bank of Botswana is therefore, anticipated to increase interest rates to keep inflation within its objective range of 3 to 6 percent. Furthermore, Bank of Botswana targets the path of the nominal exchange rate under this model, by setting the annual rate of crawl, which was -2.85 percent between 2020 and 2021 (Bank of Botswana, 2021).[39]The medium term projection profile on the other hand, mainly reflects the dynamics and equilibrium properties of the baseline model. Thus, for the remaining part of the forecast horizon, the baseline model is converging to its nominal targets and equilibrium steady states, and the speed of convergence is determined by the calibrated parameters of the model, presented in appendix C.

<u>Figure 3.7: Transition Case 1 and 2</u>



Transition case 1 and 2 are unplanned policy regime changes, triggered by external forces outside the control of policymakers. Under the first case, transition is triggered by a deep fall

39 The annual rate crawl of -2.85 percent implies that, the pula was set to depreciate against the composite basket of its trading partner currencies, by a cumulative magnitude of -2.85 percent between 2020 and 2021.

in diamond exports and foreign exchange reserves, leading to a speculative attack on the pula. In the second case, transition is still triggered by a deep fall in diamond exports, however, in this case, the Central Bank takes a precautionary decision to exit the peg before it runs out of foreign exchange reserves, which would leave the pula predisposed to speculative attacks. We therefore impose the following simulation shocks to *Transition Model 1*, under each transition case. For the first transition case, we apply two shocks to (i) *foreign output gap equation*, signifying a fall in external demand for diamonds, (ii) *UIP equation*, signifying a speculative attack on the pula. Under transition case 2, we apply only one shock, which is *foreign output shock*. Figure 3.7 above, shows the short to medium term projections of key macroeconomic variables under the two transition scenarios.

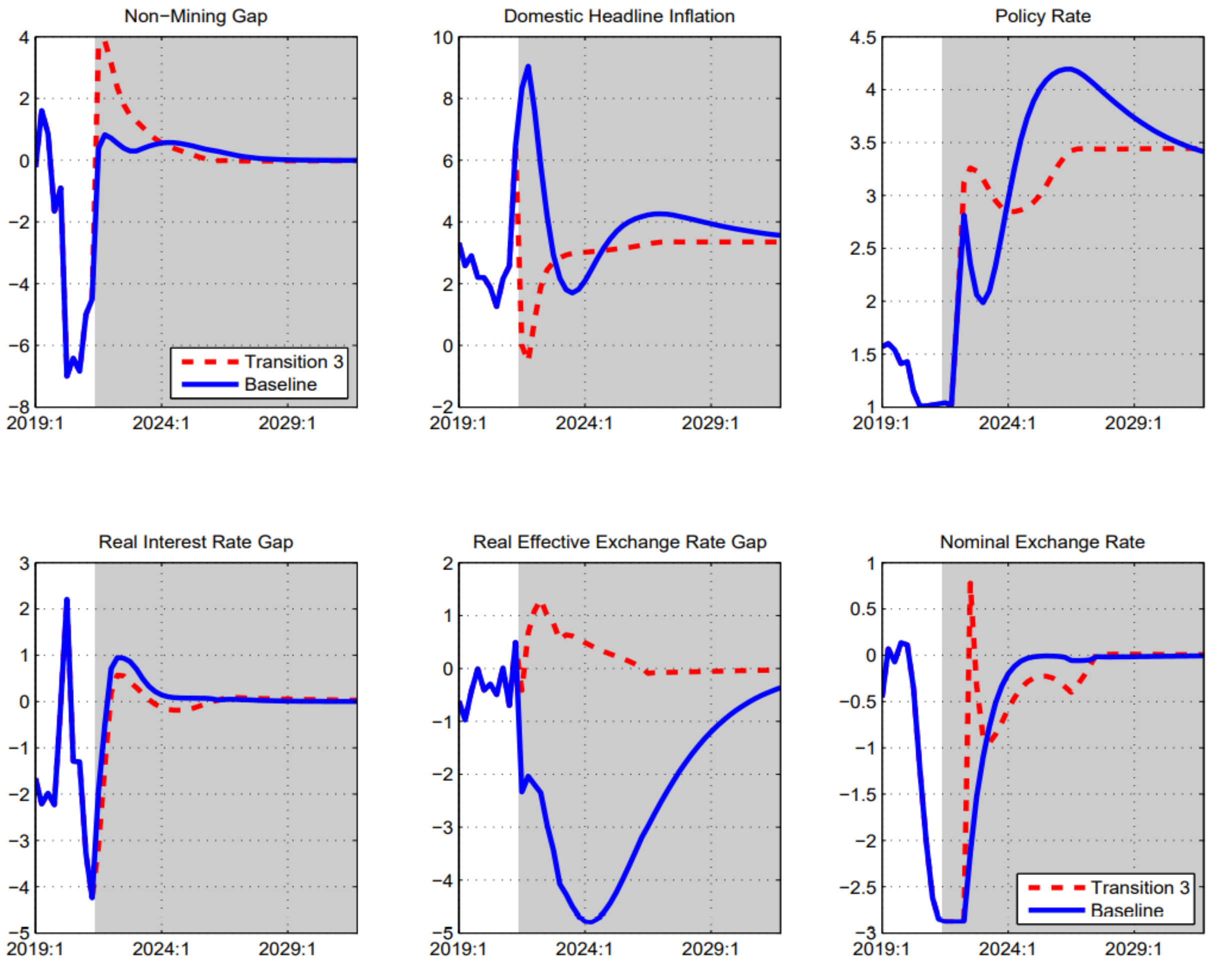
In general, the trajectory of macroeconomic variables under the two scenarios is closely similar, varying only in magnitudes. On technical grounds, these similarities are to be expected because the scenarios are outcomes of the same model design, however, there is substantive economic intuition behind these similarities. That is, a resource-dependent economy is generally bound to face profound macroeconomic instability if it exits the peg under circumstances assumed in these two scenarios. The instability stems primarily from the loss in public confidence on the domestic currency, which is the nominal anchor of the broader economy, for most of these countries. Thus, once it becomes clear that the central bank may fail to defend the peg, economic agents will dump the domestic currency in exchange for safer foreign currencies, the so-called speculative attack.

In the first transition case, Bank of Botswana puts up a fight against this attack, until it depletes almost all of its foreign exchange reserves, and at this point, no one wants to hold the pula. The pula therefore, depreciates sharply to around 40 percent. Headline inflation spirals out of control and the Central Bank takes drastic measures (set extremely high interest rates) in an attempt to reinstate calm. The simulation model (which is naturally designed to converge to equilibrium) suggest that the drastic measures taken by Bank of Botswana will ultimately restore stability in the economy in the medium term. However, case studies on similar '*real life*' crises in various resource-dependent economies, suggests otherwise.

In Angola for example, the nominal exchange rate of the kwacha against the US dollar was on average, 100 Angolan Kwacha per US dollar before the 2014 - 2016 commodity price shock, 320 per dollar in 2019, before the outbreak of COVID-19, and 600 per dollar in 2021 (National Bank of Angola, 2021). Headline inflation during this period rose from an average of 9 percent in 2013, 18 percent in 2019 to 25 percent in 2021. With this high inflation environment and a weaker Kwacha, the policy rate has been very tight for the past 8 years, increasing from 10 percent in 2013, 15 percent in 2019 to 20 percent in 2021. As already discussed in chapter one, Angola abandoned the peg in 2015 following the commodity price burst in 2014, and its economy has remained in turmoil ever since. The same phenomena are observed in other resource-rich economies such as, Egypt, Azerbaijan and Venezuela (which is an extreme case).

In the second transition case, Bank of Botswana attempts to fool the market, but fails. Economic agents' skepticism on the survival prospects of the pula is heightened by the weak fundamentals on the ground, at the time of the transition. Thus, availability of foreign exchange reserves does little to quell the panic when the announcement to exit the peg is made. The evolution of macroeconomic variables under this case is therefore, similar to what we observed in transition case 1. Overall, social welfare implied by the short-term path of the output gap and inflation is extremely low under these two transition scenarios, relative to the baseline forecast. In the medium term, social welfare remains low under these transition scenarios, on account of the higher equilibrium level of interest rates, compared to the baseline regime. The variation in the equilibrium level of interest rates reflects our assumption on the size of financial market development and the implied risk premium thereof, under these two transition cases.

Figure 3.8: Transition Case 3



Under this transition case, we assume that prior to exiting the peg, policymakers work towards building the necessary technical capacity and establishing sound institutional and operational environment to enhance the prospects for efficient implementation and durability of the floating regime. This entails developing a deep and liquid domestic security and foreign exchange market, and in the context of monetary policy, identifying an alternative nominal anchor of price stability. Most importantly, the transition is assumed to take place under a stable external and domestic economic environment, with calmness in both the global commodity and domestic foreign exchange markets. As such, we impose no shock under this transition case and take all the external assumptions presented in Figure 3.5 as given.

The macroeconomic environment exhibits benign volatility under this transition case, relative to the baseline model. Furthermore, Bank of Botswana is able to bring inflation (primary target) to its medium-term objective range within a relatively short period of time, and most importantly, with minimal output loss. Overall, social welfare implied by the short-term path of the output gap and inflation is high under these transition case, compared to the baseline forecasts. The high social welfare largely reflects, the high degree of credibility enjoyed by Bank of Botswana under this policy regime. The evolution of the nominal exchange rate under this policy regime is also worth noting. First, relative to the baseline forecast, wherein the nominal exchange rate is fixed, the exchange rate under this regime exhibits some degree of volatility, in line with the new policy framework, a floating regime. Secondly, the movements in the nominal exchange rate perfectly follow the path implied by the UIP. That is, the appreciation of the pula corresponds with episodes of interest rate hikes, and depreciations correspond with interest rate cuts. Moreover, given the low risk premium under this regime, the UIP holds even in a low domestic interest rate environment. In general, the macroeconomic environment under this transition case bears close resemblance to the transition profile of Chile, presented in chapter one.

Social Welfare Analysis (Formal Computation)

We assume a general central bank loss function L_t, adopted from (Cayen, et al., 2006). Thus, the monetary authority has preferences over inflation stability with some concern for output stabilization. We also allow for the possibility that the authority cares about the volatility in the movements of its instrument (interest rates), as well as the exchange rate. We formalize these preferences of the central bank with the following loss function;

$$L_t = (\pi_t - \pi^{Tar})^2 + \theta_y(\hat{y}_{D,t})^2 + \theta_{\Delta R}(\Delta R_t)^2 + \theta_{\Delta Z}(\Delta Z_t)^2 \quad (3.5)$$

Where; π_t, $\hat{y}_{D,t}$, ΔR_t, ΔZ_t, are inflation, output gap, interest rates and the exchange rate, respectively. The parameter θ_y, $\theta_{\Delta R}$ and $\theta_{\Delta Z}$ are respectively, the relative weight on output fluctuations and the movements of the interest rates and exchange rate in the preferences of the monetary authority.

The table below presents welfare losses from our model simulations under different monetary authority preferences.

Table 3.1: Social Welfare Analysis (Losses)

Short-to-Medium Term				
	Baseline	*Transition Case 1*	*Transition Case 2*	*Transition Case 3*
θ_y= 0.5 $\theta_{\Delta R}$= $\theta_{\Delta Z}$= 0	*1.067*	*82.402*	*30.370*	*1.100*
θ_y=$\theta_{\Delta R}$ = 0.5 $\theta_{\Delta Z}$= 0	*7.014*	*154.497*	*62.273*	*5.964*
θ_y=$\theta_{\Delta R}$ = $\theta_{\Delta Z}$= 0.5	*7.633*	*236.324*	*76.211*	*6.524*

In the short to medium term horizon, social welfare losses under transition case 1 and 2 are extremely high across all the assumed preferences of the monetary authority's loss function. Transition case 1, which assumes a full-blown currency crisis, has the worst social welfare repercussions. On the contrary, the planned transition scenario (case 3) has the lowest social welfare losses, even when contrasted against the baseline scenario. Meanwhile, social welfare losses across all the model simulations are imperceptible in the long run (equilibrium). This is mainly because in the long run, all variables converge to their respective targets and steady states. Nonetheless, the equilibrium level of interest rates varies across our simulation models as discussed above, hence the equilibrium social welfare implied by the interest rates will also vary across the models.

4. CONCLUSION

The primary objective of this study was to sketch-out of how Botswana is likely to transition to a flexible exchange rate and a full-fledged inflation targeting regime, under different set of exit conditions. To reach this end, the study conducted three counterfactual transition simulations, and made the following findings. First, the study found policy regime transitions under case 1 and 2 to be disorderly in nature, characterized by profound macroeconomic instability in the first few years of the transition. Bank of Botswana would have to take drastic measures under these transition cases to restore stability in the economy. Whether or not these drastic measures will be effectual in restoring stability in the long run is a question outside the remit of our analytical models, which focus only on short to medium term dynamics. Nevertheless, if past experiences of other resource-dependent economies through similar crises (Angola for example), are anything to rely on, then it is safe to say, Bank of Botswana's *quick fix* recovery scheme may not really work.

Secondly, the study found transition case 3 to be orderly in nature, characterized by a high degree of public confidence on the stability of key macroeconomic fundamentals. This public confidence however, comes at a hefty price. That is, Bank of Botswana, together with both private and public stakeholders, would have to invest a lot of time and effort in establishing some, if not all, the necessary institutional and operational requirements for a durable and credible floating exchange rate regime. Chile becomes a good benchmark case in this regard, and if the policymakers fancy this transition plan and desire to adapt it, then it would be ideally for them to reach-out and enlist the technical support and guidance of countries like Chile, or any other country with an orderly transition repute.

It is worth noting that, this study does not seek to prescribe any specific type of exchange rate policy regime for Botswana to adopt, but rather, to simply recommend the country to structurally position itself to avoid long-lasting macroeconomic instabilities, which are synonymous with policy regime changes in resource-rich economies. One such structural adjustment, which Botswana should prioritize, is the diversification of the economy away from the diamond exports. A well-diversified economy would present multi-faceted benefits to the country, and in the specific context of this study, having multiple streams of foreign exchange earnings would substantially lower the inherent risk of a forced policy regime transition (assuming the country desires to continue under the current fixed regime). One potentially viable area of diversification in this regard, could be the tourism sector.

However, to promote export activities in this sector, policymakers may need to review their current exchange rate competitiveness conditions, particularly against Botswana's neighbouring countries (i.e., South Africa, Lesotho, Namibia and Eswatini) which by and large, offers the same services found in Botswana's tourism market. At the current point, the currencies of all the neighboring countries are rigidly pegged at one to one basis to the South African rand (IMF, 2022a). The pula (in line with the current exchange rate policy framework pursued by Botswana) is the only currency in the region which is allowed to appreciate far beyond the point of parity with the South African rand. It would thus, be critical for policymakers to review this current exchange rate policy arrangement, if Botswana is to have any meaningful participation (or gain competitive advantage) in the regional tourism market. Last but not least, Botswana should intensify efforts to improve the depth, accessibility and efficiency of its financial markets, both the capital and foreign exchange markets. A well-developed financial system would help to facilitate a smooth transition to a floating regime, when such a time presents itself.

Chapter Four

PROSPECTS OF SUCCESSFUL EXCHANGE RATE REGIME TRANSITIONS IN RESOURCE DEPENDENT ECONOMIES

Abstract

This study explores the prospects of successful exchange rate regime transitions amongst the community of resource-dependent economies, which are currently operating fixed regimes in Sub-Saharan Africa, North Africa and the Gulf region. IMF institutional and operational requisite elements for a smooth float are used as core determinants in gauging the prospects of both orderly and disorderly transitions in these countries. The study first, estimates a Markov-switching panel model and a logistic regression, to determine the explanatory power of each requisite element considered in the transition simulations. The estimations cover a sample of over 90 countries with a fixed-to-float transition experience, at any point between 1995 and 2020. With the exception of only a few countries in the Gulf region, the study found that for most RDEs, their overall level financial market development and foreign currency risk exposure, do not currently portend well for a smooth transition. By implication therefore, a large pool of RDEs would most likely face dire macroeconomic consequences, if they were to exit their pegs today. It is thus, imperative for policymakers in RDEs to assess their economic vulnerability to exchange rate policy shifts, and put in place all the necessary measures to mitigate the risk of disorderly transitions.

1. INTRODUCTION

1.1 Background

We have observed from the preceding chapters of this thesis that, resource dependent economies (RDEs) are generally inclined towards fixed exchange rate regimes, supported by an abundance of foreign exchange reserves accrued from resource-export earnings. We also know from the fixed-to-float transition cases of some these countries that, most of them are not progressing fast enough, particularly with respect to the development of supportive elements for running credible and durable floating exchange rate regimes (Dabrowski, 2016; Gillet & Tisseyre, 2017). A framework by (Duttagupta, et al., 2004) (endorsed by the IMF Executive Board in December 2004)[40] identifies the following key institutional and operational elements, as crucial in supporting a successful transition to a floating regime. A well-developed foreign exchange (FX) market; adequate capacity by market participants to assess and manage exchange rate risk; identifying an alternative nominal anchor to replace the peg, and establishing adequate policy implementation capacity for the new anchor; formulating new foreign exchange intervention strategies for the float; as well as a liberalized capital account.

In the absence of these elements, transition from a fixed to a floating regime is highly likely to be disorderly, with dire macroeconomic consequences (Duttagupta, et al., 2004; Otker-Robe & Vavra, 2007). Such disorderly transition cases have been observed across a number of economies; e.g., emerging markets in 1997 (following the Asian currency crisis) and most recently, in RDEs during the 2014-2016 commodity price shock[41] (Asici & Wyplosz, 2003; Dabrowski, 2016; Gillet & Tisseyre, 2017). Hypothetical transition cases presented in chapter three of this thesis also shows that Botswana would also most likely face a disorderly transition, if the country's diamond sector was to experience any intense and long-lasting shock. Broadly,

[40] Referred to as the *IMF fixed-to-float guidelines or framework*, henceforth.
[41] See chapter 1, figure 1.1.

Botswana's level of foreign exchange market development and its financial sector depth, accessibility and efficiency, do not currently augur well for a smooth transition.

It would be insightful to know whether or not there are any countries currently operating fixed regimes amongst the community of RDEs, with reasonable prospects of transitioning in an orderly manner. It would also be of significant policy interest, particularly for RDEs which do not currently meet the minimum standards for a smooth float, to know, in which specific area(s) they fall-short. Accordingly, this study endeavors to extensively explore these issues, for a sample of RDEs across Sub-Saharan Africa, North Africa and the Gulf region.[42]

1.2 Motivation

In general, fixed exchange rate regimes predicated on the performance of commodity exports are not sustainable in the long run (Dabrowski, 2016). This is mainly because, commodity exports are highly susceptible to external demand shocks and volatile price swings (Dabrowski, 2016; Gillet & Tisseyre, 2017). Thus, depending on the severity and duration of external shocks that may hit the exporting country, foreign exchange reserves may come under severe stress, or at worst, become depleted. Policy interventions in the foreign exchange market to influence or defend the currency peg will become infeasible without sufficient stocks of foreign exchange reserve holdings. This was the experience of most oil-dependent economies during the 2014 – 2016 commodity price burst (IMF, 2015a; Dabrowski, 2016; Gillet & Tisseyre, 2017).[43] So, every RDE face an inherent risk and realistic prospects of exiting the peg at some point in time, either pushed-out by external shocks or depletion of resource deposits, although the latter is highly unlikely for most RDEs, especially in the foreseeable future.[44]

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42 These are the three most RDEs-dominated geographical regions across the world (World Bank, 2022).
43 This argument is also presented verbatim, in the first chapter of this thesis.
44 Resource deposits in most RDEs are adequate enough to last for many years to come, but not forever (Smit & Shirey, 2020)

1.3 Research Questions

The questions we seek to explore in this study are;

i. How high or low are the prospects of RDEs across Sub-Saharan Africa, North Africa and the Gulf region, transitioning in an orderly manner, if such transitions were to occur today?
ii. Which specific requisite element(s) for an orderly transition, are lacking across RDEs with low successful transition prospects?
iii. Do the findings established above, vary substantially across the three regions.

To address these questions, we first estimate a Markov-switching panel model (MSP) and a logistic regression, to determine the relative importance of key requisite elements for a successful float, outlined in the IMF's *Fixed-to-Float Guidelines*. Precisely, the models estimate the probability of transitioning from a fixed to a floating exchange rate regime, given a particular profile of IMF's requisite elements for a successful float. The estimations are based on a sample of 93 economies with a *fixed-to-float* transition experience (both orderly and disorderly), at any point between 1995 and 2020. Empirical evidence from these models is then applied to a sample of RDEs currently operating fixed regimes across the three regions of interest, to answer our research questions. To filter-out political noise in our analysis, which is common especially among the so-called resource-cursed countries, we only focus on RDEs with a good track record of both economic and political stability.

1.4 Contribution to Literature

Existing literature on this subject only provides conceptual guidelines on how to transition orderly to a floating regime, as well as country experiences (case study evidence) of both orderly and disorderly transitions (Duttagupta, et al., 2004; IMF, 2004; Otker-Robe & Vavra, 2007; IMF, 2015a; Gillet & Tisseyre, 2017; Hrifa, 2023). Our contribution is therefore, to consolidate evidence from these transition case studies, and estimate the likelihood of a smooth transition, given the level of requisite elements held at the time of exiting the peg. Consistent with our study objectives, the established empirical evidence is then applied to simulate the most probable transition outcome RDEs would face, if they choose or are forced to exit the peg today. The simulations take into account the prevailing level of development of the IMF's operational and institutional requisite elements for a smooth float, currently observed in each RDE.

A similar study, titled '*The Art of Gracefully Exiting a Peg*' was conducted by (Asici & Wyplosz, 2003). (Asici & Wyplosz, 2003) estimated charateristics associated with orderly transition cases, across emerging market and developing economies transitioning from pegged to floating regimes between the period 1975 and 2001. The study however, focuses on characteristics which we have already implicitly controlled for in identifying the ideal RDE sample for this study, i.e., macroeconomic characteristics and political factors. Estimations and transition simulations conducted in this paper thus, abstract from these specific factors. Moreover, (Asici & Wyplosz, 2003) came before the IMF *fixed-to-float framework* was adopted in 2004, which emphasizes the significance of structural factor over macroeconomic conditions in facilitating an orderly transition to a float. The IMF framework has subsequently been espoused in a vast number of related studies, among others; (Otker-Robe & Vavra, 2007; Durcakova, 2011; Hrifa, 2023).

The rest of the paper is organized as follows. The next section presents the literature review, Section 3 provides a detailed description of the data used in the study, and a brief discussion on stylized facts. Section 4 outlines our methodological approach, section 5 presents empirical results and apply them on a sample of RDEs covered in the study. Lastly, section 6 concludes the chapter and offers recommendations.

2. LITERATURE REVIEW

This study falls under the broad subject of *exchange rate regime choice*, founded on three main theories, namely; the Optimum Currency Area; Capital Account Openness; and Institutional and Political Characteristics hypothesis. We provide a brief review of these theories and related empirical evidence in sub-section 2.1, followed by conceptual literature, empirical and case study evidence, on exchange rate regime transitions in sub-section 2.2.

2.1 Exchange Rate Regime Choice

This sub-section explores both the theoretical and empirical determinants of exchange rate regime choice. Theories underpinning the choice of an exchange rate regime are founded on three main schools of thoughts; the Optimum Currency Area; Capital Account Openness; and Institutional and Political Characteristics hypothesis. The Optimum Currency Area (OCA), first developed by Mundell (1961) and later extended by (Mckinoon, 1963; Kenen, 1969; Fischer, 1974; Marston, 1981; Eichengreen, et al., 1998) ascribes the choice of exchange rate regimes to long-term macroeconomic fundamentals, as well as the magnitude and nature of external shocks countries are exposed to. The theory posits that, *ceterius paribus*, the higher the openness of the economy, the more amenable wages and prices will be to changes in the nominal exchange rate. Therefore, small and highly open economies will generally be inclined towards fixed exchange rate regimes, whilst large open economies will lean more towards flexible exchange rate arrangements (Mckinoon, 1963). (Eichengreen, et al., 1998) further argues that, high degree of trade openness implies high degree of vulnerability to external shocks, hence a strong case for a flexible nominal exchange rate to absorb the shocks.

The Capital Account Openness (CAO) or Currency Crisis hypothesis, relates the choice of an exchange rate regime to the country's level of integration with the global financial markets and the degree of openness of its capital account (Mundell, 1963; Fleming, 1962). According to the theory, countries which are deeply integrated with the global financial system and have perfect capital mobility statutes, can only choose between two mutually exclusive macroeconomic policy options; *exchange rate stability* or *monetary policy independence* (Mundell, 1963; Fleming, 1962). That is, a country can either (i) fix the exchange rate and give up monetary policy independence or (ii) allow the exchange rate to float and gain monetary policy independence. In the first option, under perfect capital mobility, the monetary authority cannot set domestic interest rates independently from the movements in foreign interest rates without causing excessive pressure (emanating from capital flows) on the exchange rate policy position or the stability of the peg.

The second option implies that, under perfect capital mobility, the monetary authority can use interest rates to smoothen short term fluctuations in output and drive inflation to target, while the free-floating exchange rate regime corrects for any imbalances that may be instigated by developments in the capital markets. This principle is commonly referred to as *the trilemma* or *impossible trinity*, based on (Mundell, 1963; Fleming, 1962).

The theory was in recent years propounded by the *Vanishing Intermediate Regime* hypothesis or *Bipolar view* (Obstfeld & Rogoff, 1995; Fischer, 2001). According to the bipolar view, intermediate exchange rate regimes or soft pegs in countries that are deeply integrated with global financial markets and have perfect capital mobility, are not sustainable in the long term (Fischer, 2001; Krugman, 1998). (Fischer, 2001), based on the financial and currency crises experience of some emerging market economies[45], observed an increasing tendency among affected countries (with the above attributes) to abandon their soft peg regimes, during or after the crises. Some countries transitioning to extremely hard pegs (currency board or monetary unions) while others, allowing their currencies to free float (Fischer, 2001).

[45] Mexico in 1994, East Asia in 1997, Russia in 1998, Argentina and Turkey in 2000.

The Institutional and Political Characteristics hypothesis on the other hand, is predicated on the notion that countries with persistent problems of political instability and weak macroeconomic institutions generally lack credibility in ensuring low and stable inflation, and hence may choose to peg their currencies to low inflation countries to gain credibility, but at the expense of monetary policy independence (Giavazzi & Pagano, 1988; Berger, et al., 2001). Fixing the exchange rate to a credible country with a low and stable inflation reputation will stir domestic inflation towards the inflation of the credible country; a phenomenon that will help to anchor inflation expectations and enhance credibility (Giavazzi & Pagano, 1988). However, (Milesi-Ferretti, 1995) argued against this thought process, indicating that, countries with consistent problems of political instability and weak macroeconomic institutions may choose to relinquish any commitment to enter into fixed exchange rate regimes due to lack of adequate foreign exchange reserves to support and defend the peg. (Rogoff, 1985) also does not support the notion that pegging the currency to a low and stable inflation country out-rightly assures credibility. According to (Rogoff, 1985), even after pegging the domestic currency to a low and stable inflation country, credibility will still depend on the degree of independence of the central bank (in terms of freedom from political or governmental persuasion in the formulation and implementation of monetary policy), and its attitude towards inflation in general.

Extensive empirical research exploring the external validity of these three theories has been conducted across different countries and regions (Papaioannon, 2003; Daly, 2011; Ondina, et al., 2011; Tahir, et al., 2016). The commonly used explanatory variables to capture choice determinants under the *OCA theory* are; trade openness (ratio of export and imports to GDP), geographical concentration of trade (proportion of trade with major trade partners), economic development (per capita GDP), economic size (real GDP); variables under the *CAO hypothesis* include; capital openness (ratio of capital inflows and outflows to GDP), international financial integration (capital controls); *Institutional and Political Characteristics hypothesis* variables *include*; political stability (democracy indicators, for example, the number of years the incumbent administration has been in office), central bank independence (legal independence and the frequency at which central bank governors are changed), external debt (ratio of foreign debt to GDP), foreign exchange reserve adequacy (ratio of foreign exchange reserves to imports) and the historical behavior of domestic inflation (Papaioannon, 2003; Daly, 2011; Ondina, et al., 2011; Tahir, et al., 2016).

Most of the studies employed discrete outcome estimation techniques to model this relationship between exchange rate regime choice and the postulated choice determinants. The general finding is that, the direction and significance of explanatory variables differ across countries, regions, and time (sample period); with exception of one variable *viz.*, economic size. (Daly, 2011) for example, explored the influence of exchange rate regime choice determinants laid-out by the three theories, in 17 Middle East and North African (MENA) oil-dependent economies, using binomial and multinomial probit models for a period spanning 1990 to 2000. Only two variables were found to be statistically significant and synonymous with fixed exchange rate regimes, that is, high level of economic development and foreign exchange reserves holding. With regard to foreign exchange reserve holdings, the study underscores that, since most MENA economies are oil-export dependent countries, high stock of foreign exchange reserves increases appeal and ensures sustainability of fixed exchange regimes (Daly, 2011). The findings are broadly in line with, (Kisu, 2010) on choice of exchange rate regimes for African countries; (Saif Al-Abri, 2014) looking at optimal exchange rate policy regime for a small oil-exporting country; and (Aliyev, 2014).

(Aliyev, 2014) assessed the choice of exchange rate regime in 145 RDEs using a multinomial logit model over the period 1975 to 2004. First, the study established that RDEs are generally inclined towards fixed exchange rate regimes. The study further found that, output volatility, adequate foreign exchange holdings, non-democratic political environment and non-independent central bank increases the likelihood of choosing fixed regimes in RDEs. With respect to lack of democracy, (Aliyev, 2014) argues that, corrupt governments are less accountable on how natural resource revenues are spent and rarely build sovereign wealth funds (to save some of the resources earnings for future use). Therefore, to mitigate exchange rate volatility stemming from inflows of resources earnings, fixed regimes are usually preferred.

2.2 Fixed-To-Float Exchange Rate Regime Transitions

Another important branch of literature on exchange rate regime choice, deals specifically with requisite elements for a smooth or orderly transition, from a fixed to a floating exchange rate regime (Duttagupta, et al., 2004; IMF, 2004; Otker-Robe & Vavra, 2007). (Duttagupta, et al., 2004) use the term *orderly transition* in the context of a shift from a fixed or intermediate exchange rate regime to a freely floating regime, characterized by negligible volatility or persistent downward or upward trend in both the exchange rate and the broader macro-economy. According to (Duttagupta, et al., 2004), countries transitioning in an orderly manner adequately prepares for the envisioned change. They work towards establishing a sound institutional and operational environment to support and enhance the prospects for efficient implementation and durability of the floating exchange rate regime.

This entails; developing a deep, liquid and efficient domestic foreign exchange market for effective price discovery; formulating foreign exchange intervention strategies consistent with the new regime; in the context of monetary policy, identifying an alternative nominal anchor of price stability; determining potential exchange rate risks and building supervisory capacity to manage the risks; liberalizing the capital account; and above all, effective and timely communication of the intended change in the exchange rate policy framework[46] (Duttagupta,

[46] To anchor credibility and financial stability in the economy, during and after the transition.

et al., 2004; IMF, 2004). On the contrary, disorderly transitions, which are often undertaken with immense pressure, occur under economic environments devoid of the institutional and operational elements outlined above. These transitions are commonly characterized by profuse exchange rate and broader macroeconomic volatility (Duttagupta, et al., 2004). This conceptual framework by (Duttagupta, et al., 2004), was formally endorsed by the IMF Executive Board in December 2004. Empirical literature on the framework is however, generally sparse. There is nonetheless, a number of case study evidence on the matter, which we discuss below.

Empirical and Case Study Evidence

(Asici & Wyplosz, 2003) estimated characteristics associated with orderly transitions, across a sample of 55 emerging market and developing economies transitioning from pegged to floating regimes, between the period 1975 and 2001. (Asici & Wyplosz, 2003) defines a transition outcome as orderly, if the depreciation in the nominal exchange rate six months after the exit, does not exceed the average depreciation six months before the exit, by 25 percent. Otherwise, the transition is deemed to be disorderly. The study considered the following explanatory characteristics; macroeconomic characteristics, political factors, as well as financial market development. Based on probit model estimations, the study made the following findings. First, the odds of a smooth transition increases with a stable political and macroeconomic environment. Secondly and most surprisingly, development in the financial markets is found to be harmful to the prospects of transitioning orderly. This is presumably because, capital flows are quite large and fast when financial markets are deep and efficient; which may be harmful to the transition, especially if the transition is undertaken under excessive market pressure (Asici & Wyplosz, 2003). This was the experience of most East Asian countries during the 1997 currency crisis.

So, contrary to conversional belief underpinning the two-corner solution,[47] (Asici & Wyplosz, 2003) argues that, maybe it would be prudent for countries planning to transition, to consider financial opening many years before de-pegging. The problem of small sample bias can however, not be ruled out from this specific finding. There is generally a high concentration of transition cases linked to the Asian crisis in the study sample. Another important finding made by the (Asici & Wyplosz, 2003), especially in the context of our study focus (RDEs transitions), is that, waiting too long to exit the peg in the face of a potential currency crisis, and losing substantial foreign exchange reserves while waiting, reduces the odds of transitioning in an orderly manner, but not considerably so. The estimated marginal effect is 4 percent in this regard. The study also found that, high incidence of exit cases in a given a year, lowers the odds of peaceful transitions across individual countries. This suggests strong contagion effects (Asici & Wyplosz, 2003).

(Duttagupta, et al., 2004) reviewed the nature of exchange rate regime transitions from; (i) hard pegs to bands (soft pegs) and floats (ii) from bands to managed floats, and (iii) from managed floats to free floats, between 1990 and 2001 for a sample of 139 countries. The study applied (Asici & Wyplosz, 2003) criterion and their own criterion, in defining orderly and disorderly transition outcomes. Using the (Asici & Wyplosz, 2003) criterion, the study identified 77 cases (55 percent) of disorderly transitions and 62 cases (45 percent) of orderly transitions. By their criterion, which declares a transition to be disorderly if the depreciation in the nominal exchange rate during the month of the exit, exceeds the depreciation in the past six months by more than two standard deviations, identified 84 disorderly transition cases (65 percent) and 55 orderly cases (40 percent). Majority of disorderly transitions were observed in emerging market and developing economies. With respect to orderly transition cases, most of the

[47] A fixed regime cannot be effectively operated with an open capital account (Mundell, 1963; Fleming, 1962).

countries with this transition profile shared the following structural characteristics; deep, liquid and efficient foreign exchange and capital markets; well defined policy frameworks governing the central banks' interventions in the foreign exchange markets; adequate exchange rate risk management capacity by financial and non-financial institutions, as well as a liberalized capital account (Duttagupta, et al., 2004).

Also, majority of orderly transition cases were associated with inflation targeting regimes relative to monetary targeting frameworks. According to (Duttagupta, et al., 2004), a reasonable inference could thus be made that, inflation targeting regimes are more effective and reliable alternative nominal anchors compared to monetary targeting. There are however, other countries that exited without any officially declared alternative nominal anchor, e.g., Singapore and Switzerland. Central Banks in these countries however, enjoy high public credibility which may be very difficult to earn in emerging market and developing economies (Duttagupta, et al., 2004).

(Otker-Robe & Vavra, 2007) undertook a comprehensive assessment of the fixed-to-float exchange rate regime transition of 9 developed, emerging market and developing economies between 1984 and 2000; Chile 1984 – 1999, Israel 1985 – 2005, Poland 1990 – 2000, Brazil 1999, Czech Republic 1996 - 1997, Uruguay 2002, Pakistan 1998 - 2000, Ecuador 1999 and Uzbekistan 2001. The study adapted (Duttagupta, et al., 2004) criterion of measuring orderly and disorderly transitions, modified to include cases of steep appreciations in the nominal exchange rate after the exit. Overall, the study found the transition case of Chile, Israel and Poland to be gradual and orderly, and the rest to be disorderly. The following elements or characteristics were observed amongst countries with an orderly transition experience to flexibility. A deep, liquid and efficient foreign exchange spot and forward markets, characterized by narrow bid-ask spread, relatively high turnover and lower transaction costs (Otker-Robe & Vavra, 2007). Turnover in the foreign exchange derivative market for example, had increased from around 0.06 percent of GDP at the beginning of the transition process in Chile, to 1.4 percent at the time of exiting the peg, from 0.15 percent to 7.7 percent in Poland and from 0.001 percent to 0.6 percent in Israel (Otker-Robe & Vavra, 2007).

Secondly, capacity in the corporate and financial sector to assess and manage exchange rate risk exposure, had increased substantially in these countries before the exit. Most of their exchange rate risk exposures were hedged onshore and/or offshore before the exit. Furthermore, their foreign currency denominated asset quality had improved substantially towards the exit period, and well within their respective country prudential limits (Otker-Robe & Vavra, 2007). Thirdly, the countries had gained adequate experience in operating alternative monetary policy regime, particularly inflation-targeting framework, before exiting the peg. According to (Otker-Robe & Vavra, 2007), almost all countries which transitioned orderly had gained reasonable experience in conducting monetary policy in a relatively high exchange rate flexibility environment, under the intermediate regimes. In addition, most of the supportive elements of a full-fledged inflation targeting regime were in place before the exit. These include, Central Banks' capacity to model and forecast inflation, and a well-developed money market to support monetary policy implementation. Most of these Central Banks enjoyed high public credence, and inflation expectations were thus, well-anchored when the ultimate decision to exit the peg was taken in these countries (Otker-Robe & Vavra, 2007).

Furthermore, new foreign exchange intervention strategies/policies under a flexible exchange rate regime were formulated in most of these countries, before completely de-pegging. The policies focused mainly on instilling and promoting credibility on the float, through explicit and detailed communication of each intended intervention (De Gregorio & Tokman, 2004; Otker-Robe & Vavra, 2007). Last but not least, virtually all the restrictions on capital mobility, were lifted by the time of the exit. Meanwhile, (Otker-Robe & Vavra, 2007) established that virtually all cases of disorderly transitions were undertaken with immense pressure, under economic environments devoid of the institutional and operational elements outlined above. Turnover in the foreign exchange derivative market for example, was below 1 percent of GDP for most of these countries, save for Brazil and Czech Republic, which markets boomed shortly before the exit (Otker-Robe & Vavra, 2007). Financial and corporate institutions in most of these countries also lacked capacity to manage foreign exchange risk exposure.

While prudential and supervisory frameworks were already in place in some of these countries before the transition, the frameworks however, did not deal specifically with foreign exchange risk exposure. There were no foreign currency prudential requirements before the float, in Pakistan, Ecuador and Uzbekistan, for example (Otker-Robe & Vavra, 2007). Institutional and technical capacity to shift to a credible alternative nominal anchor was also limited in most of these countries. Although most of the countries opted for an IT framework after the float, they however, lacked essential supportive elements for the framework to be credible, e.g., clear constitutional mandate to pursue price stability (central bank independence), modelling and forecasting capacity and well-developed financial markets to support monetary policy implementation (Otker-Robe & Vavra, 2007). The study also observed that the severity of the disorderly transitions varied across these countries. Countries with reasonably developed FX market and low FX risk exposure experienced relatively moderate exchange rate and macroeconomic volatility (i.e., Brazil and Czech Republic), whilst transitions were severely disorderly in countries where institutional and operational weakness were profound.

(Otker-Robe & Vavra, 2007) also assessed the prospects of a successful transition in Ukraine, which had begun the process of shifting towards a more flexible exchange rate regime in 2007. The desire to transition was mainly motivated by the increasing challenge in maintaining a fixed currency, under an open capital account and rising foreign exchange inflows[48].

[48] Inflows largely from the 2003-04 above average rise in global metal prices, Ukraine's major export commodity (National Bank of Ukraine, 2005).

According to (Otker-Robe & Vavra, 2007), while significant efforts were undertaken by the Ukrainian authorities towards flexibility, e.g introduction of an exchange rate band, establishment of essential elements for an IT regime and liberalizing the capital account, further efforts were still needed to increase the odds of a smooth transition. In particularly, foreign exchange and financial markets were substantially underdeveloped, and the financial sector was highly exposed to foreign exchange related-risk. Foreign-currency denominated loans for example, were over 40 percent of total lending in the banking sector (Otker-Robe & Vavra, 2007).

A similar study was recently conducted by (Hrifa, 2023), assessing the prospect of a successful fixed-to-float transition in the economy of Morocco, given the current level of development of its financial markets and other supportive institutional elements for a durable float. The study, based on comparative analysis of past transition cases across the world, found that, Morocco may still need to wait for a while, as the ground is not yet fertile to support a successful transition to a credible and durable floating regime. We undertake a similar assessment in this study, focusing on RDEs across Sub-Saharan Africa, North Africa and the Gulf region.

Summary of the Literature Review

Table 4.1 below summarizes all the case study evidence presented under this section.

Table 4.1: Degree of Preparedness for Transition											
Supportive elements for an orderly floating Regime	Morocco (2023)	Kazakhstan (2015)	Uruguay (2002)	Uzbekistan (2001)	Pakistan (1999)	Ecuador (1999)	Brazil (1999)	Czech Rep (1996)	Poland (1995)	Israel (1992)	Chile (1989)
(1) Foreign Exchange (FX) Market Development											
Turnover & Bid-Ask Spread											
Spot Market	√1	√1	√2	√3	√2	√2	√1	√1	√1	√1	√1
FX Derivative Markets	√3	√3	x	x	x	x	√3	√1	√1	√1	√1
(2) FX Risk Management											
FX Derivative Markets/ Hedging Instruments	√3	√3	x	x	x	x	√3	√2	√1	√1	√1
FX-related Prudential and Supervisory Framework	√3	√3	x	x	x	x	x	√1	√1	√1	√1
(3) Alternative Nominal Anchor											
Implicit Inflation Targeting under soft pegs	√2	√3	x	x	x	√3	x	x	√1	√1	√1
Monetary Policy Implementation Capacity	√3	√3	x	x	x	x	√3	√2	√1	√1	√1

(4) Capital Account Liberalization	√	√	√	x	x	√	√	√	√	√	√
Overall Transition Outcome	Still Waiting	Disorderly	Disorderly	Disorderly	Disorderly	Disorderly	Disorderly	Disorderly	Orderly	Orderly	Orderly
Pace of the Transition and Exit Trigger	N/A	Fast (crisis)	Fast (crisis)	Fast (crisis)	Fast (crisis)	Fast (crisis)	Fast (crisis)	Fast (crisis)	Gradual (Planned)	Gradual (Planned)	Gradual (Planned)
Post-Exit Changes in the Nominal Exchange Rate from the Central Rate (Targeted under the peg)	N/A	Large	Large	Very Large	Very Large	Very Large	Moderate	Moderate	Small	Small	Small

Note: √1 developed, √2 moderately developed, √3 under-developed, X non-existent
Source: (Hrifa, 2023; Otker-Robe & Vavra, 2007; IMF, 1997-2019)

3. DATA DESCRIPTION AND STYLISED FACTS

The study uses data on a sample of 93 economies with a *fixed-to-float* transition experience at any point between 1995 and 2020[49], to estimate our transition models. Empirical evidence from these models is then applied to simulate the potential transition outcome of 17 RDEs currently operating fixed exchange rate regimes in Sub-Saharan Africa, North Africa and the Gulf region. Almost all these RDEs do not have any fixed-to-float transition experience, hence reliance on evidence from the empirical models. The study thus, has two separate samples; (i) the estimation sample of 93 economies with actual *fixed-to-float* transition experience, referred to as the *training sample*[50] henceforth, and (ii) the simulation sample of 17 RDEs, most of which have not experienced any fixed-to-float transition in their lifetime. Cases of fixed-to-float transitions are also identified in two distinctive ways, namely, *Reported* and *Unreported* transitions. Reported transitions are officially declared exchange rate regime changes from *hard and soft pegs* to either *managed or independent floating* regimes. These policy regime changes are captured in a series of IMF annual reports on *Exchange Arrangements and Exchange Restrictions*. Unreported transitions on the other hand, are undeclared exchange rate regime changes, observed directly from the evolution of the nominal exchange rate overtime. The classification is based on the (Ghosh, et al., 1997) criterion[51].

It is important however to underscore that, officially declared transitions are also covered under *unreported* transition cases, except that, such transitions under this classification are identified by the actual behavior of the nominal exchange rate at the time of the exit, rather than de jure declaration of exchange rate regime change (which is the case under *reported* transitions). Empirical estimations are conducted in a binary logit model under reported transition cases,

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49 Data on most of the model variables in the pre-1995 period, is unavailable.

50 Because we use the estimates produced from the sample to parameterize our simulation model.

51 (Ghosh, et al., 1997) criterion classifies exchange rate regimes on the basis of observed behavior of the nominal exchange rate overtime, NOT what is officially declared by the authorities as the prevailing regime, the so-called *de jure* classification.

similar to (Asici & Wyplosz, 2003), and in a Markov-switching model for unreported cases. Below is a list of all the variables used in our empirical models and their corresponding data sources. The choice of the model variables is informed by extant literature on this subject matter, which is extensively discussed in the preceding section above.

Table 4.2. Model Variables

Variables	Description	Source
Response variable Nominal Exchange rate Transition Outcome	*Reported transitions* A binary variable that assumes the value, 1 if transition is orderly 0 if transition is disorderly. The classification of orderly and disorderly transition outcomes is based on the Duttagupta, et al., (2004) criterion. *Unreported Transitions* Annual change in the nominal exchange rate of country *i* against the US dollar over time.	IMF, World Bank
FX Market Development	Size of derivative market (annual turnover) as a percentage of GDP, at the point of exiting the peg.	BIS
Financial Sector Exchange Rate Risk Exposure	Ratio of foreign liabilities to foreign assets, at the point of exiting the peg	IMF, BIS
Alternative Nominal Anchor	Based on the degree of flexibility of the exchange rate regime in place before the transition.[52] Categorical Variable 1 if exchange rate pre-floating is soft pegged (i.e., crawling-pegs and pegged within horizontal bands) 0 otherwise	IMF, Central Banks' Reports
Monetary Policy Implementation Capacity under the New Anchor	Financial Market Development Index, range from 0 to 1.	IMF

52 The degree of flexibility of a pegged regime according to (Otker-Robe & Vavra, 2007), may signify efforts to move towards alternative anchors compatible with full-fledged floating regimes.

Capital Account Restrictions	Binary Variable 1 if there are No Restrictions 0 otherwise	IMF
Foreign Exchange Intervention Policy	Proxied by the level of Foreign Exchange Reserve holdings at the point of exiting the peg.[53]	World Bank

The use of proxy variables mainly reflects the unavailability of direct measurement variables for certain indicators. There are however, substantive benefits presented by some of the chosen proxies, particularly those that are linked to more than one requisite element, e.g., size of derivative markets and financial market development index. The size of derivative markets for example, reflects both the level of foreign exchange market development, as well as availability of instruments to hedge against exchange rate risk exposure. Financial market development index is also an encompassing proxy, for the level of development in the foreign exchange market, capital markets and money markets.

Stylized facts

The discussions below analyze frequency distributions of transition outcomes, and the corresponding level of requisite elements for a smooth float, observed at the time of exiting the peg. The analysis covers both reported and unreported transition cases. It should be noted however that, unreported transition outcomes (both orderly and disorderly transitions) are endogenously estimated under the Markov-switching framework. The frequency distribution of unreported transition cases presented in this section is thus, a simplified approximation, which does not accurately match the actual estimated transitions under the Markov model.

53 Information on the availability of foreign exchange intervention policies is quite sparse across our sample. The essence of the chosen proxy is that, before a country formulates any intervention strategy, it should, at the very least, hold some level of foreign reserves at the point of exiting the peg.

Reported Transition Cases

Based on the criterion we use to define *reported* orderly and disorderly transition outcomes (Duttagupta, et al., 2004), there are about 60 percent cases of orderly transitions and 40 percent cases of disorderly transitions, from the training sample. We also observe a strong positive association between orderly transition cases and foreign exchange market development (turnover in derivative markets), availability of alternative nominal anchor, overall financial market development, capital account openness, as well as high level of foreign exchange reserve holdings. These observed correlations are consistent with both conceptual literature on *fixed-to-float* transitions and related case study evidence. Empirical estimates in the upcoming sections, are however, much more conclusive on the direction and significance of these correlations.

Table 4.3 Summary Statistics

	Orderly Float	Disorderly Float
Transition Outcome	59.7	40.3
Derivative Market Turnover (Percent of GDP)	7.69	0.19
Foreign Exchange Risk Exposure	0.50	3.2
Alternative Nominal Anchor (Percent)		
❖ Soft pegs pre-floating	85.6	14.4
❖ Hard pegs pre-floating[54]	30.1	69.9
Financial Market Development Index	0.73	0.18
Capital Account Liberalization (Percent)	68.9	31.1
Foreign Exchange Reserve Holding	2.5	1.6

Note: Values on transition outcomes, alternative nominal anchor and capital account liberalization are proportions, and the rest are averages.

[54] Include conventional pegs, which are classified under soft pegs in the IMF annual reports on *Exchange Arrangements and Exchange Restrictions*. However, the margin of currency flexibility under this regime is quite narrow (less than ±1 percent) for what the variable is intended to reflect in this study.

Unreported Transition Cases

Table 4.4 below presents a matrix of transition incidents from pegged regimes to orderly and disorderly floating regimes. Pegged regimes entail both hard and soft pegs, as define in the IMF annual reports on *Exchange Arrangements and Exchange Restrictions*. Orderly and disorderly floating regimes classifications are based on the Duttagupta, et al., (2004) criterion. Transition incidents follow a first-order Markov process. That is, for all the three states or exchange rate regimes, the transition matrix provides the frequency of time the exchange rate was in state *j* in the previous year (period *t-1*), followed by state *k* in the current year, *t*. See also Figure I.a in appendix I.

Table 4.4. Transition Incidents

	Pegged State	Orderly State	Disorderly State
Pegged State	1292	81	52
Orderly State	80	48	57
Disorderly State	150	58	456

Overall, the transition incident matrix shows that, moving away from pegged regimes is generally a rare occurrence. Between 1995 and 2020, there have only been about 130 *fixed-to-float* transitions incidents; 81 of which were orderly and 52 were disorderly transitions. The frequency of transition incidents reflected by the matrix, is broadly similarly to officially reported cases in Table 4.3. However, the matrix reveals much more substantive insights on the dynamics of these transitions. Precisely, we observe that, a pegged regime is almost an 'absorbing state'[55] of the three exchange rate regime categories. Secondly, the matrix shows that, it is quite common for countries to be trapped in a disorderly floating state. There are over 400 observed incidents of countries remaining in a disorderly floating state for more than two consecutive years. Chapter one and two of this thesis, dealt at length with the macroeconomic

[55] A safe state that once entered, it is rarely abandoned for another state.

costs of such a phenomenon. These include, hyperinflation, high interest rates, subdued economic growth, and a substantial rise in the country's foreign-debt burden.

Another equally important observation is that, disorderly transitions seldom stabilize into orderly floats. The frequency of transitions from a disorderly state to orderly floats (58), are about 3 times fewer (150) than re-pegging from a disorderly state. It is thus, reasonable to infer that, disorderly transitions are generally quite difficult to correct (into an orderly float), at least in the short term. Overall, it is quite difficult to relate the transition incidents to the covariates of interest (i.e., IMF requisite elements for a smooth float), as we did under reported transitions in Table 4.3. For this case, transition incidents are not a once-off thing (which is the case in Table 4.3), and hence, complex to correlate with covariates using simple frequency tables. The correlations (between transition incidents and IMF requisite elements) are however, reliably estimated under the Markov-switching regression model, in section 5.

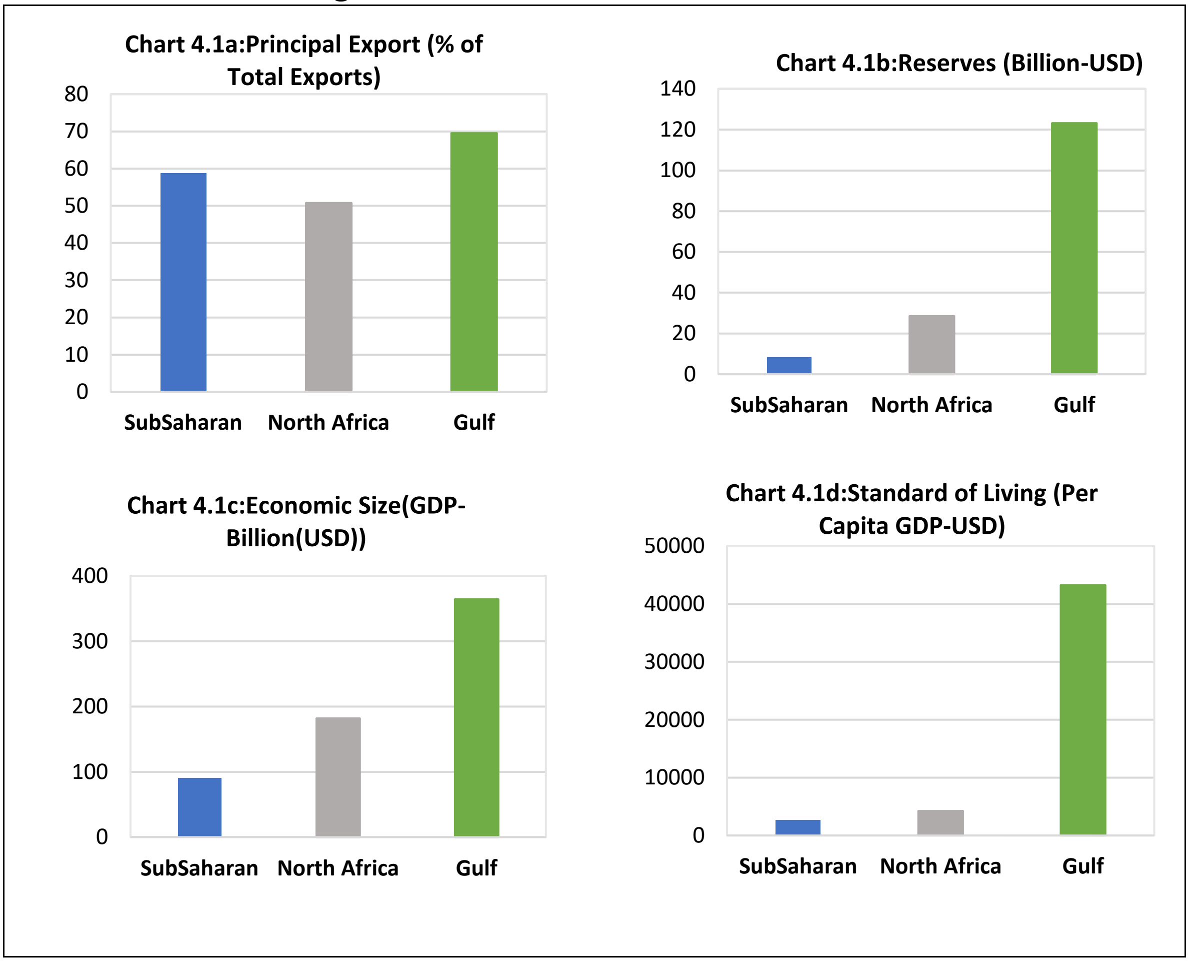
Institutional and Operational Requisite Elements for an Orderly Transition in RDEs

To contextualize variations in the level of development of requisite elements across RDE regions of interest in this study, it is important to first, present a snapshot of their macroeconomic profile (Figure 4.1). We have surveyed the following countries in each region; Sub-Saharan Africa - Botswana, Lesotho, Namibia, Nigeria, Mozambique, Tanzania and Zambia; North Africa – Algeria, Egypt, Mauritania and Tunisia; Gulf – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates (UAE).[56] Chart 4.1a shows the degree of resource dependency across the regions. We observe that, resource dependency is generally high in the Gulf and Sub-Saharan region. The principal export commodity in the Gulf region is oil, which account for about 70 percent of total exports in the region (World Bank, 2022). Resource exports in Sub-Sahara are quite diversified, and include oil, metals and precious

[56] Economic and political stability indicators for each individual RDE is presented in Figure I.b (appendix I).

stones (World Bank, 2022). Meanwhile, chart 4.1b – 4.1d reveals the economic superiority of RDEs in the Gulf region over their peers in Sub-Sahara and North Africa. On average, the level of foreign exchange reserves held by RDEs in the Gulf region, their economic size and quality of life, is substantially higher that the prevailing levels in the two African regions combined.

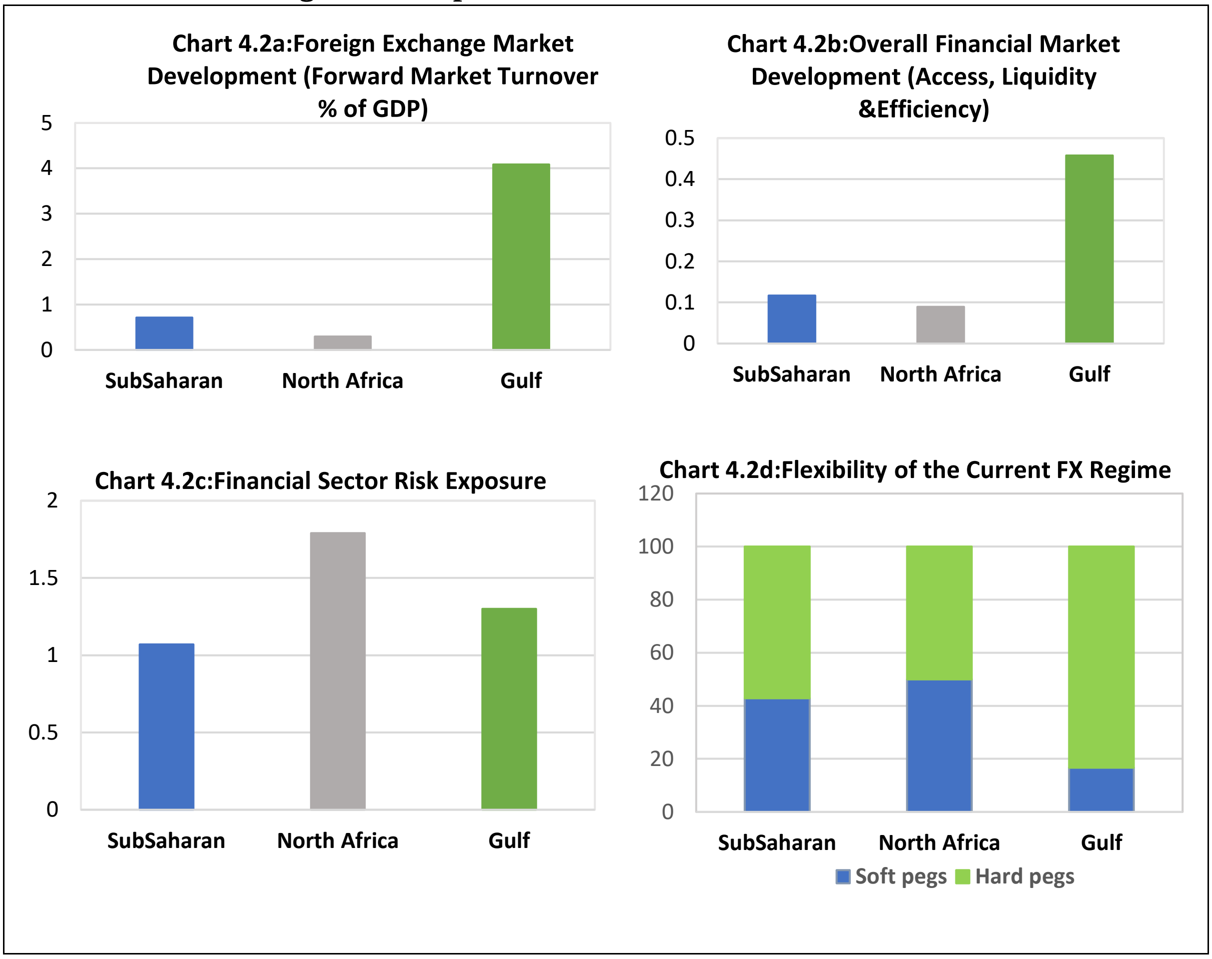
Figure 4.1: Macroeconomic Profile of RDEs



Source: World Bank

The level of requisite elements for an orderly transition across the three RDE regions (between 2019 and 2022) is presented in Figure 4.2 below. The Gulf region on average, has a relatively high level of foreign exchange and financial market development, compared to the other regions (chart 4.2a and 4.2b). The level of foreign exchange risk exposure is however, relatively lower in Sub-Saharan Africa (chart 4.2c), and quite high in the North African region. With respect to the degree of flexibility of the exchange rate regime currently in places across the three regions, high degree of flexibility (mainly crawling pegs) is generally observed across the Sub-Saharan and North African regions. Gulf countries seem to be more inclined towards hard pegs[57], a phenomenon that to large extent, reflects the substantially high level of foreign exchange reserves held in the region.

Figure 4.2: Operational & Institutional Elements



Source: BIS and IMF

57 Conventional pegs, in particular. Whereby, the domestic currency is anchored to a currency or basket of currencies of trading and financial partners, within margins of less than ±1 percent (IMF, 2020).

4. METHODOLOGY

This section presents analytical models used in this study, namely; a *Markov-switching (MS) model* for unreported transitions, which also serves as a baseline approach, and a *logistic model* for reported transitions. The MS model is chosen as a leading or baseline framework primarily because of its comprehensiveness in addressing the core objectives of this study. The model is able to identify turning points in the data (i.e., orderly and disorderly regime transitions); relate the turning points to the covariates of interest, i.e., IMF institutional and operational requisite elements for a smooth float; and estimate the probability of transitioning from one regime to another, given a particular profile of these covariates. Regime change or transitions, are identified by the actual behavior of the nominal exchange rate, rather than *de jure* exchange rate regime re-classifications. The binary logit model on the other hand, deals much more with orderly and disorderly exits, rather than continuous recurring transitions. For each country in the training sample, we classify (outside the model) whether an officially declared exchange rate regime change was orderly or disorderly. The classification is based on Duttagupta, et al., (2004) criterion. The model then relates the regime-change outcome to the covariates of interest, as observed at the time of the exit. This approach is similar to (Asici & Wyplosz, 2003).

A standard procedure adopted to address our main objectives is as follows. First, we produce empirical estimates from the sample of countries with actual *fixed-to-float* transition experience (*training sample*), using the models discussed above. The established empirical evidence is then applied to predict counterfactual transition probabilities for RDEs of interest in this study. The predictions take into account the prevailing level of development of operational and institutional requisite elements for a smooth float, currently observed in each RDE. It is important to recall that, most RDEs covered in this study do not have any fixed-to-float transition experience, hence reliance on empirical evidence from the training sample.

We also estimate a *threshold-switch model*, to establish factors that could potentially trigger an exchange rate regime change, particularly amongst the community of RDEs. Literature shows that, broadly, there are two main potential transition triggers in RDEs, i.e., external shocks and cases of planned transitions (see chapter one). Planned transitions in RDEs are however, very rare (Dabrowski, 2016; Gillet & Tisseyre, 2017). The most common transition triggers in these economies are found to be external shocks to the principal export commodity sector, and the effects thereof on the optimal level of foreign exchange reserve for running stable pegs, the so-called *foreign exchange reserve adequacy*.[58] Against this background, we estimate foreign exchange reserve adequacy for RDEs. That is, the level of foreign exchange reserves below which, it is impractical to fix the domestic currency. The estimation is based on a subset of countries from the training sample, with an established history of reserve-dependency in their foreign exchange and international trade policy design. A detailed description of each of these three models, is discussed below.

4.1 Markov-Switching Model

Markov-switching models (Goldfeld & Quandt, 1973; Hamilton, 1989; Hamilton & Owyang, 2012; Bartolucci, et al., 2014) are widely used in economic research to model processes which exhibit different behavioral patterns, across unobserved states. The probability of the process transitioning from one state to another, follows a Markov chain, and in our specific case, we assume the response variable (nominal exchange rate) undergoes three possible states; i.e., a *fixed state*, an *orderly floating state* and a *disorderly floating state*. We use the (Ghosh, et al., 1997) exchange rate regime classification criterion, to define the three states. Accordingly, a *fixed state* is identified by infrequent or absence of adjustments in the nominal exchange rate, from its central rate; and for an *orderly floating state,* the nominal exchange rate is frequently

[58] See IMF policy papers (2011, 2013, 2015 and 2023).

but moderately fluctuating, whilst under *disorderly floating state*, the nominal exchange rate exhibits high volatility.

Our interest therefore, lies primarily in estimating the probability of transition from a fixed state to any of the two floating states, and how the covariates of interest in this study affect these transitions. We provide below, a brief description of the general Markovian framework in the context of our problem, as well as the actual estimated Markov model, adapted from (Bartolucci, et al., 2014).

General Markov-Switching Framework

The specific model of interest in our case, is a Markov-switching panel (MSP) model, similar to (Kaufmann, 2010; Hamilton & Owyang, 2012; Bartolucci, et al., 2014). In the model, we have $P(\ p=1,\dots,P)$ sample observation of covariates of interest for each i^{th} individual country in the training sample $(i=1,\dots,N)$, over time period $T(\ t=1,\dots,T)$. The dependent variable for the i^{th} country at any given time, y_{it}, is a function of a state-dependent intercept, and exogenous covariates specific to that country. There are, as already alluded, $k=1,2,3$ possible unobservable states, country i can assume at any given point. A general model can be formulated as follows;

$$y_{it} = \mu_k^i + \sum_{p=1}^{P} \beta_{p,kt}^i X_{p,it} + \varepsilon_{ikt} \quad for\ k = 1,2,3 \tag{4.1}$$

Where y_{it} is the quarterly log-differenced nominal exchange rate *log* $(y_{i,t} - y_{i,t-1})$, for country (i) at time period t, μ_k^i are individual country means under each state, $X_{p,it}$ are covariates of interest, $\beta_{p,kt}^i$ are state dependent parameters and ε_{ikt} are independently and identically distributed normal errors with mean zero and state-dependent variance σ_k^2.

MSP model (1.1) assumes a non-constant mean and variance in the evolution of the response variable y_{it}, across the three states. Thus, it is presumed that, when $k=1$ the evolution of y_{it} is drawn from a $N(\mu_1^i, \sigma_1^2)$ distribution, when $k=2$ the distribution of y_{it} is $N(\mu_2^i, \sigma_2^2)$, and

y_{it} is $N(\mu_3^i, \sigma_3^2)$ distributed, when $k = 3$, (Engel & Hamilton, 1990; Kaufmann, 2010). Unlike some models of a mixture of normal distributions, wherein the y_{it} are independent, in this class of models, transition probabilities (which we discuss below), provides guidance on the distribution y_{it} is likely to be drawn at time t, if the distribution at time $t-1$ is known.

Transition Probabilities

Transition from one state to another, follows a first order Markov chain, where by the probability that $s_{i,t}$ is equal to $k \in (1, 2, 3)$ depends on the most recent realized state, $s_{i,t-1}$. This transition probability is represented by;

$$P(s_t = k \mid s_{t-1} = \bar{k}) = p_{\bar{k}k}$$

Where $s_{i,t}$ and $s_{i,t-1}$ are the current and previous states assumed by y_{it}.

The probability for the initial state is assumed to be given by $\rho_k = P(s_0 = k)$, i.e., the ergodic probability for $s_0 = k$ (Hamilton, 1989). All the transition probabilities from our model can be collected in a 3 x 3 transition matrix P, which governs the evolution of the Markov chain.

$$\mathrm{P} = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix}$$

Each row of matric P must sum up to 1, and consistent with the specific objectives of this study, our interest lies mainly in the transition probabilities captured by the elements of the first row, in particular p_{12} and p_{13}. p_{12} is the probability of the exchange rate transitioning to an orderly floating state in the next period, given that it is currently in a fixed state. Likewise, p_{13} is the probability of transitioning to a disorderly floating state in the next period, given that the exchange rate is currently fixed. Meanwhile, p_{11} is the probability of remaining in a fixed regime, and it can be loosely interpreted as a measure of persistence or longevity of a pegged regime (Masson, 2001). While the elements outside the first row may not be that relevant to the overall objective of this study, they do however, still carry an intuitive and meaningful interpretation. For example, p_{31} is the probability of the exchange rate transitioning to a fixed state, given that it is in a disorderly floating state in the current period. Intuitively, this transition case is likely to occur if for example, a country running a fixed exchange rate regime experiences a substantial fall in its foreign exchange reserves (maybe due to an intense external shock), and transition to a disorderly floating state. If it manages to replenish its stock of foreign exchange reserves after some time, it is then reasonable to assume that, in order to stabilize the economy, the country may seek to transition back from a disorderly floating state, to a fixed state.

Empirical Model Formulation

We follow the approach by (Bartolucci, et al., 2014) in the formulation of our empirical Markov-switching panel model. The model posits existence of a latent process Z^T, which is a function of the covariate vector X^T. The latent process follows a first order Markov chain with K number of states. The evolution of the response variable Y^T, is conditional on this latent process. The Bartolucci, et al., (2014) approach thus, comprises two main components; a *measurement model*, which is the conditional distribution of Y^T given Z^T, and the *latent model*, which concerns the distribution of Z^T given covariate vector X^T. The full description of the framework is provided under appendix G.

Transition Simulations/Predictions for RDEs across the Three Regions

Using empirical estimates from the training sample, we predict the floating state (i.e., orderly or disorderly floating state) each RDE covered in the three regions of interest in this study, would most likely transition to, if they were to exit the peg today. The predictions take into account the prevailing level of development of operational and institutional requisite elements for a smooth float, observed in each country. The predictions are simulated under the restriction that, the state assumed by each RDE in time period $t-1$ is known, and in accordance with actual reality, it is a *fixed state* i.e., $\overline{k}=1$.

$$\widehat{p}^{RDE^{i}}(k|\,\bar{k},\ x_i^{RDE}) = \hat{\gamma}_{0\bar{k}k} + x^{'}\hat{\gamma}_{\bar{k}k} \quad for\ k = 1{,}2{,}3\ and\ \bar{k} = 1 \tag{4.2}$$

Where, x_i^{RDE}, is the 3-year average for each operational and institutional requisite element of RDE i, and $\hat{\gamma}$ are estimated parameters from the training model.

4.2 Logistic Regression Model

As already alluded above, this model is implemented for reported transition cases, and it is estimated as a binary logit model, which assumes the values; 1 if an officially declared transition from a fixed exchange rate regime to a floating regime is orderly; and 0 if the transition is disorderly. We follow (Duttagupta, et al., 2004) criterion, in separating orderly from disorderly transitions. Converse to the Markovian counterpart model discussed above, the logit model is time invariant or a cross-sectional model. The model focuses only on the association between transition outcome *y* and the vector of covariates X, estimated at the actual point of the transition. This approach is the same as (Asici & Wyplosz, 2003), except that our study focuses on a different set of orderly transition determinants.

The functional form of the model is captured by equation (4.3) below, where the outcome variable y_i, is determined as a linear function of a vector of operational and institutional characteristics X_i.

$y_i = X_i\beta + u_i$, for *i = 1, 2, ..., N* (4.3)

Where u_i is an error term which we assume to be i.i.d with standard logistic distribution. The probability of country *i* experiencing transition outcome *j* is defined as follows;

$$y_i = j\begin{cases} j = 1, if\ country\ i\ transition\ experience\ is\ orderly \\ j = 0, if\ country\ i\ transtion\ experience\ is\ disordely \end{cases}$$

$$P(y_i = 1| X_i) = \Lambda(X_i\beta) = \frac{e^{(X_i\beta)}}{1+e^{(X_i\beta)}} \tag{4.4}$$

Where, Λ is the logistic cumulative distribution function (cdf). Parameter β is estimated using the maximum likelihood estimation technique, as described below.

The conditional density function of y_i given the vector of covariates X_i, is given by

$$f(y|X_i;\beta) = [\Lambda(X_i\beta)]^y\ [1 - \Lambda(X_i\beta)]^{1-y},\ \ y = 0, 1 \tag{4.5}$$

The log likelihood for observation i, is given by

$$l_i(\beta) = y_i \log[\Lambda(X_i\beta)] + (1 - y_i)[1 - \Lambda(X_i\beta)]$$

The log likelihood for N sample size is simply

$$L(\beta) = \sum_{i=1}^{N} l_i(\beta)$$

The maximum likelihood estimator $\hat{\beta}$, maximizes this log likelihood function.

Transition Predictions for RDEs across the Three Regions

The probability of an RDE i , experiencing an orderly transition outcome, given the level of development of its operational and institutional requisite elements for a smooth float is predicted as;

$$P(\hat{y}_i^{rde} = 1| X_i^{rde}) = \frac{e^{\left(X_i^{rde}\hat{b}\right)}}{1+e^{\left(X_i^{rde}\hat{b}\right)}} \tag{4.6}$$

Where $\hat{y}_i^{rde}$, is RDE i , $X_{i,s}^{rde}$ is the current level of development of operational and institutional elements of that RDE, $\hat{b}$ is a vector of estimated coefficients from the training sample.

4.3 Transition Triggers (Reserve Adequacy Threshold Model)

As already discussed, this is a standalone model that is not directly linked to the core objectives of this study. The main purpose of the model is to estimate the level of foreign exchange reserves below which a fixed exchange rate regime is likely to collapse, and trigger an exit or transition to alternative regimes.[59] The so-called *reserve adequacy threshold*. We then evaluate how far below or above each individual country's current level of foreign exchange reserves in our RDE sample, lies from the estimated threshold. A formal description of the estimation model, a *panel threshold regression (PTR) model*, is provided under appendix H.

Summary of the methodology

Table 4.5 below summarizes all the analytical models used in the study and the rationale behind each model.

59 Consistent with the general theme of this thesis, the implied alternative option is a floating regime.

Table 4.5: Summary of Methodology		
Model	Rationale	Specification
Markov Switching Panel Model (MSP)	❖ This is an all-encompassing model that covers transition incidents between 1995 and 2020, for a sample of 93 countries with a fixed-to-float transition experience. ❖ The transition incidents are observed directly from the evolution of the nominal exchange rate overtime, similar (Ghosh, et al., 1997). ❖ The model covers both cases of officially declared and undeclared exchange rate regime transitions. ❖ NB, officially declared transitions under this model are however, identified by the actual behavior of the nominal exchange rate at the time of the exit, rather than de jure declaration of exchange rate policy regime change (which is the case under the logistic model). ❖ The role of the MSP model is to estimate the likelihood of transition from one state to another (i.e., pegged state, orderly floating state and disorderly floating state) given a particular profile of conditioning variables (i.e. IMF requisite elements for a smooth float). ❖ The estimated coefficients from the model (i.e., transition logits) are then used to predict the likelihood of the 17 RDEs covered in this study, transitioning from a pegged state to either one of the two floating states. ❖ The predictions take into account the prevailing level of development of operational and institutional requisite elements for a smooth float, observed in each RDE. ❖ NB., none of the 17 RDEs covered in this study has any real-life *fixed-to-float transition experience*, hence reliance on empirical evidence from the MSP model to predict their most likely transition outcome, if they were to exit their pegs today.	❖ Panel Model ❖ Dependent variable: Annual change in the nominal exchange rate ❖ Independent Variable: IMF requisite elements for a smooth float (i.e., conditioning variables) ❖ The model output includes; conditional mean and variance of the response variable in each state or regime; initial and transition logits for the state variable; as well as the transition probability matrix.
Logistic Model (Binary logit model)	❖ The model focuses strictly on officially declared exchange rate regime change/transition; from a pegged state to a floating state. ❖ Classification on whether the transition was orderly or disorderly is based on the (Duttagupta, et al., 2004) criterion.[1] ❖ So, in contrast to the MSP approach, there is little room for measurement bias in both identification and classification of transition cases, under the logistic model.	❖ Cross-sectional Model ❖ Dependent variable: Transition outcome (1 for orderly transition and 0 for disorderly transition) ❖ Independent variables:

	❖ This is because (1) identification of regime change is taken as reported by the authorities, and (2) classification of the transition outcome is based on an established rule (Duttagupta, et al., 2004 criterion). ❖ The approach is however, narrow in scope, i.e., undeclared transitions are omitted from the analysis. This is precisely the reason we employ an alternative and much more comprehensive approach (i.e., MSP model). ❖ The estimated coefficients from the logistic model are however, applied to predict the transition probabilities for all the 17 RDEs in a similar manner described under the MSP approach.	IMF requisite elements for a smooth float.
Panel Threshold Regression Model (PTR)	❖ This is a standalone model that is not directly linked to the core objectives of this study. ❖ The purpose of the model is to estimate the level of foreign exchange reserves below which, a stable peg cannot be sustained (i.e., foreign reserve adequacy threshold). ❖ We then evaluate how far below or above each individual country's current level of foreign exchange reserves in our RDE sample, lies from this threshold. ❖ The analysis helps us to establish whether there are any foreign exchange liquidity challenges in any of our 17 RDEs, serious enough to potentially trigger an unplanned transition if the reserves are not replenished. ❖ The threshold estimation is based on a panel of countries with both; (1) a fixed-to-float transition experience; (2) an established history of reserve-dependency in their foreign exchange and international trade policy design.	❖ Panel Model ❖ Dependent variable: Annual change in the nominal exchange rate ❖ Threshold variable: Foreign exchange reserves ❖ Independent variable: IMF requisite elements for a smooth float (control variables).
1. (Duttagupta, et al., 2004) classification criterion declares a transition to be disorderly if the depreciation in the nominal exchange rate during the month of the exit, exceeds the depreciation in the past six months by more than two standard deviations; otherwise the transition is declared orderly. This is the criterion adopted in the IMF (2004) Fixed-to-Float Guidelines.		

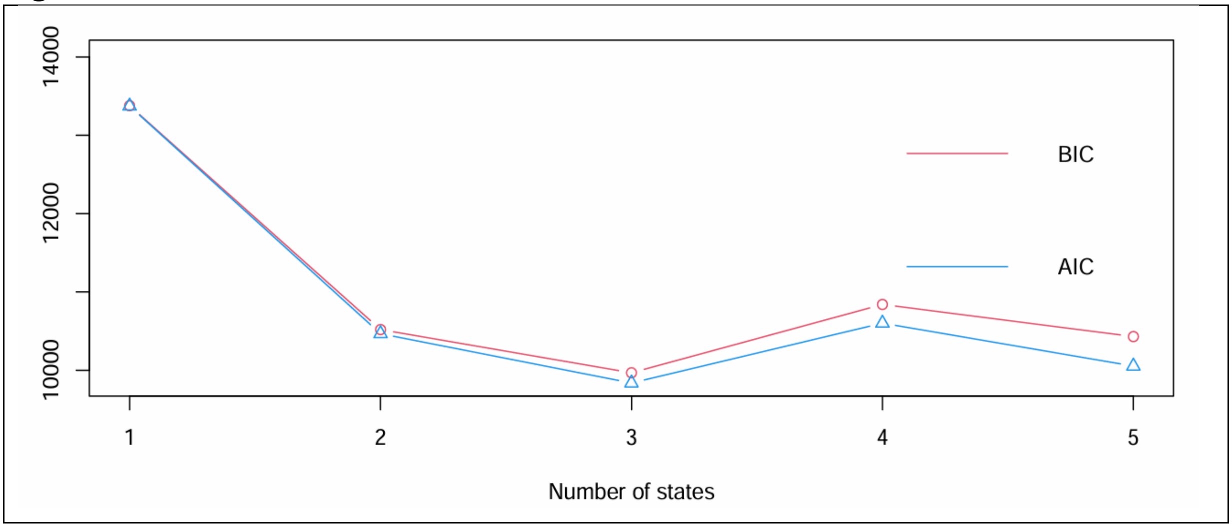
5. ESTIMATION RESULTS AND PREDICTIONS

This section presents empirical evidence from all the three models estimated in this study. Established evidence is then applied to predict the most likely transition outcome across RDEs of interest. Empirical estimates from the Markov-switching model are presented under subsection 5.1, followed by the logistic model estimates in subsection 5.2, and the threshold model results in 5.3.

5.1 Markov-Switching Model: Empirical Estimates

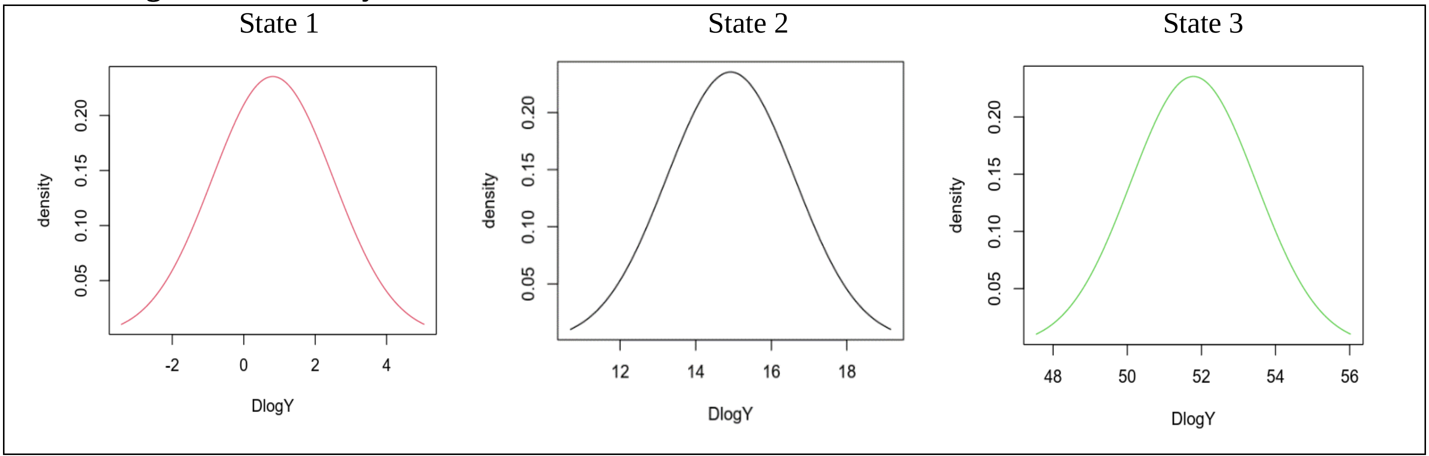
The most critical estimate under this framework, is the number of latent states K the response variable undergoes over time. According to both the BIC and AIC information criteria (Figure 4.3), there are approximately three exchange rate states or regimes, implied by observed data (i.e., annual change in the nominal exchange rate).

Figure 4.3: Model Selection



The estimated number of states corresponds to a priori definition of the state space adopted in this study, i.e., *pegged state*, *orderly floating state* and *disorderly floating state*. The density functions below, describe how the response variable is distributed across these three states.

Figure 4.4: Density Functions



The probability density functions from the estimated Markov-switching model show that, the annual average depreciation (appreciation)[60] of the nominal exchange rate against the reference currency (USD), is around 0 percent under state 1, 14 percent under state 2 and 52 percent under state 3. By implication therefore, under an orderly *fixed-to-float* transition, the exchange rate deviates from an average annual depreciation of 0.8 percent in the previous year, to a depreciation of around 14 percent in the following year. Similarly, under a disorderly transition, the exchange rate switches from an average depreciation of 0.8 percent in the previous year, to an average depreciation of more than 50 percent in the following year. The estimated *mean and standard deviation* of each state are statistically significant (Table 4.6), and broadly consistent with extant empirical evidence (and stylized facts) on exchange rate regime transitions (Asici & Wyplosz, 2003; Duttagupta, et al., 2004; Otker-Robe & Vavra, 2007).

Markov-Switching Model Results

Table 4.6 below presents the estimated results from the Markov-switching regression model. The results include; initial logits of falling within either one of the two extreme exchange rate regimes (i.e., pegs and disorderly floats) at the beginning of the sample period (orderly float is

60 We refer only to exchange rate depreciation henceforth, which is the most common outcome under both orderly and disorderly transition cases.

the base category); transition logits from a pegged regime to orderly and disorderly floating regimes; as well as conditional mean and standard deviation of the response variable across the three regimes.

Table 4.6 Regression Estimates[61]

	Initial Logits		Transition Logits	
	Pegged State	Disorderly Floating State	Orderly Floating State	Disorderly Floating State
FX Market Development	0.0003 (0.6308)	0.012 (0.0117)**	0.002 (0.0001) ***	-0.024 (0.0000)***
Financial Market Development	0.006 (0.0002)***	0.111 (0.0001)***	0.002 (0.0018) ***	-0.054 (0.0000)***
FX Risk Exposure	0.001 (0.6472)	-0.192 (0.0001)***	-0.005 (0.0000) ***	0.001 (0.0208)**
Alternative Nominal Anchor	0.012 (0.1114)	-0.7723 (0.0203)**	0.003 (0.0001)***	-0.224 (0.0000)***
Reserves	0.001 (0.1716)	-0.481 (0.0001)***	0.001 (0.0000) ***	-0.118 (0.0038)***
Intercept	0.074 (0.0001)***	0.611 (0.0001)***	-0.293 (0.0000) ***	-0.436 (0.0000)***
Conditional Response Mean and Standard deviation				
	Mean	Sigma		
Pegged State	0.813 (0.0000)***	0.507 (0.0001)***		
Orderly Floating State	14.923 (0.0000)***	3.127 (0.0000)***		
Disorderly Floating State	51.785 (0.0000)***	13.538 (0.0000)***		
Model Convergence Summary				
LogLikelihood	K (No of States)	AIC	BIC	N x T (Sample Size)
-4866.724	3	9837.449	9968.014	2366

Note: *Brackets are P-values*, ***, **,* signifies statistical significance at 1%, 5% and 10% level, respectively.

The estimated initial logits show that, in general, there is a low tendency to fall within the disorderly floating state for countries with high foreign exchange risk exposure, high foreign exchange reserves and alternative nominal anchors, at the beginning of the sample period. With respect to transition logits, the estimated results are broadly consistent with both conceptual literature on *fixed-to-float* transitions and related case study evidence (IMF, 2004; Hrifa, 2023; Otker-Robe & Vavra, 2007). In particular, the estimated transition logits show that, the

[61] Full results are presented in appendix J.

likelihood of transitioning from a peg to an orderly floating state increases with; high level of development in both foreign exchange markets and the broader financial system (overall financial market development); low foreign exchange risk exposure; availability of alternative nominal anchor to replace the peg; and high foreign exchange reserve holdings. Most of the estimated correlations are strongly statistically significant, and the model converges to a mode of the log-likelihood that corresponds to the global maximum. The estimated transition probability matrix is discussed below.

Transition Probability Matrix

	Pegged State	Orderly State	Disorderly State
Pegged State	0.49	0.47	0.04
Orderly State	0.95	0.04	0.01
Disorderly State	0.55	0.13	0.32

According to the estimated transition probability matrix of the training sample, there is almost an equal chance of remaining pegged (49 percent), and transitioning from a peg to a floating regime in an orderly manner (47 percent). It is however likely that, the model fails to draw a clear distinction between pegged regimes and orderly floating regimes. This classification bias could particularly be true for soft pegs with very wide flexibility bandwidth (e.g. ±5 percent from the policy target rate). In the same way, orderly floating currencies with very low annual depreciation/appreciation rates against the reference currency (between 0.5 and 1 percent for example), may be misclassified as pegged. This is perhaps one of the unavoidable shortfalls of the (Ghosh, et al., 1997) exchange rate regime classification criterion. That, currencies that are *de facto* pegged or orderly floating may be subjected to classification bias, particularly if their movements over time, closely resemble characteristic properties of the counterpart regime.

This bias however, does not extend to disorderly floating regimes, wherein the estimated mean and standard deviation is very high (Table 4.6), and manifestly distinguishable from the other two regimes. Notwithstanding, a case could still be made that, all pegged and orderly floating regime, even of special types[62], require strong fundamentals estimated in Table 4.6 to remain credible and sustainable.[63] The classification bias is thus, inconsequential, at least with respect to the overarching objectives of this study. Meanwhile, the transition probability matrix also shows that, disorderly floats are quite persistent in nature. The probability of remaining within this state for two consecutive years, is estimated at approximately 32 percent. Moreover, the transition matrix reveals that, disorderly transitions rarely stabilize into orderly floats. Most countries would rather backtrack to a pegged state, than to attempt to correct a disorderly float. The estimated probability of transitioning from a disorderly state to a pegged state, is about 4 times more than the corrective transition (of moving from a disorderly float to an orderly floating state). In general, the estimated transition probability matrix implied by the Markov-switching model, is largely consistent with the transition incident matrix presented under section 3. Predicted transition incidents from the model are presented under appendix J, and closely reflect the transition probability matrix above.

Transition Simulations - RDEs Sample

Table 4.7 below presents the simulated transition probabilities for each RDE in Sub-Saharan Africa, North Africa and the Gulf region, given the prevailing level of development of operational and institutional requisite elements for a smooth float, currently observed in each country. The simulations are based on the estimated transition logits from the training sample, presented under Table 4.6. We use a heat map to highlight how far above or below each RDEs' requisite element for a smooth float, lies from the ideal level.[64] Accordingly, a green code signifies that the current level of the requisite element is adequate to support a smooth transition, whilst the red code signifies the opposite. Likewise, green coded transition outcomes

62 E.g., soft pegs with wide flexibility bandwidth and orderly floats with very low fluctuation margins.

63 A soft peg with very wide flexibility bandwidth for example, would generally require strong supportive elements for a float, to remain sustainable (and resilient from speculative attacks).

64 Training sample averages observed under orderly transition cases are used as benchmarks (see Table 4.3).

are orderly floats and red coded transitions are disorderly floats. The simulations are conducted under the following assumptions pertaining to the RDEs' level of foreign exchange reserve holdings, at the point of exiting the peg; (i) *RDEs hold the current observed level of reserves* (ii) *RDEs level of reserves are below the reserve-adequacy threshold, estimated under the panel threshold model*.

Table 4.7 RDEs Predicted Transition Probabilities

Country	FX Market Development	Financial Market Development	FX Risk Exposure	Alternative Nominal Anchor	Reserves	Orderly Transition Probability	Disorderly Probability	Remain Pegged	Orderly Transition Probability	Disorderly Probability	Remain Pegged
Benchmark	**7.69**	**0.73**	**0.50**	**1**	**2.50**	**With Current level of Reserves**			**Without Reserves**		
Botswana	0.95	0.23	1.50	1	6.10	0.27	0.26	0.47	0.27	0.42	0.31
Lesotho	0.66	0.00	2.07	0	3.94	0.15	0.36	0.49	0.15	0.47	0.38
Namibia	0.88	0.09	0.99	0	4.23	0.32	0.30	0.38	0.32	0.41	0.27
Nigeria	0.91	0.20	0.99	0	4.66	0.32	0.29	0.39	0.32	0.41	0.27
Zambia	0.54	0.19	0.38	1	3.07	0.34	0.34	0.32	0.34	0.40	0.26
Mozambique	0.29	0.09	0.88	1	2.07	0.33	0.36	0.31	0.33	0.41	0.26
Tanzania	0.24	0.01	0.68	0	7.70	0.33	0.25	0.42	0.33	0.43	0.24
Sub-Saharan Africa	**0.64**	**0.12**	**1.07**	**0**	**4.54**	**0.29**	**0.31**	**0.40**	**0.29**	**0.42**	**0.29**
Mauritania	0.50	0.01	1.97	1	5.41	0.23	0.30	0.48	0.23	0.44	0.33
Algeria	0.15	0.00	3.27	0	16.20	0.14	0.12	0.74	0.14	0.48	0.38
Egypt	0.35	0.29	0.60	0	4.38	0.36	0.29	0.35	0.36	0.40	0.24
Tunisia	0.18	0.06	1.31	1	4.07	0.29	0.31	0.40	0.29	0.43	0.29
North Africa	**0.30**	**0.09**	**1.79**	**0**	**7.52**	**0.25**	**0.25**	**0.50**	**0.25**	**0.44**	**0.31**
Qatar	3.95	0.60	0.37	0	5.86	0.40	0.22	0.38	0.40	0.36	0.24
UAE	7.27	0.55	0.95	0	3.80	0.35	0.27	0.38	0.35	0.35	0.30
Kuwait	4.17	0.25	3.11	0	10.32	0.15	0.19	0.66	0.15	0.45	0.40
Bahrain	7.38	0.48	0.69	0	2.03	0.36	0.31	0.33	0.36	0.35	0.29
Saudi Arabia	0.71	0.54	1.90	0	20.93	0.24	0.06	0.70	0.23	0.43	0.33
Oman	1.03	0.32	0.77	0	5.40	0.35	0.26	0.39	0.35	0.40	0.25
Gulf	**4.09**	**0.46**	**1.30**	**0**	**8.06**	**0.31**	**0.21**	**0.48**	**0.31**	**0.39**	**0.30**

Benchmark values are averages observed under orderly transition cases from the training sample, see Table 4.3.
RDEs values for each requisite element (i.e., FX Market Development, Overall Financial Market Development, FX Risk Exposure and Reserves) are individual country averages between 2019 and 2022.

The predicted transition probabilities show that, RDEs with underdeveloped financial markets, foreign exchange markets and high foreign exchange risk exposure, have a lower probability of transitioning smoothly to a floating exchange rate regime. The predictions further indicate that, without adequate foreign exchange reserve holdings[65], it is almost impossible to remain within a pegged regime, and the risk of experiencing a disorderly transition becomes highly elevated. Overall, there are very few countries, mostly in the Gulf region, predicted to have a reasonable chance of orderly transitioning to a floating regime.[66] The level of foreign exchange market development, overall financial market development and foreign currency risk exposure in these specific RDEs, generally augur well for an orderly transition. However, because of the substantially high level of foreign exchange reserves held in the region, there seem to be limited interest in trying-out exchange rate arrangements that allows for high degree of currency flexibility. A strong possibility of orderly transitions in the Gulf region is thus, largely undermined by lack of appetite to move towards intermediate exchange rate arrangements, as well as alternative nominal anchors that are compatible with floating regimes.

Logistic Regression Model: Empirical Estimates

From the general model, only three explanatory variables were found to be statistically significant in explaining transition outcomes of interest. These are, foreign exchange market development, financial market development and the level of foreign exchange risk exposure. The empirical estimations discussed in this section are thus, based only on these specific requisite elements for a smooth float. Broadly, the model produces results which are fairly consistent with the estimated transition logits from the MSP model (discussed above).

65 Of 2 months of import cover estimated in the PTR model.
66 Arbitrarily, probability of 35 percent and above.

Table 4.8 Regression Estimates

	Coefficients	Marginal Effects
FX Market Development	0.246 (0.093)*	0.054 (0.045)**
Financial Market Development	0.045 (0.000)***	0.010 (0.000)***
FX Risk Exposure	-0.0113 (0.031)**	-0.003 (0.061)*
Intercept	-0.451 (0.323)	
Number of observations	129	
Prob > chi2	0.0000***	
Pseudo R2	0.2991	
Predicted Transition Outcomes		
Orderly Transition		*Disorderly Transition*
61.9 Percent		38.1 Percent

Note: *Brackets are P-values*

Table 4.8 above provides a summary of the estimated binary logit model, based on the abovementioned requisite elements for a smooth float. The estimated coefficients are broadly in line with the IMF conceptual framework on requisite elements for an orderly fixed-to-float transitions, as well as related case study evidence (Duttagupta, et al., 2004; Otker-Robe & Vavra, 2007; Hrifa, 2023) and fairly consistent with results presented in Table 4.6 under the MSP model. The estimated results show that, holding all other factors constant, countries with a high level of foreign exchange market development, overall financial market development and low foreign exchange risk exposure, are more likely to experience an orderly transition to a floating regime. Based on the estimated marginal effects, a 1 percent increase in the level of foreign exchange and financial market development, increases the likelihood of a country transitioning in an orderly manner by 5 percent and 1 percent, respectively.

A 1 percent increase in the level of foreign exchange risk exposure on the contrary, undermines the likelihood of an orderly transition by 0.3 percent. Meanwhile, the predicted transition outcomes by the model, are close to the actual observed averages presented in Table 4.3 (i.e., for the training sample). The estimated model thus, behaves fairly well, and it is applied to predict the most likely transition outcome across our RDEs sample.

Table 4.9 RDEs Predicted Transition Probabilities

Country	FX Market Development	Financial Market Development	FX Risk Exposure	Reserves	Orderly Transition Probability	Disorderly Transition Probability
Benchmark	**7.69**	**0.73**	**0.50**	**2.50**		
Botswana	0.95	0.23	1.50	6.10	0.13	0.87
Lesotho	0.66	0.00	2.07	3.94	0.02	0.98
Namibia	0.88	0.09	0.99	4.23	0.20	0.80
Nigeria	0.91	0.20	0.99	4.66	0.21	0.79
Zambia	0.54	0.19	0.38	3.07	0.28	0.72
Mozambique	0.29	0.09	0.88	2.07	0.20	0.80
Tanzania	0.24	0.01	0.68	7.70	0.24	0.76
Sub-Saharan Africa	**0.64**	**0.12**	**1.07**	**4.54**	**0.18**	**0.82**
Mauritania	0.50	0.01	1.97	5.41	0.07	0.93
Algeria	0.15	0.00	3.27	16.20	0.02	0.98
Egypt	0.35	0.29	0.60	4.38	0.26	0.74
Tunisia	0.18	0.06	1.31	4.07	0.13	0.87
North Africa	**0.30**	**0.09**	**1.79**	**7.52**	**0.12**	**0.88**
Qatar	3.95	0.60	0.37	5.86	0.53	0.47
UAE	7.27	0.55	0.95	3.80	0.57	0.43
Kuwait	4.17	0.25	3.11	10.32	0.05	0.95
Bahrain	7.38	0.48	0.69	2.03	0.65	0.35
Saudi Arabia	0.71	0.54	1.90	20.93	0.08	0.92
Oman	1.03	0.32	0.77	5.40	0.26	0.74
Gulf	**4.09**	**0.46**	**1.30**	**8.06**	**0.36**	**0.64**

Table 4.9 presents the probability of RDEs transition orderly to a floating regime, given their current level of foreign exchange market development, overall financial market development and foreign exchange-related risk exposure. In general, the results show that, at the current point in time, only few RDEs in the Gulf region face a decent change of transitioning to a floating regime in an orderly manner. In particular, the prospects of an orderly transition are quite high for Qatar, UAE and Bahrain, and much higher than the predictions under Table 4.7. We also observe that Saudi Arabia (the biggest economy in the Gulf region) has an elevated risk of experience a disorderly transition. This is mainly because of its high foreign exchange

exposure and undeveloped foreign exchange forward markets.[67] This essentially implies that, Saudi's foreign exchange risk exposure is not adequately hedged. We highlight under the literature review that, it is primarily the confluence of these two factors (i.e., high foreign currency risk exposure and limited hedging instruments) that was at play in instigating and exacerbating the currency-crisis across emerging market economies, in East Asia, Europe and Latin America during the 90's and early 2000's.

The prospects of orderly transitions in the Sub-Saharan and North African regions are also substantially low. This is mainly on account of underdeveloped foreign exchange and financial markets, as well as substantially high foreign exchange-related risk exposure (particularly in countries like Algeria, Tunisia, Lesotho and Botswana).

Foreign Exchange Reserve Adequacy Threshold

Results on reserve adequacy threshold for operating fixed exchange rate regimes are shown in Table 4.11 below. It is worth noting that, IMF policy papers (2011, 2013, 2015 and 2023) construct similar reserve adequacy metrics, based on months of import cover, ratio of reserves to short-term debt, ratio of reserves to broad money, and a combination of a wide variety of other relevant indicators. The *months of import cover-based metric* by the IMF, which is comparably close to the one used in this study, estimates reserve adequacy threshold at 3 months of import cover. Our study estimates 2.2 months of import cover (Table 4.11). The main contrast between the two indicators is that; import cover by the IMF concerns the level of reserves below which imports cannot be sustained, whilst our estimated indicator, deals with the level of reserves below which fixing the domestic currency becomes infeasible.

[67] Annual turnover in the country's foreign exchange forward markets (as a percent of GDP) is 0.7 percent, relative to a benchmark average of 7.9 percent. Saudi Arabia's foreign exchange risk exposure (ratio of foreign liabilities to foreign assets) is also quite high at 1.9, compared to a benchmark average of 0.5.

Meanwhile, covariates used in the model (Table 4.11), are not that crucial to the estimation of the threshold, but they carry intuitively meaningful signs nonetheless. That is, institutional factors such as foreign exchange market development and overall financial market development do not vary with the level of foreign exchange reserves. For the sample of countries covered in this model (mainly developing economies), both foreign exchange market development and overall financial market development are estimated to be low on both sides of the threshold.

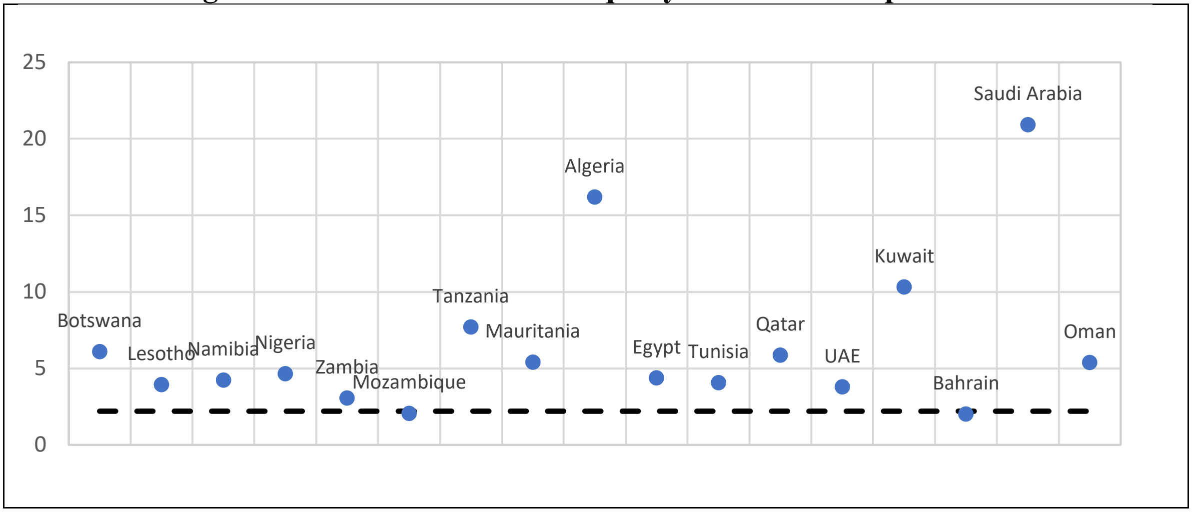
Table 4.11. Regression Estimates

		Below Threshold	Above Threshold
Lag		-0.245 (0.086)*	1.114 (0.029)**
FX Market Development		-0.049 (0.000)***	-0.113 (0.014)**
Financial Market Development		-0.099 (0.012)**	-0.195 (0.027)**
FX Risk Exposure		-0.027 (0.005)***	0.062 (0.084)*
Threshold	2.19 (0.000)***		
Number of Observation	N = 30 T = 19		
Number of moment conditions	357		
Bootstrap *p-value* for linearity test	0		

Note: *Brackets are P-values*

Figure 4.5 below shows the RDEs' average level of foreign exchange reserves (between 2019 and 2022) relative to the estimated reserve adequacy threshold. We observe that, the current level of foreign reserves for all RDEs lies above the estimated reserve adequacy threshold. Notwithstanding, reserves for most of these RDEs are quite low and very close to the threshold, with the exception of only a few countries, notably Saudi Arabia, Algeria and Kuwait. This however, should not be understood to imply an imminent threat to the collapse of any specific RDE's exchange rate policy framework. As observed in the past, cyclical upturns in global demand has the potential to bolster the current level of foreign reserve holdings, and by extension, durability prospects of the RDEs' pegged regimes.

Figure 4.5: RDE's Reserve Adequacy: Months of Import Cover



6. CONCLUSION AND RECOMMENDATIONS

This study explored the prospects of successful exchange rate regime transitions amongst the community of RDEs currently operating fixed regimes in Sub-Saharan Africa, North Africa and the Gulf region. IMF institutional and operational requisite elements for a smooth float are used as core determinants in gauging the prospects of both orderly and disorderly transitions in these countries. With the exception of only a few countries in the Gulf region, the study found that for most RDEs, their current level of foreign exchange market development, overall financial market development and foreign currency risk exposure, do not portend well for a successful transition to a float. By implication therefore, in the event of any substantive foreign exchange liquidity challenges, most RDEs considered in this study would likely face an unpleasant exchange rate regime transition, with dire consequences to their broader economic well-being.

Furthermore, the study found that the current level of foreign exchange reserve holdings for a large number of RDEs is quite low, and very close to the estimated *reserve-adequacy* threshold, of about 2 months of import cover. This however, should not be understood to imply an imminent threat to the collapse of any specific RDE's exchange rate policy framework. As observed in the past, cyclical upturns in global demand has the potential to bolster the current level of foreign reserve holdings, and by extension, durability prospects of pegged regimes. Notwithstanding, policymakers across all RDEs should however, be gravely concerned about the fast pace of disruptive technological inventions, which threatens to render most of the natural resources completely obsolete in the global value chain. Some of the inventions that are already markedly progressing and competing both directly and indirectly with resource exporting sectors include; artificial diamonds, electric-powered vehicles and green energy production technologies, just to mention a notable few.

It is imperative therefore, for policymakers in RDEs to begin to imagine and prepare for a future where pegged regimes, particularly those backed by commodity export earnings, are no longer feasible to effectively implement. As a necessary contingency measure, we recommend RDEs to fast-track efforts to develop requisite elements for operating alternative exchange rate regimes. If policymakers find floating regimes appealing, then a detailed guidance on the necessary ingredients for operating these regimes, is provided in the IMF's *fixed-to-float* framework of 2004. A catalogue of case studies presented in this chapter, particularly on orderly fixed-to-float transitions, also provide useful insights on *how, when and how fast* transitions to floating exchange rate regimes should be handled.

Chapter Five

MEASURING TRADE COMPETITIVENESS IN A RESOURCE-DEPENDENT ECONOMY OF BOTSWANA

Abstract

This study assesses the relative performance of different measures of the real exchange rate in explaining and predicting Botswana's trade flows over the period 2005q1-2020q4, using a single equation error correction model and a suite of model performance evaluation tools. The import-price real exchange rate is found to outperform other alternative measures of the real exchange rate. This identity of the real exchange rate shows a consistent, sensible and economically meaningful association with Botswana's trade flows, both in the short and long run. Meanwhile, the association between Botswana's trade flows and the CPI-derived real exchange rate (which is the current target variable in Botswana's exchange rate policy framework) is contrary to theory. We thus, recommend Botswana's exchange rate policymakers to start paying considerable attention to the trade competitiveness conditions implied by the import-price real exchange rate in their policy discussions. This is particularly important because, the import-price real exchange rate focuses mainly on the aspect of trade competition most relevant for countries with special trade features like Botswana, and other structurally identical resource-dependent economies.

1. INTRODUCTION

1.1 Background

Diversification of external trade away from commodity exports remains one of the most important economic policy agenda, for virtually all resource-dependent economies (RDEs) (Fosu & Abass, 2020; African Development Bank, 2021). In the specific case of Botswana, wherein the mineral sector (diamonds in particular) account for over 90 percent of total exports, economic diversification, as we have already discussed in chapter one and two, is anchored to the country's exchange rate policy framework. The policy framework seeks to promote competitiveness of non-commodity sectors by maintaining a stable real exchange rate (RER) of the pula against major trading partner currencies (Bank of Botswana, 2021). The RER is thus, a critical component of the policy framework, and its measurement and application is therefore crucial to achieve the desired policy ends. Measuring and applying the RER to gauge trade competitiveness of a country with special trade features like Botswana (or any other RDE) is however, not a simple and clear-cut matter. This study therefore, takes a deep look into this concept of the RER, focusing primarily on its reliability as an indicator of trade competitiveness of an RDE.

The RER, according to (Maciejewski, 1983), measures two main aspects of a country's relative competitiveness in international trade, namely; price and cost competitiveness. Various relative prices and cost deflators are used for each one of these two aspects of trade competitiveness, e.g., wholesale prices, export prices, unit labour cost, consumer price index (CPI) etc. The choice of the most appropriate price (cost) deflator to use according to (Maciejewski, 1983), should ideally be guided by the informational content of the deflator and the relevance thereof, to the specific aspect of trade competitiveness being measured.[68] What is of utmost importance however, is whether the RER derived from any deflator of choice has a sensible and economically meaningful correlation with the underlying developments in the country's balance of payments; the current account more precisely (Maciejewski, 1983; Ca' Zorzi & Schnatz, 2007; Ahn, et al., 2020). This is a critical test any RER identity should pass, to be considered as a reliable trade competitiveness indicator for any given economy (Ahn, et al., 2020).

1.2 Problem Statement

For many economies, the CPI-derived RER[69] has become a standard or core measure of the RER in both research and economic policy (Opoku-Afari, 2004; Ntwaepelo & Motsumi, 2019; Ahn, et al., 2020). This is largely the case across developing economies, where there is generally a paucity of alternative price and cost statistics with a comparable level of quality, timely periodic publications and historical availability as the CPI statistics (Opoku-Afari, 2004; Ntwaepelo & Motsumi, 2019). These limitations apply also to Botswana, which employs the CPI-RER as the core indicator of trade competitiveness in its exchange rate policy framework (Ntwaepelo & Motsumi, 2019; Bank of Botswana, 2020). Empirical evidence however, shows that this identity of the RER does not seem to be a reliable trade competitiveness indicator for the economy of Botswana. The nexus between the CPI-RER and Botswana's trade flows is quite ambiguous, with about three sets of conflicting empirical findings. One set of finding shows that, improvements in trade competitiveness (RER depreciation) has a positive and statistically significant impact on Botswana's trade flows (Ghura & Grennes, 1993; Koitsiwe

68 The most natural RER indicator of export price competitiveness for example, would be the one deflated by relative export prices, whilst the unit labour cost deflated RER would also be the most ideal measure of relative cost competitiveness conditions.

69 Measured as the differential between domestic and foreign CPI, adjusted by the nominal exchange rate. We refer to this definition of the RER as CPI-RER, henceforth.

& Adachi, 2015; Jeanneney & Hua, 2015). This finding is broadly consistent with the general theoretical proposition on this subject.[70]

Another set of empirical finding shows no significant relationship between the CPI-RER and developments in Botswana's trade account, and two main reasons are advanced in support of this finding (Modisaatsone & Motlaleng, 2013; Sebego, et al., 2020; Mndaka, et al., 2022). First, Botswana's external trade (as is the case with many RDEs), is dominated by mineral exports, whose demand is not amenable to exchange rate movements (Sebego, et al., 2020; Engel, 1999).[71] Secondly Engel (1999) argues that, even if mineral exports were amenable to exchange rate movements, for countries wherein the Balassa-Samuelson phenomenon is a significant feature of the economy, the CPI-RER may not serve as a good indicator of trade competitiveness. This is because, CPI statistics generally comprises a large share of non-tradable commodities (over 40 percent in the case of Botswana). So, if productivity differs considerable between the non-tradable and tradable sectors of the economy, then movements in the CPI-RER many not be a reliable approximation of competitiveness dynamics of the sector that is effectively competing in international markets, i.e., the tradable sector. The third and most interesting set of evidence shows that, the relationship between the CPI-RER and developments in Botswana's trade account is negative and statistically significant (Hussain & Haque, 2014; Nyahokwe, 2021; Mhaka, et al., 2023). Loosely put, improvements in trade competitiveness (RER depreciation), is found to have a harmful impact on Botswana's external trade performance.

[70] Imperfect-substitutes model of international trade by Goldstein and Khan (1985) and the expenditure-switching hypothesis (Obstfeld & Rogoff, 2001).

[71] Mineral exports are traded in global markets and invoiced in a single-standard currency (mainly the USD). Exchange rate movements therefore, cannot engender any competitive advantage to the exporting country (Durand & Giorno, 1987).

This finding has been invariably ascribed to the 'J-curve' phenomenon[72] (Hussain & Haque, 2014; Nyahokwe, 2021; Mhaka, et al., 2023). However, none of these studies provide evidence to show that the estimated nexus still stands, even when an alternative price (cost) measure of the RER is used (a robustness test of the so-called, 'J-curve' effects). Another plausible explanation (which is under-acknowledged in literature) is once again, the typical composition of the CPI basket of most RDEs. The CPI basket of most RDEs has a very large import-component, which may grossly distort the true association between the country's RER and trade flows. For example, a steep appreciation in the nominal exchange rate of the Pula against trading partner currencies, may dampen domestic headline CPI far below trading partner CPI.[73] At the face of it, the Pula is depreciating in real terms. This 'depreciation' is however, driven predominantly by the fall in the price of imports, and therefore, does not reflect a gain, but rather a potential loss in Botswana's competitiveness position (i.e., substitution of domestic produce for cheap imports).

A study by (Ntwaepelo & Motsumi, 2019) seems to suggest that the RER based on GDP deflators could possibly solve this problem, since GDP statistics net-off the value of imports. This inference was however not empirically tested, the study is entirely descriptive in its analytical approach. Moreover, we argue that, since the export-side of RDEs is almost perfectly inelastic to exchange rate movements (for reasons already given above), the only aspect of trade competition most relevant for RDEs, would be on the import side i.e., competition between non-commodity imports and equivalent (or similar) domestically produced substitutes. So, instead of using the RER that discard the price of imports (e.g., GDP deflator-RER), it would rather be ideal for RDEs like Botswana to use a RER measurement method that

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72 That is, RER depreciation only improves trade performance in the long run; the immediate or short-term impact of a RER depreciation on the trade account, according to the J-curve hypothesis, is negative (Magee, 1973).

73 Through the fall in the import-component of the domestic headline CPI basket.

focuses primarily on the import market, and competitiveness of domestic output therein. This study proposes such a RER identity, based on the relative prices of domestically produced goods and competing imported goods. Intuitively, this RER is expected to tell us to what extent, an increase (decrease) in the price of locally produced goods relative to imported goods, is likely to create a potential loss (gain) in the domestic market share of local producers (Durand & Giorno, 1987; Maciejewski, 1983). The implicit assumption here is that, domestic and imported goods captured in this proposed RER, are substitutable.

1.3 Contribution to Literature

The proposed RER is unique in that, it is entirely based on price statistics contained in Botswana's own CPI basket (imported CPI and domestic tradable CPI)[74], and excludes all commodities that are not subject to international competition (i.e., non-tradable and mineral commodities). This measurement method of the RER is primarily adapted for an RDE with a limited pool of price and cost statistics to construct alternative indicators to the CPI-RER. To the best of our knowledge, this is the first time this specific identity of the RER is used in international trade literature. Similar RER identities employ producer price indices (PPI) and wholesale prices (Lafrance, et al., 1998; Ca' Zorzi & Schnatz, 2007; Ahn, et al., 2020), statistics which Botswana does not yet produce.[75] On the downside however, there is generally a limited pool of domestically produced import-substitutes in the RDEs' CPI baskets. Also, the CPI does not cover the cost of imported intermediate inputs, which are embedded in the final market price of domestically produced import-substitutes. So, the proposed RER has its own inherent limitations[76], and its reliability over the current measure used by policymakers in Botswana

[74] Foreign price statistics and the nominal exchange rate are therefore, not needed since imported commodities are already captured in domestic currency in the CPI basket.

[75] Botswana's Statistic office currently (since 2017) produces PPI, but only for Mining, Electricity & Water Supply industries (Statistics Botswana, 2021).

[76] Substantive measures are however, undertaken to address some of these limitations. This issue is discussed in detail in subsequent sections.

(CPI-RER), can only be determined through empirical tests. We conduct such tests in this study, to answer the following research questions.

1.4 Research Questions

i. First, the study seeks to establish whether the proposed RER and the CPI-RER have a significant influence on Botswana's trade flows, and the direction of influence. In other words, what effect does the gain (loss) in trade competitiveness implied by each of these measures of the RER have on Botswana's trade account? We also add to these analysis, other alternative measures of the RER, which we are able compute with the current available statistics for the economy Botswana; namely, RERs based on GDP deflator and sectoral disaggregation of the CPI.

ii. Secondly, the study seeks to establish whether the proposed RER performs better in explaining and predicting Botswana's trade flows than the CPI-RER, and other alternative measures of the RER consider in the study.

We employ regression models and a suite of model performance evaluation techniques to address these research questions. Our interest is particularly on the import side of the current account (import flows), which is the most relevant for the proposed identity of the RER.

The rest of the chapter is organized as follows. The next section presents the literature review and hypotheses to be tested in this study. Section 3 provides data description and a brief discussion on stylized facts, section 4 outlines our methodological approach, section 5 presents and discusses empirical findings, and lastly, section 6 concludes the chapter and offers recommendations.

2. LITERATURE REVIEW

This section presents literature on measurement methods, merits and deficiencies of different RER indicators, as well as empirical evidence on the relative performance of these RERs in explaining trade flows. We provide a brief summary at the end of the section, and set-out hypotheses to be tested in this study.

2.1 Measurement Methods of the RER

The RER captures two main aspects of a country's relative competitiveness in international trade, namely, price and cost competitiveness (Maciejewski, 1983; Durand & Giorno, 1987). The RER as measure of price competitiveness simply tells us, how changes in the relative price of the home country's tradable goods to foreign competing goods, is likely to affect both the demand and international market share of domestic output (Maciejewski, 1983). Cost competitiveness on the other hand, reflects how changes in the general cost of production in the home country relative to trading partner countries, is likely to affect domestic firms' profit incentive to invest in the production of tradable goods, and thereby, affecting the country's aggregate trade flows (Maciejewski, 1983). There are various relative price and cost deflators of the RER, which we discuss below.

Price Competitiveness indicators

This aspect of trade competitiveness measures relative price competition in both imports and export markets, and there are distinct relative price proxies for each market.

Import Price Competitiveness

The import price competitiveness-based RER measures to what extent an increase (decrease) in the price of locally produced goods relative to imported goods, is likely to create a potential loss (gain) in the domestic market share of local producers (Maciejewski, 1983; Durand & Giorno, 1987). An ideal import price index would be the one that compares the domestic price of import substitutes with the average price of competing imports, adjusted by the nominal exchange rate (Maciejewski, 1983). A commonly used index is the *ratio of import unit value to home country's wholesale prices* (Maciejewski, 1983; Durand & Giorno, 1987; Turner & Jozef, 1993). In this case, the import price component is proxied by import unit value. According to (Maciejewski, 1983), to ensure comparability of the price components of this index, imported commodities which do not have domestic equivalent substitutes should be removed from the import component of the index. The domestic price component (wholesale prices) should also comprise only tradable goods subject to import competition (Maciejewski, 1983). The main conceptual benefit of this index is that, it can be computed without foreign statistics (Maciejewski, 1983; Turner & Jozef, 1993).

Some of the major drawbacks of this index however, are that, most of the imported goods have a limited pool of domestically equivalent substitutes (Turner & Jozef, 1993). The commodity coverage of the index may thus, be very narrow. Secondly, import unit values do not represent actual transaction prices, but rather average values per physical unit of the import basket (Turner & Jozef, 1993; Ca' Zorzi & Schnatz, 2007). Thus, a substantial change in the composition of the import basket can therefore affect average unit values, but without necessarily implying changes in relative competitiveness conditions (Turner & Jozef, 1993). Alternative measures include, the ratio of foreign and home country's wholesale prices; foreign wholesale prices and home country's CPI (excluding non-tradable goods); foreign and home country's PPI (Maciejewski, 1983; Turner & Jozef, 1993). Although these alternative measures represent actual transaction prices, there is however, generally lack of homogeneity[77] across countries, especially in the definition of wholesale price indices and PPI (Durand & Giorno, 1987; Turner & Jozef, 1993). Also, there is a paucity of high-quality data across many economies (in terms of international comparability, timely publication and historical availability) on these specific price statistics (Ntwaepelo & Motsumi, 2019). With respect to

[77] Particularly, with respect to commodity coverage and weighing schemes.

the CPI, a fundamental deficiency the index suffers as a proxy for domestically produced goods is that, it does not account for imported intermediate inputs, which are embedded in the final market price of domestic output (Maciejewski, 1983; Turner & Jozef, 1993; Ca’ Zorzi & Schnatz, 2007).

Export Price Competitiveness

The export price competitiveness based-RER measures to what extent an increase (decrease) in the price of domestically produced goods relative to foreign goods, is likely to create a potential loss (gain) in the foreign market share of domestic producers (Maciejewski, 1983). A relevant index would be the one that compares domestic export prices to foreign prices, adjusted by the nominal exchange rate (Maciejewski, 1983; Durand & Giorno, 1987; Turner & Jozef, 1993). The commonly used indices include, the ratio of *home country and foreign competitors’ export unit values* as well as the ratio of *home country and foreign competitors’ wholesale prices or PPI*. Both indices suffer similar conceptual weakness as their close equivalent indices under import price competition discussed above (Maciejewski, 1983; Turner & Jozef, 1993). In addition, export unit values has the weakness of only covering commodities which are effectively traded or exported, and miss other tradable commodities which could potential be exported if relative prices were more favorable (Maciejewski, 1983; Turner & Jozef, 1993; Ca’ Zorzi & Schnatz, 2007).

Cost Competitiveness

There are various relative cost indicators of the RER used to measure cost or profitability competitiveness conditions, these include; the ratio of the *home country’s unit labor costs, total unit cost, CPI, GDP deflator to those of foreign competitors* (Maciejewski, 1983; Turner & Jozef, 1993; Ca’ Zorzi & Schnatz, 2007; Ca’ Zorzi, et al., 2013). The costs are measured either for a segment of the economy (e.g manufacturing sector) or at aggregate level. The *unit labor costs, CPI and GDP deflator* are all proxies for total unit cost, but each suffer the following drawbacks. With respect to unit labour costs, the index only captures a fraction of the firms total production cost (Maciejewski, 1983; Turner & Jozef, 1993; Ca' Zorzi & Schnatz, 2007). So, it assumes that the incidence of other factor costs is closely similar across competing economies so that, changes in labour cost is the main driver of production cost differentials between competing countries (Maciejewski, 1983; Ca' Zorzi & Schnatz, 2007). These assumptions may not hold, especially for relative costs involving countries which are at vastly different stages of industrial development (Ca' Zorzi & Schnatz, 2007).[78]

The index based on CPI also suffers similar deficiencies. This index attempts to capture difference in producer costs between competing countries, induced by above-average increases in inflation (Maciejewski, 1983; Ca' Zorzi & Schnatz, 2007; Ahn, et al., 2020). It thus assumes, changes in the CPI have material bearing in the determination of the cost of factors of production. CPI statistics however, captures prices movements that may not reflect or be associated with production costs (imported consumer prices for example), and where CPI are relevant in the determination of production cost, the pass-through occurs with a considerable time lag (Ahn, et al., 2020).

Furthermore, for countries wherein the Balassa-Samuelson phenomenon is a significant feature of the economy, the CPI-RER may not serve as a good indicator of trade competitiveness (Engel, 1999). This is because, CPI statistics generally comprises a large share of non-tradable commodities, therefore, if productivity differs considerable between the non-tradable and tradable sectors of the economy, then movements in the CPI-RER many not be a reliable approximation of competitiveness dynamics in the tradable sector (Engel, 2003; Ca' Zorzi & Schnatz, 2007).

[78] Production is generally labour intensive in developing economies and more capital intensive in industrialized economies (Ca' Zorzi & Schnatz, 2007).

Developments in the non-tradable sector are however, also of considerable significance in other alternative broadly defined measures of cost competitiveness. Precisely, the sectoral RER, measured as the ratio of the *home country's price of non-tradable goods to tradable goods* (Maciejewski, 1983; Frohberg & Hartmann, 1997). The essence of this index is that, the price of tradable goods varies across countries mainly on account of difference in cost of non-tradable inputs involved in their production. So, the higher the cost of production of tradable commodities (proxied by the price of non-tradable commodities), the more likely domestic producers will be discouraged from investing in production of this goods (Frohberg & Hartmann, 1997).

Table 5.1 Summary of RER Indicators

<table>
<tr><th colspan="2">Price Competitiveness indicators</th><th>Costs Competitiveness Indicators</th></tr>
<tr><td colspan="2">• Measures relative price competition in both imports and export markets.</td><td rowspan="3">• Measures relative cost competitiveness conditions.
• The costs are measured either for a segment of the economy (e.g manufacturing sector) or at aggregate level
• Indicators include;
The ratio of the home country's unit labor costs, total unit cost, CPI, GDP deflator to those of foreign competitors (Maciejewski, 1983; Turner & Jozef, 1993; Ca' Zorzi & Schnatz, 2007; Ca' Zorzi, et al., 2013)</td></tr>
<tr><td>Import Price Indicators</td><td>Export Price indicators</td></tr>
<tr><td>ratio of home country's wholesale prices to import unit value; home country and foreign wholesale prices; home country's CPI (excluding non-tradable goods) and foreign wholesale prices; home country and foreign PPI (Maciejewski, 1983; Turner & Jozef, 1993)</td><td>ratio of home country and foreign competitors' export unit values; home country and foreign competitors' wholesale prices or PPI (Maciejewski, 1983; Durand & Giorno, 1987; Turner & Jozef, 1993).</td></tr>
</table>

In summary, correlation between all these identities of the RER irrespective of the specific aspect of competitiveness they measure, should at least on conceptual grounds, be reasonably high (Maciejewski, 1983; Turner & Jozef, 1993; Ca' Zorzi & Schnatz, 2007). Thus, the signals on the direction of competitiveness implied by different RER measures should be consistent for any given economy. This is broadly the case, especially in developed economies, but not much so in developing countries, where substantive contradictions are observed with the respect to the direction of competitiveness implied by different RER measures (Turner & Jozef, 1993; Ellis, 2001; Opoku-Afari, 2004; Ntwaepelo & Motsumi, 2019). For example, (Opoku-Afari, 2004) compared Ghana's level of trade competitiveness implied by RER based on the CPI and GDP deflators, and found episodes of inconsistencies in the graphical profile of these RER measures. (Motlaleng, 2004; Ntwaepelo & Motsumi, 2019) also observed sustained long periods of discrepancies, both in direction and magnitude of the level competitiveness implied by the RER based on CPI and GDP deflators, in the economy of Botswana.

The reliability of RERs of developing economies like Botswana, in signaling trade directions can thus, only be conclusively determined through empirical test. Precisely on how the movements of each RER identity are closely linked or associated with the country's trade flows. The next sub-section zooms-in on this matter.

2.2 Relative Performance of different RER Measures: Empirical Evidence

This sub-section presents a survey of empirical evidence on the relative performance of different RER measures in explaining and predicting trade flows. Given the inconsistencies in the direction of trade competitiveness implied by different measures of the RER (especially in developing economies), we are also interested on evidence relating to the specific direction of influence these RER measures have on the trade account. Two main theoretical models are prominent in this strand of literature, namely; the imperfect-substitutes model of international trade by (Goldstein & Khan, 1985) and the expenditure-switching model of (Obstfeld & Rogoff, 2001).

In the partial-equilibrium imperfect-substitutes model, import and export demand are functions of the RER, domestic demand (in the case of import flows) and foreign demand (for export trade) (Goldstein & Khan, 1985). According to the model, an appreciation in the RER is associated with an increase in imports and a fall in exports. Increase in domestic and foreign demand in the model, exert positive impact on both import and export flows, respectively (Goldstein & Khan, 1985; Ca' Zorzi & Schnatz, 2007). A similar functional relationship is posited in the expenditure-switching model. In this model, an appreciation in the nominal exchange rate is expected to induce changes in relative prices. As a result, domestic goods become relatively expensive, which prompt consumers to switch their expenditure towards foreign goods, leading to a deterioration in the country's trade account (Obstfeld & Rogoff, 2001). The opposite is true regarding a depreciation in the exchange rate. Below is a summary of empirical studies on this subject.

(Marsh & Tokarick, 1996) assessed the relative ability of measures of the RER based on CPI, export unit value and normalized unit labour cost[79] in explaining import and export trade performance of G-7 countries, between the period 1975q1 to 1991q4. The study used an error correction model (ECM) following the standard formulation of the imperfect-substitutes model of international trade, by (Goldstein & Khan, 1985). The study further employed the non-nested hypothesis J-test of (Davidson & MacKinnon, 1981) to evaluate if any of the RER identities considered in the study, performs uniformly better than others in explaining trade flows. The study found that, none of the RER identities perform uniformly better across all the G-7

[79] Normalized unit labour cost are used to control for cyclical effects of productivity change on labour costs (Maciejewski, 1983). The deflator is derived from the trend of unit labour cost.

countries. The study could thus, not recommend any identity as the most appropriate for use in explaining trade flows in every G-7 country.

(Lafrance, et al., 1998) also compared the relative ability of RERs derived from the CPI and unit labour cost in explaining movements in Canadian exports and economic growth, from the period 1961q1 to 1997q1, in a vector autoregressive (VAR) framework. Using the Granger-Geweke causality test, the study found that, much of the leading information on both the country's net exports and GDP growth is contained in the unit labour cost derived-RER (Lafrance, et al., 1998). This RER identity was found to perform far much better in explaining movements in net exports and GDP growth than the CPI-RER.

(Ca' Zorzi & Schnatz, 2007) sought to establish which measure of the RER best explain and predict the level of export performance in the Euro area, focusing on the RER derived from CPI, PPI, export prices, unit labour costs in the manufacturing sector (ULCM) and, unit labour costs in the total economy (ULCT). The study first estimated an ECM of export demand based on (Goldstein & Khan, 1985) imperfect-substitutes model, for each of the RER indicators. All the indicators were found to have a sensible (theory consistent sign) and strong explanatory power on export growth. Export price-based RER however, showed a much stronger impact relative to the other RERs. According to (Ca' Zorzi & Schnatz, 2007), the high relative explanatory effect of the export price-based RER mainly reflects existence of 'pricing-to-market' strategies [80] as well as, the strong natural link between export prices and export growth.

In the second step, the study assessed both the in-sample and out-of-sample properties of each of the estimated models and found that, no particular RER appears to be performing uniformly better than others. According to (Ca' Zorzi & Schnatz, 2007), in light of these findings, the RER based on CPI which offer considerable benefits in terms of international comparability,

80 Where domestic producers maintain competitiveness by keeping their export prices close to the prices of competing goods in external markets.

timely publication, historical availability, could thus be considered the most ideal in approximating trade competitiveness in the Euro area.

More recently, (Ahn, et al., 2020) examined the validity of the expenditure-switching mechanism across 35 developed and emerging market economics, between the period 2001q1 to 2014q4. The study compared the explanatory power and direction of influence of the RER based on CPI, unit labour cost and GDP deflator on the countries' trade accounts. Using a single-equation ECM, but focusing predominantly on short term dynamics, which the expenditure-switching theory appeals to, (Ahn, et al., 2020) found that, only the RER based on unit labour cost affect the trade account in a manner consistent with theory. A strong contemporaneous positive and statistically significant nexus was established between the unit labour cost derived RER and changes in the trade account.[81] The impact of the CPI-RER was found to be positive but statistically insignificant, whilst the GDP deflator-RER carried a wrong sign and was statistically insignificant. The estimations were subjected to a number of robustness tests[82], but the underlying finding remained unchanged.

Meanwhile, empirical evidence on the relative performance of different measures of the RER in explaining the trade flows of developing economies, RDEs in particular, is quite sparse. Nonetheless, there is a large pool of evidence on the nexus between their CPI-RER and trade flows. In the specific case of Botswana, the nexus between the CPI-RER and Botswana's trade flows is quite ambiguous, with about three sets of conflicting empirical findings. (Modisaatsone & Motlaleng, 2013) found the nexus to be positive but statistically insignificant. The findings are broadly in line with (Sebego, et al., 2020). (Ghura & Grennes, 1993; Koitsiwe & Adachi, 2015; Jeanneney & Hua, 2015) found the nexus to be positive and statistically

81 Upward movement in the RER is depreciation

82 This include, re-estimating the model with an annual sample; excluding the pre-global financial crisis period from the estimation; removing countries with volatile labour productivity from the panel estimation; and adding additional lags of the RER variables to enrich the short-term dynamics.

significant, consistent with both the imperfect-substitutes and expenditure-switching models' propositions. (Hussain & Haque, 2014; Nyahokwe, 2021; Mhaka, et al., 2023) however, found the relationship between the CPI-RER and Botswana's trade balance to be negative and statistically significant, and ascribed the finding to the 'J-curve' phenomenon. The J-curve describes the short-to-long run path of the trade account in response to a currency depreciation or devaluation. According to the hypothesis, the initial response of the trade account to currency depreciation/devaluation is negative, but improves overtime (Magee, 1973). Critiques of the J-Curve hypothesis however, requires robustness test with alternative measures of the RER, which none of these studies undertook.

2.3 Summary and Limitations of the Reviewed Literature

The surveyed literature does not provide a definite position or consensus on the most reliable measurement of the RER to use in gauging a country's level of trade competitiveness. The impact of various measures of the RER on trade flows varies vastly across countries and regions. More significantly, the most widely used identity of the RER, i.e., CPI-RER, does not have a consistent impact on trade flows, both at country level, and across countries and regions. In the specific case of Botswana, different studies have found the impact of the CPI-RER on Botswana's trade flows to be both in line and against theoretical underpinnings (i.e., imperfect-substitutes and expediture-switching models). Furthermore, as is the case for other developing economies, we did not find any empirical evidence on the impact of other alternative RER measures on Botswana's trade flows. According to (Ntwaepelo & Motsumi, 2019), empirical evidence on this matter is generally sparse in developing economies mainly on account of data limitations, precisely in terms of quality and availability of statistics on alternative price and cost deflators of the RER.

Against this background, we propose an alternative measure of the RER to the standard CPI-RER, based on the relative prices of domestically produced goods and competing imported goods captured in Botswana's very own CPI basket. The aspect of competitiveness the proposed RER attempts to measure is thus, import-price competiveness. The reliability of the proposed RER over the CPI-RER is assessed empirically, by testing the following hypotheses;

i. Both the proposed RER and the CPI-RER have a significant impact on Botswana's trade flows, but only the proposed RER has the correct sign.
ii. The proposed RER performs better in explaining and predicting movements in Botswana's trade flows than the CPI-RER.

3. DATA DESCRIPTION AND STYLISED FACTS

This study uses quarterly data from 2005q1 to 2020q4 on Botswana's real imports, CPI-RER, GDP deflator-RER, sectoral-RER and domestic GDP. The sample covers the period between the adoption of the current crawling-peg exchange rate policy framework by Botswana, and the post-COVID-19 high global inflation era.[83] The definitions used for CPI-RER, GDP deflator-RER and sectoral-RER are presented below.

Table 5.2 RER Indicators

CPI-based RER	GDP Deflator- based RER	Sectoral-RER
$\boldsymbol{CPI_{RER} = NER * \left(\frac{CPI^d}{CPI^f}\right)}$ $\boldsymbol{NER}$ is the nominal exchange rate, $\boldsymbol{CPI^d}$ and $\boldsymbol{CPI^f}$ are domestic and foreign (trade weighted) consumer price index, respectively**.**	$GDP\ deflator_{RER} = NER * \left(\frac{GDPDeflator^d}{GDPDeflator^f}\right)$ $GDP_{deflator} = \frac{GDP_{nominal}}{GDP_{real}}$ $GDPdeflator^d$ and $GDPdeflator^f$ are domestic and foreign (trade weighted) GDP deflators, respectively**.**	$S\_RER = \left(\frac{CPI^{NT}}{CPI^T}\right)$ CPI^{NT} and CPI^T are non-tradable and tradable price indices in Botswana's CPI.

The trade weights are; 55 percent SDR and 45 South Africa (Bank of Botswana, 2020)

The study also uses the proposed import-price competitiveness RER (IMP-RER, henceforth), based on the relative prices of domestically produced goods and competing imported goods, captured in Botswana headline CPI basket. We also disaggregate this RER by sector (i.e., Food-RER and Nonfood-RER) to capture potential sectoral heterogeneity. Below is a formal definition of the proposed RER and sectoral disaggregates thereof.

$$IMP\_RER_t = \frac{\prod_{j=1}^{N} dom\_cpi(j)_t^{w(j)}}{\prod_{k=1}^{N} imp\_cpi(k)_t^{w(k)}}$$

Where; $dom\_cpi(j)_t^{w(j)}$ is the weighted index of the j^{th} domestic import-substitute commodity item in the basket of domestic import-substitutes, and $imp\_cpi(k)_t^{w(k)}$ is the weighted index of the k^{th} imported commodity item in

83 Botswana's current exchange rate policy framework was adopted in May 2005 (Bank of Botswana, 2008).

the basket of competing imported commodities. The weights $w(j)$ and $w(k)$ are taken as given from Botswana's CPI basket, adjusted such that;

$\sum_{j=1}^{N} w(j) = 1$ and $\sum_{k=1}^{N} w(k) = 1$

$$Food\_RER_t = \frac{\prod_{j=1}^{n} dom\_food\_cpi(j)_t^{w(j)}}{\prod_{k=1}^{n} imp\_food\_cpi(k)_t^{w(k)}}$$

Where; $dom\_food\_cpi(j)_t^{w(j)}$ is the weighted index of the j[th] domestic import-substitute food item in the food basket of domestic import-substitutes, and $imp\_foodcpi(k)_t^{w(k)}$ is the weighted index of the k[th] imported food item in the food basket of competing imported commodities. The weights $w(j)$ and $w(k)$ are taken as given from Botswana's CPI basket, adjusted such that;

$\sum_{j=1}^{n} w(j) = 1$ and $\sum_{k=1}^{n} w(k) = 1$

$$Nonfood\_RER_t = \frac{\prod_{j=1}^{n} dom\_nfood\_cpi(j)_t^{w(j)}}{\prod_{k=1}^{n} imp\_nfood\_cpi(k)_t^{w(k)}}$$

Where; $dom\_nfood\_cpi(j)_t^{w(j)}$ is the weighted index of the j[th] domestic import-substitute nonfood item in the nonfood basket of domestic import-substitutes, and $imp\_nfoodcpi(k)_t^{w(k)}$ is the weighted index of the k[th] imported nonfood item in the nonfood basket of competing imported commodities. The weights $w(j)$ and $w(k)$ are taken as given from Botswana's CPI basket, adjusted such that;

$\sum_{j=1}^{n} w(j) = 1$ and $\sum_{k=1}^{n} w(k) = 1$

Consistent with Botswana's current measurement of the RER, upward movement of all the RER identities defined above, signifies an appreciation and downward movement is depreciation. Also, as already highlighted in preceding sections, the proposed RER (IMP-RER) is expected to tell us to what extent, an increase (decrease) in the price of locally produced goods relative to imported goods, is likely to create a potential loss (gain) in the domestic market share of local producers (Maciejewski, 1983). Some of the main advantages of this identity of the RER are that, it is entirely based on price statistics contained in Botswana's own CPI basket (and hence does not require foreign statistics), and exclude all commodities that are not subject to international competition (non-tradable and mineral commodities). Although there is a limited pool of domestic import-substitutes in Botswana's CPI basket, we have however, filtered-out from the import basket, all commodities that do not have equivalent substitutes, so that the import basket closely matches the domestic basket with respect to commodity composition.

It should be noted that, commodity coverage of RERs in general, is not exhaustive. In fact, some of the commonly used RER indicators only covers commodity prices or factor costs only in the manufacturing sector; a sector which accounts for less than 20 percent of the aggregate economy in most countries (Turner & Jozef, 1993; Ca' Zorzi & Schnatz, 2007; Castellares, 2021). So, as is the case with almost all RERs, the proposed RER is not a perfect indicator of trade competitiveness, but rather a close approximation of the ideal. Moreover, notwithstanding the limitation pertain to the scope of its commodity coverage, this indicator can still however, shed some important light on whether or not the prevailing relative price conditions are favorable for new potential domestic investments.[84]

One of the major inherent pitfalls involved in the measurement of this RER however, is that, CPI statistics do not capture the cost of imported intermediate inputs, which are embedded in the final market price of the domestic price component of the IMP-RER index. That is, we are unable to completely filter-out import prices and the effects thereof, on domestic output prices of the proposed RER index. This defect is however, more pronounced in the CPI-RER, wherein the domestic price component of the index captures both the import prices of final consumer goods and intermediate inputs (used in domestic output).

[84] An overvalued RER for example, may undermine efforts to attract new investment opportunities in the domestic economy.

Stylized facts

The analysis below shows stylized facts on the evolution of measures of the RER considered in this study, and their co-movements with Botswana's trade flows.

Figure 5.1: Botswana's RER Measures

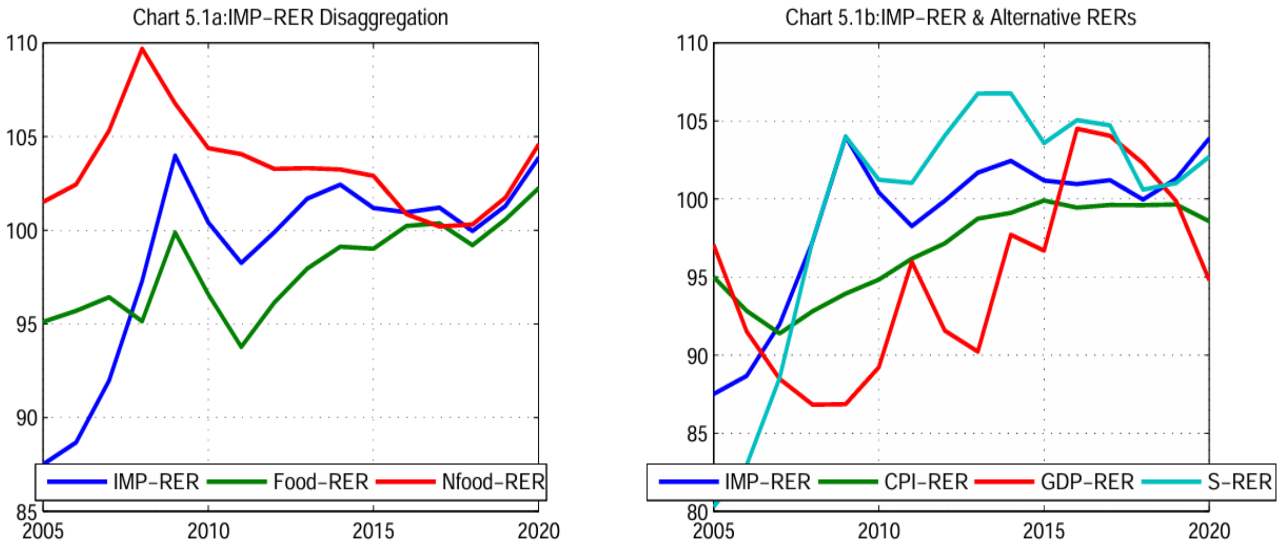

Chart 5.1a and 5.1b shows the profile of all the RER measures considered in this study over time. We observe that, the proposed RER (IMP-RER) and its disaggregated components, i.e., food-RER and Nonfood-RER exhibit very close co-movements (Chart 5.1a). That is, there is no discernible sectoral heterogeneity in the competiveness signals implied by these RER identities. Therefore, only the composite measure (IMP-RER) will be used henceforth. Chart 5.1b shows the evolution of the IMP-RER and other alternative measures of Botswana's RER, namely the CPI-RER, GDP deflator-RER and S-RER. We observe sustained episodes of discrepancies in the competitiveness signals implied by these measures of the RER, save for the IMP-RER and S-RER, which shows a relatively high degree of co-movements over time. (Motlaleng, 2004; Ntwaepelo & Motsumi, 2019) have also made similarly observations, assessing co-movements in Botswana's RERs derived from CPI and GDP deflators.

Another key observation is that, Botswana's CPI-RER is relatively flat or exhibit a very low degree of volatility. This is broadly in line with the core objective of the country's exchange rate policy framework, which seeks to maintain a stable RER by keeping Botswana's CPI inflation at par with trading partners' inflation (Bank of Botswana, 2020).

Figure 5.2: RER Indices and Botswana's Import Demand (Million USD)

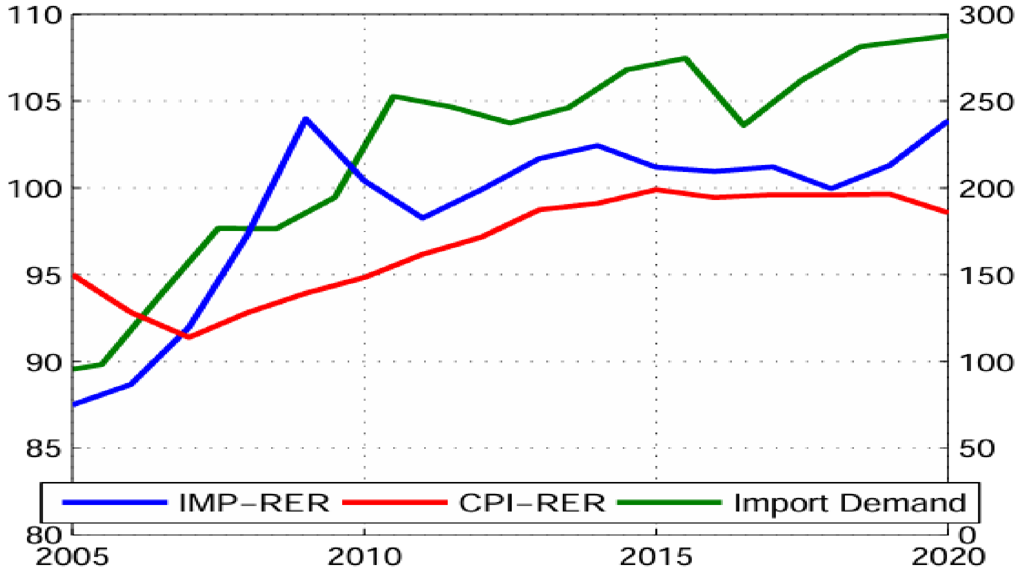

Figure 5.2 shows the relationship between the main RER indices of interest in this study (IMP-RER and CPI-RER) and Botswana's import flow (in million USD). In generally, the IMP-RER seems to be closely linked with the movements in Botswana's imports demand than the CPI-RER. The IMP-RER is able to explain most of the import flow fluctuations over the review period. For example, the steep appreciation in the IMP-RER between 2005 and 2009 is reflected in the substantial rise in import flows over the same period. The CPI-RER was however, also appreciation during this period, but at moderate rate nonetheless. The association between the IMP-RER and Botswana's import flows is much clearer between 2012 and 2020, where import flows almost mimic the movements in the IMP-RER. The CPI-RER movements during this period, were somewhat misaligned to actual import trade developments.

4. METHODOLOGY

This study estimates an import demand function for the economy of Botswana, adapted from the imperfect-substitutes model of international trade by (Goldstein & Khan, 1985). In the model, import demand is a function of the RER and aggregate domestic demand, proxied by Botswana's GDP. We also add to the specification, a productivity variable as measured by (Castellares, 2021)[85]. The pre-estimation diagnostic tests show that, our model variables are stationary at first difference and cointergrated. The appropriate estimation technique to use is therefore, an error correction model (Stock, 1987). So, to test our hypotheses, we first estimate four import demand functions for each RER identity considered in this study (IMP-RER, CPI-RER, GDP deflator-RER and S-RER), in a single-equation ECM framework, specified below.

$$\Delta \ln M_{it} = \mu(M - \alpha \ln RER - \alpha_1 \ln GDP - \alpha_2 \ln PRD)_{it-1} + \sum_{j=1}^{n} \beta \Delta \ln M_{it-j} + \sum_{j=0}^{n} \beta_1 \Delta \ln RER_{it-j} + \sum_{j=0}^{n} \beta_2 \Delta \ln GDP_{t-j} + \sum_{j=0}^{n} \beta_3 \Delta \ln PRD_{t-j} + \delta_i + e_{it} \quad (5.1)$$

Where; $\Delta \ln Y_{i,t}$ is import demand growth , RER_{it} is the ith real exchange rate identity (upward movement of the RER_{it} is appreciation and downward movement is depreciation), GDP_t is Botswana's real GDP, proxy for domestic demand, PRD_t is productivity, measured as the ratio of domestic output of import-substitutes to non-tradable output, δ_i is the constant term and e_{it} is the error term in the ith equation.

In line with (Goldstein & Khan, 1985), we expect improvements in trade competitiveness to dampen import demand, and the increase in domestic GDP to lead to a rise in import demand. We have also added a productivity variable as measured by (Castellares, 2021), and we expect an increasing productivity in the domestic economy to be associated with a fall in import demand.

85 In his study, (Castellares, 2021) measured productivity level in the traditional tradable sector, as a ratio of a country's traditional exports to total non-traditional exports.

In the second step, we evaluate the relative performance of each of the four models in explaining and predicting Botswana's import flows, by comparing in-sample and out-of-sample errors of the models. With respect to out-of-sample analysis, we first assume perfect foresight on the future evolution of explanatory variables. Thus, we re-estimated the models over a shorter sample period (2005q1 to 2019q4), and project the import flow over the period (2020q1 to 2020q4), using already observed explanatory variables. Secondly, we re-produce the forecasts but with a more realistic assumption on explanatory variables, precisely that, the future values of explanatory variables over the forecast horizon are unknown. So, in the second case, the forecasts for import demand are based on projected values of explanatory variables (RERs values in particular)[86], using autoregressive integrated moving average (ARIMA) models. The root mean square error (RMSE) is then used to measure the forecast errors. Since the specification of the models is identical and the only difference is the RER identities used in each case, the model with the lowest RMSE therefore reflects that the specific RER used in that model, outperforms other alternative measures of the RER in predicting Botswana's import flows (Keck, et al., 2010; Ca' Zorzi, et al., 2013).

We also conduct a much more formal comparative analysis, based on the non-nested model hypothesis testing (J-test) by (Davidson & MacKinnon, 1993). Our approach follows (Marsh & Tokarick, 1996) but with slight variations. In (Marsh & Tokarick, 1996) approach, the test is whether a given RER identity (say CPI-RER) captures all the useful information relevant in explaining trade flows, which is not contained in the alternative RER identity (say IMP-RER). In other words, the test is whether the CPI-RER encompasses the IMP-RER. Our interpretation is however, slightly different. First, we know that IMP-RER is an extract or sub-set of the CPI-RER, and therefore, CPI-RER certainly encompasses IMP-RER. So, our interest is rather establishing, in which of these two identities of the RER is useful information relevant in

[86] Other additional explanatory variables (GDP and Productivity) are taken as given.

explaining Botswana's trade flows appropriately captured. Loosely, which of the two RER identities is sensibly and meaningfully associated with developments in Botswana's import flows.

The empirical procedure we implement in making the comparisons is thus, different from (Marsh & Tokarick, 1996) albeit based on the same J-test of Davidson and MacKinnon. The general idea in (Marsh & Tokarick, 1996) procedure is that, a given RER (say CPI-RER) outperforms other alternative RER measures if the fitted values from the models of the alternative RERs, do not have a significant explanatory power when added as a regressor in the model that contains the CPI-RER. In our approach, we estimate an encompassing model, comprising both the RER identities of interest as regressors (e.g., IMP-RER and CPI-RER in the same model). The most reliable identity of the RER would be the one that has a significant statistical explanatory power on import demand, and most importantly, carrying the correct sign. This is the so-called '*Encompassing test of Davidson & MacKinnon for comparing non-nested models*' (Davidson & MacKinnon, 1993; Greene, 2003). The encompassing model is specified below.

$$\Delta \ln Y_{it} = \varphi(Y - \theta \ln IMP\_RER - \theta_1 \ln RER - \theta_2 \ln X)_{it-1} + \sum_{j=1}^{n} \delta \, \Delta \ln Y_{it-j} + \sum_{j=0}^{n} \delta_1 \, \Delta \ln IMP\_RER_{it-j} + \sum_{j=0}^{n} \delta_2 \, \Delta \ln RER_{it-j} + \sum_{j=0}^{n} \delta_3 \, \Delta \ln X_{t-j} + \mu_i + e_{it} \qquad (5.2)$$

Where: IMP_RER_t is the proposed RER in this study, $RER_{i,t}$ is the i[th] alternative RER identity, X_t is a vector of control variables (GDP and productivity).

We also conduct a Wald test, which provides a summary statistic on the relative performance of the models. For each case, e.g., IMP-RER model vs CPI-RER model, the Wald test compares each model specification against the encompassing model. The test assesses whether adding the alternative RER identity (say CPI-RER), as a regressor in the IMP-RER model (i.e., encompassing model), statistically improves the performance or prediction power of the IMP-

RER model specification, and vice versa. The decision rule, which is based on an F-statistic, is that, the RER-model specification in which the incremental contribution of the alternative RER identity is statistically insignificant, is the best model, and so is the RER identity associated with that model, by extension. As can be observed, the Wald test deals primarily with the relative prediction power of the models, whilst the elaborate approach discussed above, deals with the interpretation of the estimated parameters of the competing models.

The two approaches are thus complementary, but given the principal objective of this study, which is to establish, '*which measure or identity of the RER is sensibly and meaningfully associated with Botswana's trade flows'*, considerable attention is thus, placed on the results from the elaborate approach.

Summary of the Methodology

The table presented below summarizes all the procedures adopted in evaluating the relative performance of the proposed RER (IMP-RER), against the other three RER identities considered in the study (mainly CPI-RER).

Table 5.3 Summary of the Methodology

Procedure	
Step 1: Estimation of the trade flow (import demand) model	
❖ We estimate four ECM models	Models based on i. IMP-RER ii. CPI-RER iii. GDP deflator-RER iv. S-RER
Step 2: Model performance evaluation	
❖ We assess which RER-based model best explains and predict Botswana's trade flows ❖ Key focus is on the relative performance of the proposed IMP-RER against other three RER identities (mainly CPI-RER)	
Evaluation Tools	
❖ In-Sample evaluation	
❖ Out-of-sample predictions	Assumption on explanatory variables i. *Perfect-foresight* (future values of the explanatory variables are known) ii. Future values of the explanatory variables are *predicted* via ARIMA model
❖ Non-nested models hypothesis testing by (Davidson & MacKinnon, 1993)	Approach i. Wald test- assess the relative predictive power of the RER identities (IMP-RER vs Other RERs) ii. Encompassing Approach- assess which RER (IMP-RER vs Other RERs) exhibit a sensible and economically meaningful association with Botswana's trade flows

5. EMPIRICAL ESTIMATION RESULTS

This section presents empirical findings in this study. We first discuss the ECM estimation results in Table 5.5, followed by model comparison analysis in Table 5.6, 5.7 and 5.8.

Error Correction Model Estimation Results

The pre-estimation tests show that, all the model variables are stationary at first difference and there is evidence of cointergration in all the four equations (appendices vi and vii). The Johansen cointegration tests results shown in Table 5.4 below, indicate two cointegration vector for the IMP-RER and CPI-RER models at the 0.05 level of significance, and one cointegration vector for the GDP-deflator RER and Sectoral RER models.[87]

Table 5.4 Johansen cointegration Results

Unrestricted Cointegration Rank Test (Trace)	IMP-RER	CPI-RER	GDP deflator-RER	Sectoral-RER
Hypothesized No. of CE(s)				
None	0.0151*	0.0005*	0.0365*	0.0301*
At most 1	0.0218*	0.0190*	0.1626	0.2554
At most 2	0.0709	0.0591	0.2613	0.7056
At most 3	0.0313*	0.0203*	0.0390*	0.4820

Note: The statistics presented above are MacKinnon-Haug-Michelis (1999) p-values and * denotes rejection of the hypothesis at the 0.05 level

Given the cointergration results above, we ran four error correction models under each RER identity of interest in this study. The estimation results are presented and discussed below.

87 The cointergration model specifications include all the explanatory variables considered in the study.

Table 5.5 ECM Estimation Results[88]

	IMP-RER	CPI-RER	GDP deflator-RER	Sectoral-RER
Error Correction Term	-0.73 (0.0065)***	-0.50 (0.0276)**	-0.60 (0.0017)***	-0.63 (0.0068)***
Long-run elasticities				
Lagged Import Demand	0.32 (0.0028)***	0.69(0.0000)***	0.50 (0.0000)***	0.46 (0.0003)***
Competitiveness (RER)	-1.82 (0.1067)	-5.79 (0.0099)***	-0.28 (0.3830)	0.18 (0.8417)
Lag 1	1.06 (0.4716)	1.21 (0.6635)	-0.34 (0.2217)	-0.17 (0.8874)
Lag 2	1.67 (0.0916)*	0.82 (0.6894)		0.86 (0.3038)
Domestic Demand	0.31 (0.0084)***	1.18 (0.0005)***	0.58 (0.0002)***	1.09 (0.0018)***
Productivity Growth	-0.25 (0.0002)***	-0.19 (0.0038)***	-0.16 (0.0207)***	-0.18 (0.0074)***
Constant	-0.93 (0.6746)	13.94 (0.0072)***	1.73 (0.1378)	-1.90 (0.1428)
Short-run elasticities				
Lagged Import Demand	0.33 (0.1491)	0.13 (0.4472)	0.26 (0.0760)*	0.26 (0.1624)
Competitiveness (RER)	-0.61 (0.5052)	-3.65 (0.0825)*	0.20 (0.4565)	-0.14 (0.8418)
Lag 1	0.99 (0.3179)	-3.58 (0.0553)*	0.47 (0.0656)*	-0.44 (0.5426)
Lag 2	2.14 (0.0278)**	1.22 (0.2811)		1.65 (0.0257)**
Domestic Demand	0.96 (0.0012)***	0.98 (0.0009)***	1.22 (0.0001)***	1.05 (0.0013)***
Lag 1		0.17 (0.6496)		
Productivity Growth	-0.37 (0.0000)***	-0.36 (0.0000)***	-0.31 (0.0000)***	-0.39 (0.0000)***
Lag 1	0.06 (0.6068)			

Note: *Brackets are P-values*, ***, **,* signifies statistical significance at 1%, 5% and 10% level, respectively.

The estimated short and long run elasticities in Table 5.5 shows that, both the proposed RER (IMP-RER) and the CPI-RER have statistically significant impact on Botswana's import flows. However, the impact of the CPI-RER is found to be contemporaneous and quite strong, whilst the IMP-RER has a delayed impact of about two quarters. The impact of other alternative RERs (GDP deflator-RER and S-RER) also come with a time lag of one and two quarters, respectively, but only in the short term. The results also show that, the impact of the CPI-RER is inconsistent with the guiding theoretical underpinnings espoused in this study, both in the short and long run. Our estimations show that, *ceteris paribus*, a 1 percent depreciation in the CPI-RER is associated with approximately 6 percent increase in Botswana's import demand in

88 Full results are presented in appendix O. We also provide estimates based on the unfiltered current account as a dependent variable (robustness check).

the long run. In the short run, the impact is about 3.5 percent at both current period and after a time lag of one quarter. Similar short run findings were made by (Hussain & Haque, 2014; Nyahokwe, 2021; Mhaka, et al., 2023) arguing that, the estimated phenomenon is in line with the conventional ‘J-curve’ effects.

However, two important elements from our estimation results seem to dispel the J-curve claim by the abovementioned studies. First, the negative impact of the CPI-RER on Botswana’s import demand does not change over time. Secondly, none of the alternative RERs (IMP-RER, GDP deflator-RER and S-RER) exhibit association with import demand posited by the J-curve hypothesis. So, evidence of the J-curve effects does not meet standard robustness tests, at least based on our estimated results. Contrary to (Hussain & Haque, 2014; Nyahokwe, 2021; Mhaka, et al., 2023), we argue that, the negative nexus between the CPI-RER and import demand most likely reflects the composition of Botswana’s CPI basket, which in our own view, is not properly constituted to serve as a reliable deflator of the RER. As discussed already, Botswana’s CPI basket has a very large import-component, which accounts for over 40 percent of the entire basket. Appreciation in the nominal exchange rate may thus, at times, dampen domestic headline CPI (through the fall in imported-CPI), far below trading partner CPI and thereby, creating a RER ‘depreciation illusion’.

This is an illusion because, the depreciation is driven predominantly by the fall in the price of final consumer imports, and therefore, does not reflect a gain, but rather a potential loss in Botswana’s competitiveness position (i.e., substitution of domestic produce for cheap imports). It is for this very reason, in our own view, that such a ‘RER depreciation’ is found to be associated with a rise in import demand, as shown in Table 5.5. It is important to underscore that the J-curve posits that, a depreciation in the RER harms the trade account (in the short term), through the rise in the cost of imports NOT the demand thereof (which appears to be the transmission mechanism in the case of Botswana, under CPI-RER). We also observe a negative contemporaneous relationship between the proposed RER (IMP-RER) and import demand, although statistically insignificant. This negative relationship most probably reflects the effects of imported intermediate inputs costs embedded in the domestic price component of the IMP-RER index, which we were unable to filter-out. [89]

Meanwhile, the impact of domestic demand (GDP) and productivity growth are consistent with theory and past empirical findings (Keck, et al., 2010; Ca' Zorzi, et al., 2013; Castellares, 2021). So overall, the estimated elasticities in Table 5.5 shed important light on the reliability of RERs measures of interest in this study, in explaining Botswana's import flows, but to definitively choose the most reliable RER, more formal model comparison analysis tests are necessary. Otherwise, all the relevant post-estimation diagnostics tests from the models above are presented in appendix M. In general, the test shows that all the model estimations are stable (based on the CUSUM test) and there is also no evidence of serial correlation (based on the Breusch-Godfrey Serial Correlation LM Test).

Model Comparison Analysis

Two main model comparison techniques are used, namely in-sample and out-of-sample model performance evaluation tests and the non-nested model hypothesis test. The study finds it difficult to unequivocally choose any RER identity as the most reliable over others, based on the in-sample properties of their respective models. The standard errors from all the four models are closely the same (appendix O). Comparison results based on the out-of-sample forecast performance of the models are however, quite clear. The forecast errors from the four models (Chart 5.3a and 5.3b) shows that, the IMP-RER and GDP Deflator-RER provides the

[89] That is, an appreciation in the nominal exchange rate could dampen the IMP-RER index (depreciation), on account of the fall in the imported intermediate inputs costs. This depreciation may also, as is the case for the CPI-RER, deemed to be an illusion. However, since the appreciation in the nominal exchange rate would also dampen the final-imported goods price component of the IMP-RER index (denominator), the depreciation illusion would thus not be highly pronounced. It is mainly because of this reason that the negative contemporaneous relationship between the proposed IMP-RER and Botswana's import demand is NOT statistically significant.

most accurate prediction of Botswana’s import flows, under both assumption we made on how the values of explanatory variables over the forecast period are derived. RMSEs of the models are presented in Table 5.6.

Figure 5.3: Out-Of-Sample Forecast Performance[90]

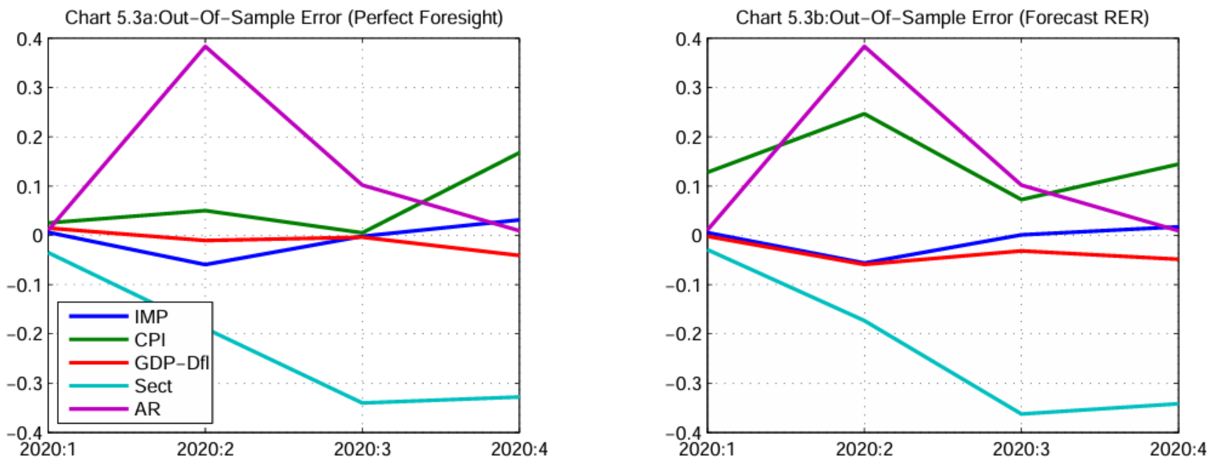

Table 5.6 Out-of-Sample RMSE

Assumption on Explanatory Variables	IMP-RER	CPI-RER	GDP Deflator-RER	Sectoral-RER	AR Process
Perfect Foresight	0.03	0.08	0.02	0.25	0.19
Forecast RER	0.02	0.16	0.04	0.27	0.19

Non-Nested Model Hypothesis Testing

Comparison results based on the non-nested hypothesis test are quite conclusive, and the findings therefrom are presented in Table 5.7 and 5.8 below.

Table 5.7: Wald Test Results

Competing Models	**Wald-test Summary Output**

CPI RER vs IMP RER	`Res.Df Df F Pr(>F)`
	`M1 vs. ME 49 -5 10.1110 1.078e-06 ***`
	`M2 vs. ME 49 -4 4.3053 0.004602 **`
	`---`

GDP Deflator RER vs IMP RER	`Res.Df Df F Pr(>F)`
	`M1 vs. ME 49 -5 6.0510 0.0001947 ***`
	`M2 vs. ME 49 -4 0.9999 0.4166553`
	`---`

90 We also presents forecast from 2021q1 to 2021q4, in Appendix P.

Sectoral RER vs IMP RER	Res.Df Df F Pr(>F) M1 vs. ME 48 -5 7.9466 1.617e-05 *** M2 vs. ME 48 -5 0.3934 0.851 ---

Note: M1 is the alternative RER Model and M2 is the proposed IMP-RER based model

The Wald test results in Table 5.7 show that, the model based on the proposed IMP-RER (M2) performance as good as the CPI-RER based model (M1). These results are however, not surprising because both measures of the RER contain similar informational content, although captured differently. Therefore, what is of fundamental importance, as far as the reliability of the two RERs as indicators of direction of trade competitiveness is concerned, is not their relative *prediction power or goodness of fit* (which is what the Wald test provides). It is rather, the *interpretation* of their marginal effect on trade flows (i.e., both sign and statistical significance), which is provided in a more elaborate encompassing test approach, presented in Table 5.8 below. Meanwhile, with respect to the other alternative RER identities (GDP Deflator RER and Sectoral RER), the Wald test shows that, the model based on the IMP-RER significantly outperforms the two RER based models.

Table 5.8 Encompassing Model Estimation Results[91]

	CPI-RER vs IMP-RER	GDP Deflator-RER vs IMP-RER	Sectoral-RER vs IMP-RER
Error Correction Term	-0.70 (0.0015)***	-0.75 (0.0055)***	-0.72 (0.0066)***
Long-Run elasticities			
Lagged Import Demand	0.55 (0.0000)*	0.56 (0.0000)***	0.51 (0.0001)***
IMP-RER	-1.48 (0.1180)	-0.91 (0.4236)	-1.22 (0.3180)
Lag 1	0.84 (0.5086)	1.50 (0.3445)	1.44 (0.3724)
Lag 2	2.00 (0.0417)**	0.30 (0.7879)	0.26 (0.8195)
Alternative RER	-6.06 (0.0021)***	-0.18 (0.5671)	0.75 (0.4260)
Lag 1	0.47 (0.8341)	-0.05 (0.8735)	-0.26 (0.7941)
Lag 2	0.16 (0.8780)		
Domestic Demand	0.75 (0.0000)***	0.35 (0.0364)**	0.31 (0.0146)**
Productivity Growth	-0.38 (0.0000)***	-0.37(0.0000)***	-0.36 (0.0001)***
Constant	15.65 (0.0005)***	-2.41 (0.4151)	-3.15 (0.2154)
Short-term elasticities			
Lagged Import Demand	0.17 (0.3490)	0.35 (0.1259)	0.30 (0.1718)
IMP-RER	-0.94 (0.2405)	-0.55 (0.5610)	-0.47 (0.6894)
Lag 1	0.18 (0.8333)	1.13 (0.2656)	0.74 (0.5193)
Lag 2	2.28 (0.0080)***	1.85 (0.0629)*	2.33 (0.0194)**
Alternative RER	-4.41 (0.0215)**	0.16 (0.5690)	-0.29 (0.7301)
Lag 1	-2.93 (0.1192)	0.44 (0.1144)	-0.59 (0.5164)
Lag 2	1.22 (0.2449)		
Domestic Demand	1.03 (0.0004)***	1.08 (0.0004)***	0.93 (0.0023)***
Productivity Growth	-0.39 (0.0000)***	-0.34 (0.0000)***	-0.39 (0.0000)***

Table 5.8 shows the estimated results from the encompassing model presented in equation 5.2. The model compares the reliability of the proposed RER (IMP-RER) against each alternative RER identity considered in this study. In this pairwise comparison, the proposed RER is consider a more reliable trade competitiveness indicator, if its estimated coefficient is (i) statistically significant and (ii) carries the correct sign; and the alternative RER fails in either one of these two conditions. First, we observe that the IMP-RER satisfies both of these

91 Full estimation results are presented in appendix Q.

conditions when compared against the GDP deflator and Sectoral RERs. The second lag of the IMP-RER is both statistically significant and has a positive sign, whilst the GDP deflator-RER and Sectoral-RER are both statistically insignificant, in their respective comparison models. Loosely interpreted, the IMP-RER captures vital information relevant in explaining Botswana's import demand, which is not contained in either one of the two alternative RER identities. These results are consistent with the findings established under the Wald test.

Secondly and most importantly, the IMP-RER still passes the reliability test when compared against the CPI-RER, an identity which is currently used in Botswana's exchange rate policy framework. We observe that, while the estimated coefficients of the CPI-RER are statistically significant, they however carry wrong signs. Intuitively, these results imply that, although the CPI-RER contains vital information on Botswana's import demand, this information is however not properly captured to provide a sensible and economically meaningful indication on the direction of Botswana's import flows. We thus, at least based on the estimations provided in this study, find the proposed RER identity to be a more reliable indicator of Botswana's trade flows than the CPI-RER and other alternative identities, even though it's sensible and statistically significant signals comes with a time lag of two quarters.

6. CONCLUSION AND RECOMMENDATIONS

The primary objective of this study was to establish, which measure of the RER is sensibly and economically meaningfully associated with the trade flows of a resources-dependent economy of Botswana. To this end, the direction and statistical impact of four RER measures on Botswana's import flows were tested, in a single-equation ECM framework. The four RER measures include the import-price RER (IMP-RER) which proposed computational approach, is our major contribution in this area of research. Overall, the estimated ECM results and accompanying model performance tests shows that, the import-price RER outperforms other alternative measures of the real exchange rate. This identity of the RER shows a consistent, sensible and economically meaningful association with Botswana's trade flows both in the short and long run. Meanwhile, the association between Botswana's trade flows and the CPI derived RER (the current target variable in Botswana's exchange rate policy framework) is contrary to theory, both in the short and long run.

This study therefore, recommends Botswana's exchange rate policymakers to start paying considerable attention to the trade competitiveness conditions implied by the IMP-RER, in their exchange rate policy discussions. This is particularly important because, the IMP-RER focuses mainly on the aspect of trade competition most relevant for countries with special trade account features like Botswana, and other closely identical resource-dependent economies. However, as is the case with all RER indicators, the proposed IMP-RER is not a perfect indicator of trade competitiveness, but rather a close approximation of the ideal. Some of the inherent weaknesses of this RER which we were unable to circumvent, are extensively outlined in the study. Future research work should therefore, focus on how to address some these identified weaknesses, as well as those we might have missed.

Chapter Six

MAIN CONCLUSION

SUMMARY OF THE CHAPTERS, LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

Exchange rate regime change in resource-dependent economies (RDEs) is a fairly new subject in the body of economic literature, and has only become relevant after the 2014-2016 commodity price shock. To the best of our knowledge, this is the first research project to address the question of how to predict the regime change, and the associated macroeconomic outcomes under different exit conditions. In particular, we suggest key elements necessary to add to the *semi-structural New-Keynesian (NK) model for a small open economy,* to simulate the regime change. These include; adding the mineral sector in the expectation equation of the UIP, to proxy movements in the RDE's foreign reserve balances; and modifying the equilibrium risk premium equation, to account for the difference in the level of financial market and institutional development between the RDE and its foreign trading partners.

Broadly, the study is of considerable significance because for policymakers in RDEs[92] to effectively and prudently manage any transition case in a manner that will safeguard both economic and financial stability, there should have, at a bare minimum, a reasonable preconception of the probable dynamics associated with such a transition. In the specific case of this thesis, we explored the macroeconomic implications of transitioning from a fixed exchange rate regime to a floating regime, for the natural resource-dependent economy of Botswana. The main finding is that, Botswana would most likely face a disorderly transition if the country's diamond sector was to experience any intense and long-lasting shock. At the present moment, Botswana's financial sector depth, accessibility and efficiency do not augur well for a smooth and orderly transition.

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92 Most of whom have no experience in dealing with exchange rate regime change.

In general, we consider the transition simulation models developed in this thesis (presented in chapter 2 and 3) to be comprehensive enough to serve as a template for other RDEs, who might be interested in conducting similar simulations. Notwithstanding, there is however, scope for further improvements. One such area could be adding a long-run equation for mineral output in the *NK model* structure. That is, given the critical role played by the mineral sector in supporting both the exchange rate and monetary policy frameworks in RDEs, it may thus, be in the best interest of policymakers to know the process through which mineral output evolves over the long run. Structural fundamentals such as the level of capital investment, gross value of underground mineral endowments, prospects for discovery of new mineral resources, domestic and geopolitical developments etc., may be key in explaining such a process.

This process would probably be exogenous nonetheless, since the model structure in its current form, is only circumscribed to economic developments over the business cycle. In our case, we only have the evolution of the mining output gap, modelled as function of the cyclical movements in foreign demand. Secondly, simulating the regime transitions in a fully-fledged micro-founded model, could also be another key area for future studies to explore. Micro-founded models generally (if well specified and estimated), have an inherent advantage of being less vulnerable to the Lucas critique, when compared with the analytical framework employed in this thesis.

The thesis further made two important discoveries in chapter 4 and 5, respectively. First, we established that financial markets and institutions of most RDEs operating fixed regimes, are not at the present time, structurally strong enough to support smooth and orderly transitions to floating regimes. These is found to be the case amongst a select-cohort of economically stable RDEs, with good repute on political stability and good governance. These include Botswana, Namibia, Tanzania, Tunisia, Egypt, Algeria and Saudi Arabia, just to mention a few. It would be interesting therefore, for future studies to establish if there are any efforts undertaken by these countries towards building the necessary requisite elements for smooth and orderly transitions. As observed in other countries, it is generally more prudent to consider the regime change much earlier, putting in place some, if not all, the institutional and operational elements necessary to enhance the prospects for a smooth transition. In the specific context of an RDE, acting while the country's resource wealth is still sufficient enough to fund the logistical preparations, and cushion the economy from potential exchange rate volatility during the actual transition, would be an important feature of economic policy.

The second discovery we made is with respect to the measurement of the real exchange rate (RER) in RDEs (chapter 5). Precisely, we found certain components in the headline CPI basket of RDEs, to be quite useful in capturing the RER that is most relevant for the special trade account features of these countries. In particular, the ratio of domestic tradeable CPI to imported tradeable CPI contained in Botswana's headline CPI basket, produces an import-price RER indicator, which outperforms existing broad measures of the RER[93] in explaining and predicting Botswana's trade flows. Intuitively, the import-price RER tells us to what extent an increase (decrease) in the price of locally produced goods relative to competing imported goods, is likely to create a potential loss (gain) in the domestic market share of local producers. This proposed RER indicator thus, becomes the latest addition to the long list of already existing RER indicators in international trade literature.

It is worth noting nonetheless, that the proposed import-price RER is not a perfect indicator of trade competitiveness, but rather a close approximation of the ideal. Some of the inherent weaknesses of this RER which we were unable to circumvent, are extensively outlined in chapter 5. Future research work should therefore, focus on how to address some these identified weaknesses, as well as those we might have missed. The robustness of this proposed RER could

[93] Such as the headline CPI-RER and GDP-deflator RER.

also be further re-examined in a panel analysis framework, comprising both RDEs and non-RDEs. However, one of the challenges that could potentially confront such an exercise is data limitations. It would not be possible for instance, to construct the import-price RER without complete information on commodity item coverage in the CPI basket, weights assigned to each item, as well as classification of the commodity items by tradability. This information for most countries is not publicly available, special requests in some cases may thus, need to be made to the relevant statistics offices to access such information. This process may however, be very long, depending on the level of cooperation rendered by each statistics office seized with such a request.

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Appendices

A. Micro-Foundations

Micro-foundations form a critical component of the Core model structure in that, they guide and inform the specification of the model's main behavioral equations (Berg, et al., 2006). Accordingly, we present below, micro-foundations in the context of the dynamics and fundamentals of the economy of Botswana, guided by (Gali & Monacelli, 2005; Justiniano & Preston, 2010).

1. Households

A representative Botswana household derives utility from consumption of domestically produced and imported commodities, and smooths her consumption by holding both domestic and foreign bonds. The bonds earn interest rates set by Bank of Botswana and interest rates determined abroad plus a risk premium (which depends on Botswana's net foreign asset position). She also supplies labour in the domestic economy (which represent disutility in her utility function). Her overall objective is to maximise the following lifetime utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, N_t) \qquad (A.1)$$

Where: β^t is the discount factor, C_t is domestic and imported consumer goods and services, N_t is working hours and E(.) are expectations contingent on information at time t

Her period utility is assumed to take the form;

$$E_0 \sum_{t=0}^{\infty} \beta^t \gamma_t [\frac{(C_t - H_t)^{1-\vartheta}}{1-\vartheta} - \frac{N_t^{1-\delta}}{1+\delta}] \qquad (A.2)$$

Where; γ_t is a preference shock, $H_t = C_{t-1}$ are the consumption habits of the agent, ϑ is the parameter of the elasticity of intertemporal substitution and δ is the parameter of the inverse of elasticity of labor supply.

Her aggregate consumption bundle is represented by:

$$C_t = \left[(1-\alpha)^{\frac{1}{\omega}} \, C_{Dt}^{\frac{\omega-1}{\omega}} \; + \; \alpha^{\frac{1}{\omega}} \, C_{It}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{1-\omega}} \qquad \text{(A.3)}$$

Where: C_D are domestically produced commodities, C_I are imported commodities α is the share of imported commodities in the consumption bundle and ω is the elasticity of substitution between domestic and imported commodities.

The aggregation of different varieties of domestic and imported commodities is given by:

$$C_{Dt} = \left[\int_0^1 C_{Dt} \; (i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} \quad , \quad C_{It} = \left[\int_0^1 C_{It} \; (i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$$

Where: ϵ is the elasticity of substitution between commodities across different countries of origin

The representative household faces the budget constraint given below

$$P_t C_t + D_t - S_t FB_t = D_{t_{-1}} R_{t_{-1}} - \; S_t FB_{t_{-1}} R^*_{t_{-1}} \, \varphi_{t_{-1}} + W_t N_t + J_{D_t} + J_{I_t} \qquad \text{(A.4)}$$

Where: P_t is price index of domestic and imported commodities, D_t are domestic bonds with return given by R_t , S_t is nominal exchange rate quoted as weighted average of trading partner currencies per pula[94], FB_t are foreign bonds denominated in trading partner currencies yielding a return given by $R^*_t \, \varphi_t$, (where R^*_t is the foreign interest rate and φ_t is the risk premium[95]), W_t are nominal wages, J_{D_t} and J_{I_t} are domestic and foreign earned dividends.

94 Referred to as the nominal effective exchange rate henceforth.

95 It should be noted that the risk premium associated with foreign bonds is a relative measure of Botswana's own risk premium. That is, when Botswana's net foreign asset position improves, the risk premium on domestic bonds fall and this fall is reflected by a rise in the risk premium of foreign bonds, and the reverse is true. However, this measure and interpretation of the risk premium will be transposed later on.

The household's allocation of consumption or demand between domestic and imported commodities is given by

$$C_{Dt} = (1-\alpha)\left(\frac{P_{D,t}}{P_t}\right)^{-\omega} C_t \quad , \quad C_{It} = \alpha\left(\frac{P_{I,t}}{P_t}\right)^{-\omega} C_t \tag{A.5}$$

Demand for each variety of the domestic and imported commodity is therefore,

$$C_{Dt}(i) = \left(\frac{P_{Dt}(i)}{P_{Dt}}\right)^{-\epsilon} C_t \quad , \quad C_{It}(i) = \left(\frac{P_{It}(i)}{P_{It}}\right)^{-\epsilon} C_t \tag{A.6}$$

Price indices of domestic and foreign goods

$$P_{Dt}(i) = \left[\int_0^1 P_{Dt}\ (i)^{1-\epsilon}\ di\ \right]^{\frac{1}{1-\epsilon}} \quad , \quad P_{It}(i) = \left[\int_0^1 P_{It}\ (i)^{1-\epsilon}\ di\ \right]^{\frac{1}{1-\epsilon}} \tag{A.7}$$

Aggregate price index in the economy of Botswana can be expressed as

$$P_t = [(1-\alpha)\, P_{Dt}^{1-\omega} + \alpha\, P_{It}^{1-\omega}]^{\frac{1}{1-\omega}} \tag{A.8}$$

Where: P_{Dt} and P_{It} are prices of domestic and imported commodities, respectively and P_t is the aggregate price index in Botswana's commodity market.

Maximising the utility function (2) subject to the budget constraint (4) yields the following optimality conditions:

$$\frac{W_t}{P_t} = N_t^{\delta}(C_t - hC_{t-1})^{\vartheta} \tag{A.9}$$

$$R_t = \beta\, \mathrm{E_t}\left\{ \left[\frac{\gamma_{t+1}(C_{t+1}-hC_t)}{\gamma_t(C_t-hC_{t-1})}\right]^{-\vartheta} \frac{P_t}{P_{t+1}} \right\} \tag{A.10}$$

$$R_t^{*}\varphi_t = \beta\, \mathrm{E_t}\left\{ \left[\frac{\gamma_{t+1}(C_{t+1}-hC_t)}{\gamma_t(C_t-hC_{t-1})}\right]^{-\vartheta} \frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}} \right\} \tag{A.11}$$

Optimality condition (9) determines the labour supply, (10) and (11) is the household intertemporal choice between consumption and investment in domestic and foreign bonds respectively, standard Euler equations. Combining (10) and (11) yields the risk-premium adjusted UIP condition that provides the relationship between the nominal effective exchange rate path and parity between domestic and foreign interest rates adjusted for risk factors.

$$E_t \left\{ \left[\frac{\gamma_{t+1}(C_{t+1}-hC_t)}{\gamma_t(C_t-hC_{t-1})}\right]^{-\vartheta} \frac{P_t}{P_{t+1}} \left(R_t^* \varphi_t \frac{S_{t+1}}{S_t} - R_t \right) \right\} = 0 \qquad \text{(A.12)}$$

2. Firms

The economy of Botswana comprises two types of firms; domestic produces and importing retail firms. Firms operate under a monopolistic competition market structure and face constraints in the frequency with which they adjust market prices of their commodities. Price adjustments are assumed to follow Calvo (1983)'s staggered price setting mechanism. The objective of each firm at any period is to set a price that maximises its current market value of expected profits, subject to some demand constraints.

I. Domestic Producers

A continuum of domestic producers conduct business in the economy of Botswana indexed by $i \in [0, 1]$. Each producer employs labour and produce a differentiated commodity $y_{D,t}(i)$ to meet both domestic and foreign demand. All the producers are assumed to follow an identical technology represented by the production function below.

$$y_{Dt}(i) = A_t N\,(i)^{1-\alpha} \qquad \text{(A.13)}$$

Where: A_t is the level of technology, assumed to evolve exogenously over time and $1-\alpha$ is the share of labour inputs in the production function. Other terms are as defined before.

Domestic firms reset prices infrequently. Thus, following Calvo (1983) staggered price setting behavior, only a fraction $(1 - \theta_D)$ reset their prices at any given period t, while a complement of that fraction θ_D, keeps the price unchanged from the previous periods. The price setting expression of the latter can be represented as;

$$P_{Dt}(i) = P_{Dt-1}(i)\left(\frac{P_{Dt-1}}{P_{Dt-2)}}\right)^{\gamma D}$$

Where; γD measures the extent of indexation to past inflation.

The fraction of firms that reset prices in period t choose the same price since they face the same intertemporal problem, therefore

$$P_{Dt}^{*}(i) = P_{Dt}^{*}$$

Where: $P_{Dt}^{*}(i)$ is the new price set by firm (i) and P_{Dt}^{*} the new market price of all firms which reset the price at time t.

Aggregate price of domestic firms at time period *t* is therefore given by the following price index

$$P_{Dt} = [(1 - \theta_D)P_{Dt}^{*}{}^{(1-\epsilon)} + \theta_D\ (P_{Dt-1}(i)\left(\frac{P_{Dt-1}}{P_{Dt-2)}}\right)^{\gamma_D})^{1-\epsilon}]^{1/(1-\epsilon)} \quad \text{(A.14)}$$

Domestic firms resetting prices at period *t*, do so to maximise the current market value of the profit function below

$$Max \sum_{k=0}^{\infty} \theta^{k} E_{t} \left\{z_{t,t+k}\left(P_{Dt}^{*} y_{D,t+k|t} - \mu_{Dt+k} y_{Dt+1|t}\right)\right\} \quad \text{(A.15)}$$

For k = 0, 1,2, … and $z_{t,t+k} = \beta^{k}\left[\frac{\gamma_{t+k}}{\gamma_t}\frac{U_{c,t+k}}{U_{c,t}}\frac{P_t}{P_{t+k}}\right]$ is the nominal stochastic discount factor for future streams of profits, $\mu_{D,t+k}$ is the nominal cost function, θ^{k} is the degree of price rigidities, $y_{D,t+k|t}$ is output in period *k* for a firm that reset the price in period *t*.

Subject to demand constraint

$$y_{D,t+k|t} = \left(\frac{P_{Dt}^{*}}{P_{Dt+k}}\right)^{-\epsilon}(C_{Dt+k} + C_{Dt+k}^{*}) \quad \text{(A.16)}$$

Where: $C_{D,t+k}^{*}$ is the aggregate foreign demand for domestic output

First order optimality condition of the domestic producers is given by

$$\sum_{k=0}^{\infty} \theta^{k} E_{t} \left\{ z_{t,t+k}\, y_{D,t+k|t} (P_{Dt}^{*} - \mho \psi_{Dt+k}) \right\} = 0 \qquad (A.17)$$

Where: $\psi_{Dt+k} = \mu'_{Dt+k} y_{Dt+1|t}$ is the nominal marginal cost in period $t+k$ and $\mho = \frac{\epsilon}{\epsilon - 1}$ is the optimal markup in the absenceof frictions in the price adjustment mechanism.

II. Retail Importing Firms

Retail firms in Botswana acquire imported commodities at a price determined in the foreign markets. The commodities are differentiated in the domestic market at no cost (implicit assumption) and sold in local currency. Prices of these imported commodities are adjusted infrequently and indexed to past inflation, implying an imperfect pass-through from changes in foreign prices and the nominal exchange rate to domestic consumer prices. Retail firms that reset prices in period *t*, choose the same price since they face the same intertemporal problem, therefore

$P_{It}^{*}(i) = P_{It}^{*}$

Where: $P_{Dt}^{*}(i)$ is the new price set by retail firm *(i)* and P_{Dt}^{*} the new market price of all importing firms which reset the price at time *t*.

The aggregate price index of imported commodities in Botswana is given by

$$P_{It} = [(1 - \theta_{I}) P_{It}^{*\,(1-\epsilon)} + \theta_{I} \,(P_{It-1}(i) \left(\frac{P_{It-1}}{P_{It-2)}} \right)^{\gamma_{I}})^{1-\epsilon}]^{1/(1-\epsilon)} \qquad (A.18)$$

Retail firms resetting prices at period *t*, seek to maximise the current market value of the profit function given by

$$Max \sum_{k=0}^{\infty} \theta_{I}^{k} E_{t} \left\{ z_{t,t+k} \left(P_{It}^{*} C_{It+k|t} - S_{t+k} P_{t+k}^{f} C_{It+1|t} \right) \right\} \qquad (A.19)$$

Where: P_{t+k}^{f} is the foreign price of the imported commodities

Subject to the demand constraint

$$C_{It+k|t} = \left(\frac{P_{It}^{*}}{P_{It+k}}\right)^{-\epsilon} C_{It+k} \tag{A.20}$$

First order optimality condition of the importing retail firms is given by

$$\frac{\sum_{k=0}^{\infty} \theta_I^k E_t\{z_{t,t+k}\,(S_{t+k}P_{I,t}^{*}C_{It+1|t})\}}{\sum_{k=0}^{\infty} \theta_I^k E_t\,\{z_{t,t+k}\,(C_{It+1|t})\}} = 0 \tag{A.21}$$

The following factors are also important to the objective function of importing firms, but they will be applied at a later stage.

$$ZE_t = \frac{S_t P^f}{P_t}\,, \qquad ZE_{I,t} = \frac{S_t P^f}{P_{I,t}}\,, \qquad tot = \frac{P_{Dt}}{P_{It}}$$

Where: ZE_t, is the real exchange rate, ZE_{It} is the real price of imported commodities, tot is the terms of trade.

3. Log-linearisation of Optimality Conditions

Log-linearisation of key optimality conditions around steady state values yields the following equations.

Euler equation

Intertemporal choice between current household consumption and investment in bonds is expressed by

$$C_t = \left(\frac{1}{1+h}\right) E_t C_{t+1} + \left(\frac{h}{1+h}\right) + C_{t-1} - \frac{1}{\sigma(1+h)}\,(i_t - E_t\pi_{t+1}) \tag{A.21}$$

Where: C_t is consumption in period *t*, E_tC_{t+1} is expected consumption in period *t+1*, $C_{t-1}$is consumption in the preceding period, i_t is nominal interest rates, $E_t\pi_{t+1}$is expected inflation, $(i_t - E_t\pi_{t+1})$ is real interest rates, h is strength of habit formation and σ is risk aversion.

Domestic Producers Philips curve

$$\pi_{Dt} = \left(\frac{1}{1+\beta}\right) \pi_{Dt-1} + \left(\frac{\beta}{1+\beta}\right) E_t\pi_{Dt+1} + \frac{(1-\theta_D\beta)(1+\theta_D)}{(1+\beta)\theta_D}\tau\mu_{Dt} \qquad \text{(A.22)}$$

Where: $\tau\mu_{D,t}$ is the real marginal cost of domestic producers

Retail Importing Firms Philips curve

$$\pi_{It} = \left(\frac{1}{1+\beta}\right) \pi_{It-1} + \left(\frac{\beta}{1+\beta}\right) E_t\pi_{It+1} + \frac{(1-\theta_I\beta)(1+\theta_I)}{(1+\beta)\theta_I}ZE_{It} \qquad \text{(A.23)}$$

4. Market Clearing (Equilibrium) Conditions in the Economy of Botswana

Market clearing or equilibrium in the commodity market requires that aggregate output be fully absorbed by both domestic and foreign consumption. That is**,**

$$y_{Dt} = C_t \qquad \text{(A.24)}$$

B. Exchange Rate Regime Description

The descriptions below are based on the (IMF, 2019b) report on *Exchange Arrangements and Exchange Restrictions*. According to the IMF classification, there are approximately ten types of exchange rate regimes currently used acrossed the world, ranging from hard pegs to freely floating regimes.

Hard Pegs

In hard pegs, a domestic currency is rigidly fixed or pegged to a foreign currency usually of an industrialized country, for example the US dollar. There are two main classes of hard pegged currencies; *no separate legal tender* and *currency board arrangements* (IMF, 2019b). Countries operating a hard peg with no separate legal tender allow a foreign currency to be used as the sole legal tender in its economy (IMF, 2019b; IMF, 2017a). This arrangement is known as formal dollarization (IMF, 2019b). In another version of a hard peg with no separate legal tender, member countries of a monetary union share a common currency as legal tender (IMF, 2019b). The Euro area is one such example. In a currency board arrangement, the country makes a legislative commitment to exchange domestic currency for foreign currency at a specified fixed exchange rate (IMF, 2017a). The central bank or any issuing authority is legally obliged to fulfill this commitment (IMF, 2017a). Monetary policy autonomy is extremely limited under hard pegged regimes (IMF, 2019b; IMF, 2017a).

Soft Pegs

Soft peg exchange rate regimes include; *conventional fixed peg arrangements, stabilized arrangement, peg within horizontal band, crawling peg and crawling-like arrangement* (IMF, 2019b; IMF, 2017a). Unlike hard pegs, which establish a rigidly fixed exchange rate between the domestic and foreign currency, soft pegs allow for varying degree of flexibility within explicitly defined bands. Under these pegs, a country fixes its currency to a single or a basket of foreign currencies and allows some margin of fluctuations above or below the target rate (IMF, 2019b; IMF, 2017a). The domestic currency is pegged to major trading and/or financial partner(s) (with weights, in the case of a basket of currencies) reflecting trade patterns and capital flows between the country and foreign countries to which its currency is pegged (IMF, 2019b; IMF, 2017a). Policymakers maintains the peg through direct interventions in the foreign exchange market through selling and buying of foreign currency and indirectly through the use of short-term interest rates, foreign exchange regulations and moral suasion to control activities in the foreign exchange market (IMF, 2019b; IMF, 2017a). In general, soft pegs impose limitations on monetary policy independence but not as stringent as in hard pegs (IMF, 2019b; IMF, 2017a).

Floating Regimes

Next to soft pegs are *managed floating* and *free-floating exchange rate regimes*. (IMF, 2019b; IMF, 2017a). In a managed floating regime, there is no predetermined path or target of the nominal exchange rate. However, the authorities occasionally intervene in the foreign exchange market to influence exchange rate movements but without any specific or policy-targeted path (IMF, 2019b; IMF, 2017a). Some of the economic indicators guiding the interventions may include the level of foreign exchange reserves, the balance of payments position or developments in the capital market (IMF, 2019b; IMF, 2017a). With regard to free-floating regimes, the value of the domestic currency against foreign currencies is determined by market forces in the foreign exchange market (IMF, 2019b; IMF, 2017a). Market interventions by the authorities occur only in exceptional circumstances (to address disorderly market dynamics for example) and such interventions according to the IMF guidelines, should occur at most, three times in a period of six months, each intervention not lasting more than three business days (IMF, 2019b; IMF, 2017a). Managed floating and free-floating regimes guarantee a high degree of monetary policy independence (IMF, 2019b; IMF, 2017a).

The IMF classifies any exchange rate regime which does not adequately meet the criteria for the categories outlined above as *other managed arrangements*. This includes exchange rate policies prone to frequent changes (IMF, 2019b; IMF, 2017a).

Monetary Policy Options under Different Exchange Rate Regimes

As highlighted above, the type of exchange rate regime adopted by a country inherently impose restrictions on formulation and implementation of its monetary policy (IMF, 2019b). The most fundamental restriction imposed by the choice of the exchange rate regime on monetary policy design, is the so-called *trilemma or impossible trinity*, which stems from the Capital Account Openness theory by (Mundell, 1963; Fleming, 1962). According to this theory, countries which are deeply integrated with the global financial system and have perfect capital mobility statutes, can only choose between two mutually exclusive macroeconomic policy options; *exchange rate stability* or *monetary policy independence* (Mundell, 1963; Fleming, 1962).

That is, a country can either (i) fix the exchange rate and give up monetary policy independence or (ii) allow the exchange rate to float and gain monetary policy independence (Mundell, 1963; Fleming, 1962). In the first option, under perfect capital mobility, the monetary authority cannot set domestic interest rates independently from the movements in foreign interest rates without causing excessive pressure (emanating from capital flows) on the exchange rate policy position or the peg (Mundell, 1963; Fleming, 1962). Therefore, under this option, the monetary authority's role is strictly confined to the sole mission of maintaining the stability of the exchange rate, any other policy goal (price stability, for example) is subordinate to the overarching framework, i.e., the exchange rate policy (Mundell, 1963; Fleming, 1962). The second option implies that, under perfect capital mobility, the monetary authority can use interest rates to smoothen short term fluctuations in output and drive inflation to target while the free floating exchange rate regime corrects for any imbalances that may be instigated by developments in the capital markets (Mundell, 1963; Fleming, 1962). This option describes the basic features of the so-called, *Fully-Fledged Inflation Targeting Monetary Policy Framework.*

The ingenuity of the central banks has however in the recent past lead to a third policy option, the *Intermediate or Hybrid Monetary Policy Framework* (Obstfeld & Rogoff, 1995; Fischer, 2001). Under this framework, the central bank seeks to maintain exchange rate stability but with some degree of monetary policy independence to pursue other macroeconomic goals, price stability for example (Obstfeld & Rogoff, 1995; Fischer, 2001). Thus, in contrast to the two-option discussed above, wherein, price stability (inflation targeting) and exchange rate stability are mutually exclusive goals, the hybrid monetary policy framework provides space for both goals to be pursued concurrently (Obstfeld & Rogoff, 1995; Fischer, 2001). The framework mainly entails the use of soft pegs, which allows for some degree of exchange rate flexibility to absorb capital market pressures, which may be instigated by disparities in domestic and foreign interest rates (Obstfeld & Rogoff, 1995; Fischer, 2001).

While the framework has performed fairly well in other countries, a number of studies have however, found the framework to be unsustainable in the long term, particularly for countries that are deeply integrated with global financial markets and have perfect capital mobility (Fischer, 2001; Krugman, 1998). (Fischer, 2001), based on the financial and currency crises experience of some emerging market economies[96], observed an increasing tendency among affected countries (with the above attributes) to abandon their soft peg regimes, during or after the crises (Fischer, 2001). Some countries transitioning to extremely hard pegs (currency board or monetary unions) while others, allowing their currencies to free float (Fischer, 2001).

C. Baseline model Parameters

Parameter	Description	Parameter Value
a_1	Output gap persistence	0.6
a_2	Real monetary conditions	0.2
a_3	Foreign demand	0.25
b_{11}	Oil inflation persistence	0.45
b_{12}	Relative price of oil	0.25
b_{13}	Real marginal cost of oil	0.05
b_{21}	Food inflation persistence	0.45
b_{22}	Relative price of food	0.2
b_{23}	Real marginal cost of food	0.1
b_{31}	Core inflation persistence	0.45
b_{32}	Relative price of core	0.15
b_{33}	Real marginal cost of core	0.25
g_1	Speed of exchange rate adjustment to target	0.95
g_2	Exchange rate expectations	0.9
g_3	Mining output gap persistence	0.4

96 Mexico in 1994, East Asia in 1997, Russia in 1998, Argentina and Turkey in 2000.

g_4	Relative level of financial market development	0
z_1	Foreign exchange intervention	0.55
h_1	Policy rate persistence	0.5
h_2	UIP in the Taylor rule	0.1
m_1	Deviations of inflation from the target	1.5
m_2	Output gap in the Taylor rule	0.5
π^{Tar}	Implied inflation target	3.35
ΔS^{Tar}	Nominal exchange rate target	0
i^n	Equilibrium level of nominal interest rates	3.25
$prem_{ss}$	Risk premium steady state	-0.1

NB: Other model parameters are as presented in Figure 1.2

D. Transition model 1 Parameters

Parameter	**Description**	**Parameter Value**
a_1	Output gap persistence	0.6
a_2	Real monetary conditions	0.2
a_3	Foreign demand	0.25
b_{11}	Oil inflation persistence	0.55
b_{12}	Relative price of oil	0.25
b_{13}	Real marginal cost of oil	0.05
b_{21}	Food inflation persistence	0.55
b_{22}	Relative price of food	0.2
b_{23}	Real marginal cost of food	0.1
b_{31}	Core inflation persistence	0.55
b_{32}	Relative price of core	0.15
b_{33}	Real marginal cost of core	0.15
g_2	Exchange rate expectations	0.45
g_3	Mining output gap persistence	0.4
g_4	Relative level of financial market development	1
h_1	Policy rate persistence	0.5

h_2	UIP in the Taylor rule	0.4
m_1	Deviations of inflation from the target	1.5
m_2	Output gap in the Taylor rule	0.5
π^{Tar}	Inflation target	3.35
ΔS^{Tar}	Implied nominal exchange rate target	0
i^n	Equilibrium level of nominal interest rates	6.25
$prem_{ss}$	Risk premium steady state	2.9
$\overline{r_{ss}}$	Real interest rates steady state	2.9

NB: Other model parameters are as presented in Figure 1.2

E. Transition model 2 Parameters

Parameter	Description	Parameter Value
a_1	Output gap persistence	0.6
a_2	Real monetary conditions	0.2
a_3	Foreign demand	0.25
b_{11}	Oil inflation persistence	0.4
b_{12}	Relative price of oil	0.25
b_{13}	Real marginal cost of oil	0.05
b_{21}	Food inflation persistence	0.4
b_{22}	Relative price of food	0.2
b_{23}	Real marginal cost of food	0.1
b_{31}	Core inflation persistence	0.35
b_{32}	Relative price of core	0.15
b_{33}	Real marginal cost of core	0.35
g_2	Exchange rate expectations	0.45
g_3	Mining output gap persistence	0.4
g_4	Relative level of financial market development	1
h_1	Policy rate persistence	0.5
m_1	Deviations of inflation from the target	1.5
m_2	Output gap in the Taylor rule	0.5
π^{Tar}	Inflation target	3.35
ΔS^{Tar}	Implied nominal exchange rate target	0

i^n	Equilibrium level of nominal interest rates	3.55
$prem_{ss}$	Risk premium steady state	0.2
$\overline{r_{ss}}$	Real interest rates steady state	0.2

NB: Other model parameters are as presented in Figure 1.2

F. Modified UIP Derivation

We start with the perfect version of the UIP;

$$S_t = S_t^e + \left(i_t - i_t^f - prem_t\right)/4 + \varepsilon_t^s \quad \text{(F.1)}$$

To capture the peg or fixed regime in the UIP, we assume that, deviations in the nominal exchange rate (appreciation/depreciation) from the desired target is partly explained by the perfect version of the UIP, thus equation F.2 below

$$\Delta S_t - \Delta S_t^{Tar} = \frac{g_1}{1-g_1}\left[S_t^e - S_t + \left(i_t - i_t^f - prem_t\right)/4 + \varepsilon_t^s\right] \quad \text{(F.2)}$$

Where: $\Delta S_t = S_t - S_{t-1}$, ΔS_t^{Tar} is the nominal exchange rate target or steady state rate of appreciation or depreciation

Rearranging equation F.2 yield our modified UIP, which captures the peg.

$$S_t = (1 - g_1)\,(S_{t-1} + \Delta S_t^{Tar}) + g_1\left(S_t^e - S_t + \left(i_t - i_t^f - prem_t\right)/4\right) + \varepsilon_t^s \quad \text{(F.3)}$$

Where: $S_{t-1} + \Delta S_t^{Tar} = S_t^{Tar}$ (recall that all our variables are in logs), thus

$$S_t = (1 - g_1)\,S_t^{Tar} + g_1\left(S_t^e - S_t + \left(i_t - i_t^f - prem_t\right)/4\right) + \varepsilon_t^s \quad \text{(F.4)}$$

Where $g_1 \in [0,1]$ captures the degree of the market response; if $g_1 = 1$ then the UIP holds perfectly, whereas if $g_1 = 0$ then the interest rate differential has no effect on the exchange rate that, in turn, the exchange rate grows simply at the steady-state rate of nominal appreciation/depreciation. So, in our baseline model, the nominal exchange rate equation is a weighted average of the policy-desired path (S_t^{Tar}) and the path implied by the UIP. As already indicated in the paper, parameter g_1 is assigned a small value of 0.05 because the nominal exchange rate of the pula against its trading partner currencies is almost always on target, (stylized facts in Subsection 3.1).

Below is a proof that the UIP holds in equilibrium. From equation F.4, we have

$$S_t = (1 - g_1)\, S_t^{Tar} + g_1\big(S_t^e - S_t + \big(i_t - i_t^f - prem_t\big)/4\,\big) + \varepsilon_t^s$$

Where: $S_t^e - S_t = \Delta S_t^e$, $(1 - g_1)\, S_t^{Tar} + g_1 \Delta S_t^e = S_{t+1}^{Tar}$

We can re-write equation F.4 as,

$$S_{t+1}^{Tar} - S_t = -(g_1 \left(\frac{\big(i_t - i_t^f - prem_t\,\big)}{4}\right) + \varepsilon_t^s) \qquad \text{(F.5)}$$

In equilibrium, $S_{t+1}^{Tar} - S_t = \Delta S_{t+1}^{Tar} = \Delta S_t^{Tar} = \Delta S^{Tar} = 0$

Equilibrium level of domestic nominal interest rates $(i_t) = 3.25$

Equilibrium level of foreign nominal interest rates $(i_t^f) = 3.35$

Equilibrium risk premium = -0.1

See Appendix C

The UIP therefore holds in equilibrium, that is

$$S_{t+1}^{Tar} - S_t = \left(\frac{\big(i_t - i_t^f - prem_t\,\big)}{4}\right) = 0$$

G. Empirical framework- Markov Switching Model

First, we defining the following objects for the estimation procedure;
$Y^T = \{y_{i1}, y_{i2}, \dots, y_{iT}\}$ and $\tilde{Y}$ is a vector obtained by stacking Y^{T} for all countries; $X^T = \{x_{it}, x_{i2}, \dots, x_{iT}\}$ is a vector of all covariates and $\tilde{X}$ is a stacked vector of X^T for all countries, and $Z^T = \{z_{i1}, z_{i2}, \dots, z_{iT}\}$ is a latent process which follows a first order Markov chain with state space $k = 1, 2 \dots K$.

Measurement model

Conditional on z^T and X^T the density function $f(y|z,x)$ can be factorized as;

$$f(y|z,x) = \prod_{t=1}^{T} \prod_{i=1}^{N} f\left(y_{it}|z_{itk}, x_{it}, \mu_{ik}, \sigma_{ik}^2\right) \quad \text{(G.1)}$$

Where $f(y_{it}|\cdot)$ is the conditional density of the normal distribution;

$$f(y_{it}|z_{ik}, x_{it}, \mu_{ik}, \sigma_{ik}^2) = \frac{1}{\sqrt{2\pi\sigma_{ik}^2}} \exp\left\{-\frac{1}{2\pi\sigma_{ik}^2}\left(y_{it} - \mu_{ik} - \beta_k z_{itk}\right)^2\right\}$$

This is the density for the model marginalized with respect to random effects;

$$y_{it} = Z_{it}\beta + \varepsilon_{ikt}, \ \varepsilon_{ikt} \sim N(0, \sigma_k^2)$$

$$\beta = \left(\mu_{ik}, \beta_k\right)$$

Latent Model

This concerns parameterization of the initial and transition probabilities of the latent distribution. Different parameterization techniques may be applied for this task, but for convenience and consistency with the counterpart logit model for reported transition cases, we adopt a multinomial logit parameterization method.

Initial Probabilities

$$log \ \frac{\pi_{k|x}}{\pi_{1|x}} = log \ \frac{P(z_{i1}=k|\ x_{i1}=x)}{P(z_{i1}=1|\ x_{i1}=x)} = \beta_{0k} + x'\beta_k, \ k = 2, \dots K \quad \text{(G.2)}$$

Transition Probabilities

$$log \ \frac{\pi_{k|\bar{k}x}^t}{\pi_{\bar{k}|\bar{k}x}^t} = log \ \frac{P(z_{it}=k|\ z_{it-1}=\bar{k}, x_{it}=x)}{P(z_{it}=\bar{k}|\ z_{it-1}=\bar{k}, x_{it}=x)} = \gamma_{0\bar{k}k} + x'\gamma_{\bar{k}k}, \ \bar{k}, k = 1,2, \dots K, t = 2, 3, \dots, T \quad \text{(G.3)}$$

Where $\beta_{0k}, \beta_k, \gamma_{0\bar{k}k}, \gamma_{0\bar{k}k,} \gamma_{\bar{k}k}$ are parameter vectors to be estimated.

The transition matrix for the i^{th} country at time t is formulated as,

$$P = \begin{bmatrix} P(1|1,x) & P(2|1,x) & \dots & P(K|1,x) \\ P(1|2,x) & P(2|2,x) & \dots & P(K|2,x) \\ \vdots & \vdots & \vdots & \vdots \\ P(1|K,x) & P(2|K,x) & \dots & P(K|K,x) \end{bmatrix}$$

The all-encompassing transition probability matrix P^*, is the averaged matrix for all countries over the sample period T. Moreover, the generalized conditional distribution of the latent process z_{it} given covariate vector x_{it} may be expressed as

$$f\ (z_{it}|x_{it}) = \prod_{i=1}^{N} p(z_{i1}|x_{i1}) \prod_{i=1}^{N} \prod_{t=2}^{T} p(z_{it}\ |x_{it})$$

Manifest Distribution of the Response Variable

The manifest distribution of the response variable relates to the conditional distribution of $\tilde{Y}$ given $\tilde{X}$, and is defined as follows, for any realization $\tilde{y}$ of $\tilde{Y}$ and $\tilde{x}$ of $\tilde{X}$.

$$f\ (\tilde{y}|\tilde{x}) = \sum_{z} f(\tilde{y}|z,\tilde{x}) f(z|\tilde{x})$$

Where $\sum_{z}.$ is extended to all configurations of the latent process, $z = \{z_{i1}, z_{i2}, \dots, z_{iT}\}$. The log-likelihood function of the model can thus, be expressed as

$$l(\theta) = \sum_{\tilde{x}} \sum_{\tilde{y}} n_{\tilde{x}\tilde{y}}\ f\ (\tilde{y}|\tilde{x})$$

Where θ is the vector of all parameters to be estimated, $n_{\tilde{x}\tilde{y}}$ is the joint frequency of the covariate vector $\tilde{x}$ and $\tilde{y}$. The Expectation-Maximization (EM) algorithm is used to maximize the log-likelihood function $l(\theta)$, and takes the following expression

$$l^*(\theta) = \sum_{t} \sum_{k} \sum_{x} \sum_{y} a_{kxy}^{(t)}\ log f^{(t)}(y|k,x) + \sum_{z} \sum_{x} b_{kx}^{(1)} \log p(k|x) + \sum_{t \geq 2} \sum_{\bar{k}} \sum_{k} \sum_{x} b_{\bar{k},k,x}^{(t)}\ log\ p^{(t)}\left(k|\bar{k},x\right) \qquad \text{(G.4)}$$

Where $a_{kxy}^{(t)}$ are countries in latent state k with annual exchange rate change y, $b_{kx}^{(t)}$ is a frequency of the latent state k and covariate vector x at occasion $t = 1$ and $b_{\bar{k},k,x}^{(t)}$ is the frequency of transitions from state $\bar{k}$ to k. Expression (11) is based on the complete data log-likelihood. The EM algorithm is implemented in two steps (E-step and M-step), which we describe below.

E-step: derives the conditional expected values for $a_{kxy}^{(t)}$, $b_{kx}^{(t)}$ and $b_{\bar{k},k,x}^{(t)}$, as follows

$$\hat{a}_{kxy}^{(t)} = \sum_{\tilde{x}} \sum_{\tilde{y}} n_{\tilde{x}\tilde{y}}\ q^{(t)}\ (k|\tilde{x},\tilde{y}) I(x^{(t)} = x, y^{(t)} = y)$$

$\hat{b}_{kx}^{(t)} = \sum_{\tilde{x}} \sum_{\tilde{y}} n_{\tilde{x}\tilde{y}}\ q^{(t)}\ (k|\tilde{x}, \tilde{y}) I(x^{(t)} = x)$

$\hat{b}_{\bar{k}kx}^{(t)} = \sum_{\tilde{x}} \sum_{\tilde{y}} n_{\tilde{x}\tilde{y}}\ q^{(t)}\ \left(\bar{k}, k \middle| \tilde{x}, \tilde{y}\right) I(x^{(t)} = x)$

Where $q^{(t)}(\cdot)$, are the posterior distributions of the latent process $z^{(t)}$ and $I(\cdot)$ is the indicator function.

M-step: maximizes (1.5) with each frequency replaced by their corresponding expected values defined above. A detailed description of how the algorithm is operationalized is provided in (Bartolucci, 2006; Bartolucci & Farcomeni, 2009).

Model Choice

Model choice pertains to the selection of the number of states the response variable undergoes, as implied by observed data. Although in our case the number of states, is priori defined on the basis of the research problem at hand, we however, still allow the model to provide its own estimate from actual observed data. Two information criteria are used to this end, these are; the Akaike information criterion (AIC), and the Bayesian information criterion (BIC). Accordingly, the chosen number of states reflected by observed data, corresponds to the minimum of

$AIC = -2l(\hat{\theta}) + 2g$

$BIC = -2l(\hat{\theta}) + glog(n)$

Where, g is the total number of free parameters.

Path Prediction

Another important aspect of the framework, which also serves as a performance evaluation technique of the estimated model, is the prediction of transition incidents or the sequence of latent states for each country covered in the sample, given their individual characteristics. This is achieved by maximizing the joint conditional probability $\hat{f}(k|\tilde{x}, \tilde{y})$, via the Viterbi algorithm (Viterbi 1967; Juang and Rabiner 1991), illustrated below.

For a given country with covariate vector x and response variable y, let

$\hat{r}^{(1)}(k) = \hat{f}\left(k^{(1)} \middle| x^{(1)}, y^{(1)}\right)$, and for $t = 2, \dots T$ we let

$\hat{r}^{(t)}(k) \max \hat{f}(k^{(1)}, \dots, k^{(t-1)}, k^{(t)}, x^{(1)}, \dots, x^{(T)}, y^{(1)}, \dots, y^{(T)})$

Suitable forward and backward recursion, respectively, can be used to compute the above expressions and predict the latent sequence for the country of interest, as follows;

i. For $k = 1, \dots, K$ let $\hat{r}^{(1)}(k) = \hat{p}(k)\widehat{\emptyset}_{y^{(1)}|u,x}$

ii. For $t = 2, \dots T$ and $k = 1, \dots K$, we have
$\hat{r}^{(t)}(k)$, computed as $\widehat{\emptyset}_{y^{(t)}|u,x}$ max[$\hat{r}^{(t-1)})(\bar{k})\hat{p}(\bar{k}|k)$];

iii. The optimal state at period T is obtained as $\hat{k}^{*(T)} = \text{argmax}_u \hat{r}^{(T)}(k)$

iv. And for period $t = T-1, \dots, 1$,
$\hat{k}^{*(t)} = \text{argmax}_u \hat{r}^{(t)}(k)\hat{p}^{(t+1)}(\hat{k}^{*(t+1)}|k)$

The above quantities are all based on the estimated model parameter vector $\hat{\theta}$.

H. Threshold Switching Regression Model

Model specification

$$y_{it} = \mu_i + \beta' x_{it} I(q_{it} \leq \gamma) + \delta' x_{it} I(q_{it} > \gamma) + e_{it} \quad \text{(G.5)}$$

Where y_{it} is as defined under the MSP model, β *and* δ are the parameters of the covariates under each of the two regimes, q_{it} is the threshold variable, γ the threshold parameter to be estimated, $I(\cdot)$ is a transition function and e_{it} is assumed to be iid with mean zero and variance σ_ε^2.

Alternatively, equation (G.5) can be represented as;

$$y_{it} = \begin{cases} \mu_i + \beta' x_{it} + e_{it}, & q_{it} \leq \gamma, \\ \mu_i + \delta' x_{it} + e_{it}, & q_{it} > \gamma, \end{cases} \quad \text{(G.6)}$$

For estimation purposes we can compact (3.1) and (3.2) to (3.3) below,

$$y_{it} = \mu_i + x_{it}'\beta + (1, x_{it}')\delta \mathbb{1}(q_{it} > \gamma) + e_{it} \quad \text{(G.7)}$$

We use the generalized method of moments (GMM) to estimate (3.3), following (Seo & Shin, 2016). This involves eliminating individual effects μ_i with the first-difference transformation, before applying GMM to estimate the unknown parameters $\theta = (\beta', \delta', \gamma)'$, as described below.

Let $(z_{it_0}', \dots, z_{iT}')$ be a vector of instrumental variables, which include lagged and exogenous variables. The sample moment is given as

$$\bar{g}_n(\theta) = \bar{g}_{1n} - \bar{g}_{2n}(\gamma)(\beta', \delta')' = \frac{1}{n}\sum_{i=1}^{n} g_{1i} - \frac{1}{n}\sum_{i=1}^{n} g_{2i}(\gamma)(\beta', \delta')'$$

Where

$$g_{1i} = \begin{pmatrix} z_{it_0}\Delta y_{it_0} \\ \vdots \\ z_{it_T}\Delta y_{it_T} \end{pmatrix}, \; g_{2i}(\gamma) = \begin{pmatrix} z_{it_0}\left(\Delta x'_{it_0}, 1_{it_0}(\gamma)' X_{ito}\right) \\ \vdots \\ z_{iT}(\Delta x'_{iT}, 1_{iT}(\gamma)' X_{iT}) \end{pmatrix}$$

$$X_{it} = \begin{pmatrix} 1, X'_{it} \\ 1, X'_{it-1} \end{pmatrix}, \quad 1_{it}(\gamma) = \begin{pmatrix} 1\{q_{it} > \gamma\} \\ -1\{q_{it-1} > \gamma\} \end{pmatrix}$$

The GMM criterion function is thus, given by

$$\bar{J}_n(\theta) = \bar{g}_n(\theta)' W_{n\bar{g}_n}(\theta) \tag{G.8}$$

Where W_n is the weight of the matrix. We minimize (3.4) to obtain GMM estimate, $\hat{\theta}$ through the grid search since for each fixed threshold γ, we get a fixed effect linear panel model, which produce the closed-form solution given below

$$\{\hat{\beta}(\gamma)', \; \hat{\delta}(\gamma)'\}' = \{\bar{g}_{2n}(\gamma)' W_{n\bar{g}_{2n}}(\gamma)\}^{-1} \bar{g}_{2n}(\gamma)' W_{n\bar{g}_{1n}}$$

The GMM estimator by (Seo & Shin, 2016) is asymptotically normal. That is,

$$\begin{pmatrix} \sqrt{n\begin{pmatrix} \hat{\beta} - \hat{\beta}_0 \\ \hat{\delta} - \hat{\delta}_0 \end{pmatrix}} \\ n^{\frac{1}{2-\varphi}}(\hat{\gamma} - \gamma_0) \end{pmatrix} \rightarrow^d \; N\{0, (G'\Omega^{-1}G)^{-1}\}$$

Where

$$G = \{G_\beta, G_\delta(\gamma_0), G_\gamma(\gamma_0)\},$$

$$G_\beta = \begin{bmatrix} -E\left(z_{it_0}\Delta x'_{it_0}\right) \\ \vdots \\ -E(z_{iT}\Delta x'_{iT}) \end{bmatrix}, \qquad G_\delta(\gamma) = \begin{bmatrix} -E\left(z_{it_0}\mathbb{1}_{it_0}(\gamma)' X_{it_0}\right) \\ \vdots \\ -E(z_{iT}\mathbb{1}_{iT}(\gamma)' X_{iT}) \end{bmatrix},$$

$$G_\gamma = \begin{bmatrix} [E_{t_0-1}\{z_{it_0}\left(1, x'_{it_{0-1}}\right)|\gamma\} p_{t_0-1}(\gamma) - E_{t_0-1}\{z_{it_0}\left(1, x'_{it_{0-1}}\right)|\gamma\} p_{t_0}(\gamma)]\delta_0 \\ \vdots \\ [E_{T-1}\{z_{iT}(1, x'_{iT-1})|\gamma\} p_{T-1}(\gamma) - E_{T-1}\{z_{iT}(1, x'_{iT-1})|\gamma\} p_T(\gamma)]\delta_0 \end{bmatrix}$$

Where $E_t(\cdot\,|\gamma)$ is the conditional expectation given $q_{it} = \gamma$ and $p_t(\cdot)$ is the density of q_{it}.

The estimation of the variance is thus, standard, given by

$$\hat{\Omega}(\theta) = \frac{1}{n}\sum_{i=1}^{n} g_i(\theta)\, g_i(\theta)' - \frac{1}{n}\sum_{i=1}^{n} g_i(\theta) \frac{1}{n}\sum_{i=1}^{n} g_i(\theta)'$$

Where $g_i(\theta) = g_{1i} + g_{2i}(\gamma)(\beta', \delta')'$, and

$$\hat{G}_{\beta} = \begin{bmatrix} -\frac{1}{n}\sum_{i=1}^{n}\left(z_{it_0}\Delta x_{it_0}'\right) \\ \vdots \\ -\frac{1}{n}\sum_{i=1}^{n}\left(z_{iT}\Delta x_{iT}'\right) \end{bmatrix}, \quad \hat{G}_{\delta}(\gamma) = \begin{bmatrix} -\frac{1}{n}\sum_{i=1}^{n}\left(z_{it_0}\mathbb{1}_{it_0}(\gamma)'X_{it_0}\right) \\ \vdots \\ -\frac{1}{n}\sum_{i=1}^{n}\left(z_{iT}\mathbb{1}_{iT}(\gamma)'X_{iT}\right) \end{bmatrix}$$

$$\hat{G}_{\gamma}(\theta) = \begin{bmatrix} \frac{1}{nh}\sum_{i=1}^{n} z_{it_0}\left\{\left(1, x_{it_{0-1}}'\right)'K\left(\frac{\gamma - q_{it_0-1}}{h}\right) - \left(1, x_{it_0}'\right)'K\left(\frac{\gamma - q_{it_0}}{h}\right)\right\}\delta \\ \vdots \\ \frac{1}{nh}\sum_{i=1}^{n} z_{iT}\left\{\left(1, x_{iT-1}'\right)'K\left(\frac{\gamma - q_{iT-1}}{h}\right) - \left(1, x_{iT}'\right)'K\left(\frac{\gamma - q_{iT}}{h}\right)\right\}\delta \end{bmatrix}$$

i.e., the Nadaraya-Watson Kernel estimator, for some kernel K and bandwidth h (Seo & Shin, 2016).

I. Figure I.a: Annual Exchange Rate- Training Sample

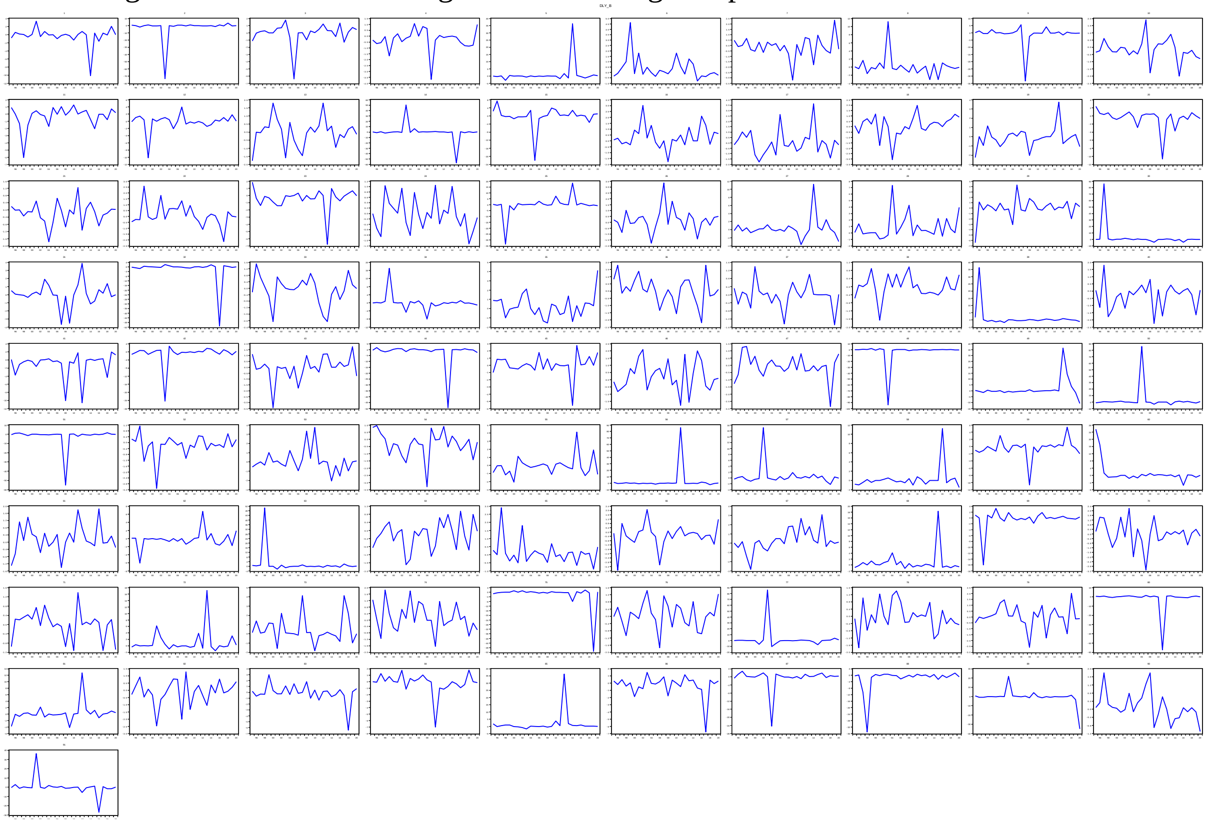
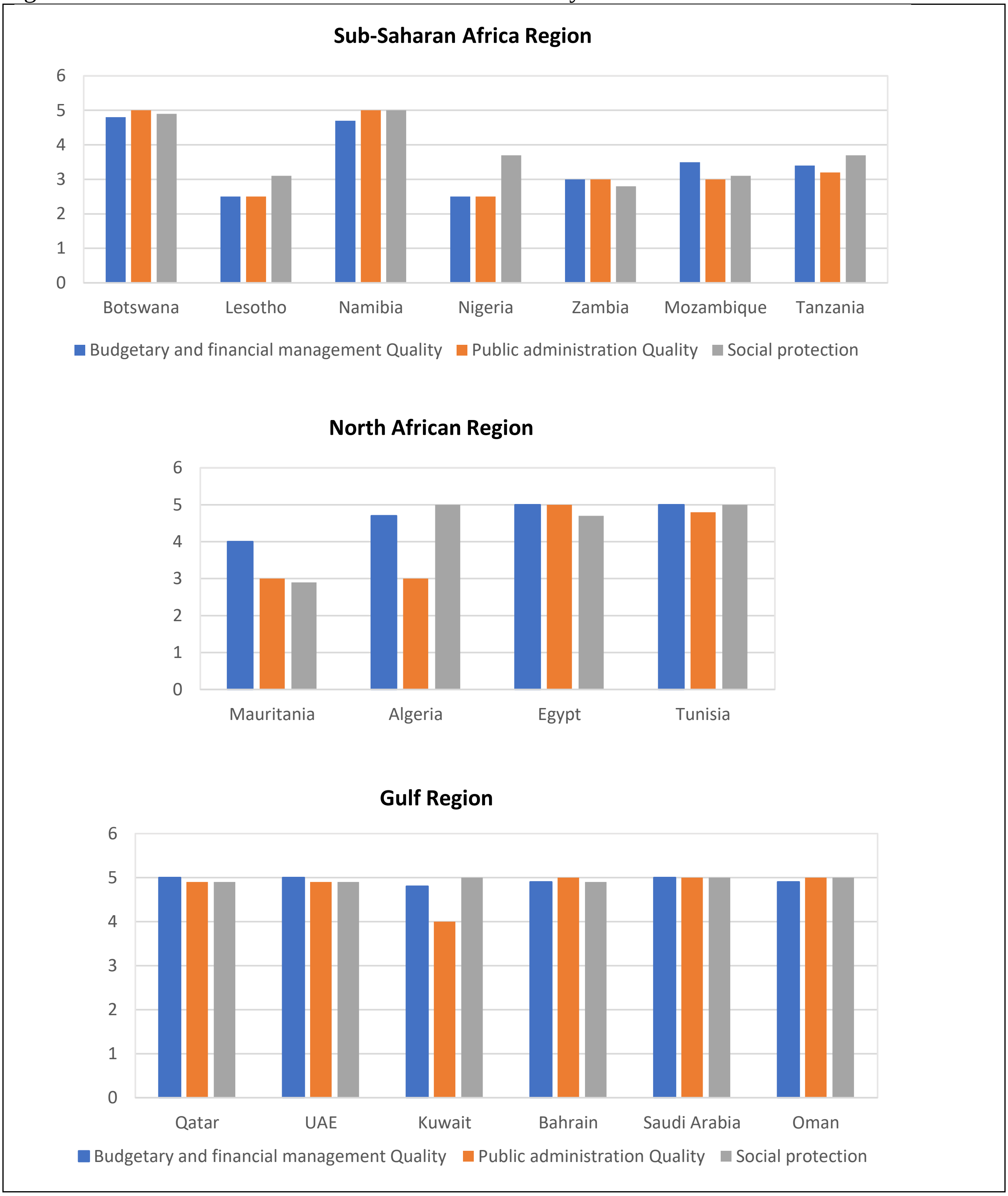


Figure I.b: World Bank Economic and Political Stability Indicators



Notes: *1. All the indicators rank from (1=low to 6=high)*

2. Budgetary and financial management quality assesses the extent to which there is a comprehensive and credible budget linked to policy priorities, effective financial management systems, and timely and accurate accounting and fiscal reporting.

3. Public administration quality assesses the extent to which civilian central government staff is structured to design and implement government policy and deliver services effectively.

4. Social protection and labor assess government policies in social protection and labor market regulations that reduce the risk of becoming poor, assist those who are poor to better manage further risks, and ensure a minimal level of welfare to all people.

J. Markov Model Estimation Output

Note: The model labeling of the states is not in increasing ordered of DlogY for state 1 and 2. State 1 is labelled 2 and state 2 is labeled 1.

```
Convergence info:
     LogLik np k      AIC      BIC  n TT
  -4866.446 52 3 9836.892 9967.456 91 26


Mu - Conditional response means:
      state
             1      2       3
 DlogY 14.9229 0.8137 51.7849

Standard errors for the conditional response means:
      state
            1     2      3
 DlogY 0.2658 0.035 0.5118



 Si - Variance-covariance matrix:
        [,1]    [,2]     [,3]
[1,]  9.7798  0.0037  -2.0428
[2,]  0.0037  0.2566  -0.2838
[3,] -2.0428 -0.2838 183.2912


 Standard errors for the variance-covariance matrix:
       [,1]   [,2]    [,3]
[1,] 0.9964 0.1012  3.7202
[2,] 0.1012 0.0149  0.3295
[3,] 3.7202 0.3295 12.0911

Coefficients:

 Be - Parameters affecting the logit for the initial probabilities:
             logit

                  2       3
(Intercept) 0.0743  0.6110
l_fxd       0.0000  0.0121
l_fmd       0.0058  0.1110
l_risk      0.0014 -0.1921
resv        0.0011 -0.4811
it          0.0123 -0.7723


 Standard errors for Be:
            logit
```

	2	3
(Intercept)	0.0552	0.5455
l_fxd	0.0059	0.0446
l_fmd	0.0154	0.0718
l_risk	0.0208	0.1257
resv	0.0070	0.4315
it	0.0721	3.1542

Ga - Parameters affecting the logit for the transition probabilities:

, , logit = 1

logit	2	3
(Intercept)	-0.0680	-0.4935
l_fxd	0.0040	-0.1272
l_fmd	-0.0164	-0.0410
l_risk	0.0248	0.0453
resv	0.0041	-0.1213
it	0.0301	-0.3763

, , logit = 2

logit	2	3
(Intercept)	-0.2926	-0.4359
l_fxd	0.0019	-0.0240
l_fmd	0.0018	-0.0540
l_risk	-0.0047	0.0011
resv	0.0011	-0.1181
it	0.0034	-0.2236

, , logit = 3

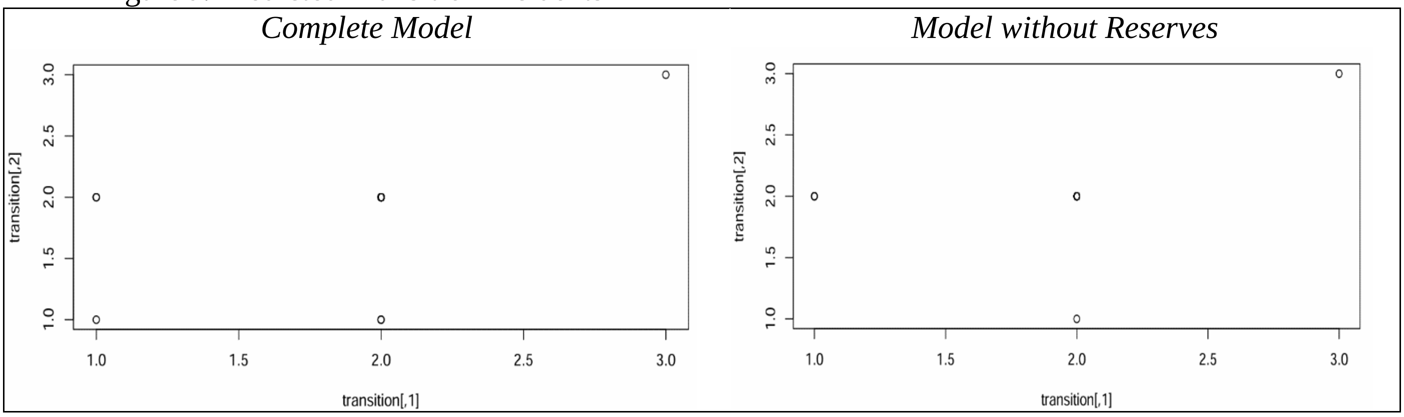
logit	2	3
(Intercept)	0.0156	0.0789
l_fxd	-0.3776	-0.4120
l_fmd	0.0122	0.0144
l_risk	0.3791	0.4300
resv	-0.1160	-0.1275
it	0.8939	0.9649

Standard errors for Ga:

, , logit = 1

```
            logit
                  2      3
  (Intercept) 0.0743 0.6300
  l_fxd       0.0279 0.1507
  l_fmd       0.0487 0.4233
  l_risk      0.0723 0.6006
  resv        0.0320 0.2869
  it          0.1859 1.0832

, , logit = 2

            logit
                  2      3
  (Intercept) 0.0203 0.1060
  l_fxd       0.0040 0.0091
  l_fmd       0.0064 0.0342
  l_risk      0.0101 0.0412
  resv        0.0016 0.0379
  it          0.0269 0.1038


, , logit = 3

            logit
                  2      3
  (Intercept) 3.2187 3.2147
  l_fxd       1.7341 1.7323
  l_fmd       1.2311 1.2289
  l_risk      1.0837 1.0749
  resv        1.5588 1.5576
  it          4.1232 4.1156
```

Figure J: Predicted Transition Incidents



The complete model (with all the covariates) predicts negligible transition cases from state 1 to 3 and state 2 to 3, which is consistent with the estimated transition probability matrix. The model without foreign exchange reserves predicts negligible cases of remaining pegged (state 1).

K. Logit Model Estimation Output

```
Logistic regression                               Number of obs   =        129
                                                  LR chi2(3)      =      52.03
                                                  Prob > chi2     =     0.0000
Log likelihood = -60.962885                       Pseudo R2       =     0.2991
```

Y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
l_fxd	.2464394	.1465589	1.68	0.093	-.0408107	.5336894
l_fmd	.0455385	.0102268	4.45	0.000	.0254943	.0655826
l_risk	-.0113477	.0052741	-2.15	0.031	-.0216848	-.0010107
_cons	-.4509989	.4562517	-0.99	0.323	-1.345236	.4432379

Note: 1 failure and 1 success completely determined.

```
Marginal effects after logit
      y  = Pr(Y) (predict)
         =  .66860873
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
l_fxd	.0546038	.02729	2.00	0.045	.001111	.108097	3.22342
l_fmd	.01009	.00266	3.79	0.000	.004876	.015304	35.1572
l_risk	-.0025143	.00134	-1.87	0.061	-.005147	.000119	109.492

Logistic model for Y

Classified	True D	True ~D	Total
+	62	16	78
-	15	36	51
Total	77	52	129

Classified + if predicted Pr(D) >= .5
True D defined as Y != 0

Sensitivity	Pr(+| D)	80.52%
Specificity	Pr(-|~D)	69.23%
Positive predictive value	Pr(D| +)	79.49%
Negative predictive value	Pr(~D| -)	70.59%
False + rate for true ~D	Pr(+|~D)	30.77%
False - rate for true D	Pr(-| D)	19.48%
False + rate for classified +	Pr(~D| +)	20.51%
False - rate for classified -	Pr(D| -)	29.41%
Correctly classified		75.97%

.

L. Threshold Switching Regression Estimation Output

```
N = 30, T = 19
Panel Var. = c_id
Time Var. = year
Number of moment conditions = 357
Bootstrap p-value for linearity test = 0
```

dlogY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Lag_y_b	-.24483	.1424846	-1.72	0.086	-.5240947	.0344347
l_fxd_b	-.0497174	.0102427	-4.85	0.000	-.0697928	-.029642
l_risk_b	-.0272129	.0096718	-2.81	0.005	-.0461693	-.0082565
l_fmd_b	-.0994217	.0397836	-2.50	0.012	-.177396	-.0214473
cons_d	1.51785	.3969663	3.82	0.000	.7398103	2.29589
Lag_y_d	1.114718	.5113204	2.18	0.029	.1125487	2.116888
l_fxd_d	-.1134945	.0461339	-2.46	0.014	-.2039152	-.0230738
l_risk_d	.0620244	.0358813	1.73	0.084	-.0083017	.1323504
l_fmd_d	-.1959432	.0888411	-2.21	0.027	-.3700686	-.0218179
r	2.199675	.2143667	10.26	0.000	1.779524	2.619826

.

M. Pre-Estimation Tests

UNIT ROOT TEST RESULTS TABLE (ADF)

Null Hypothesis: the variable has a unit root

	At Level							
		LTIMPT	LIMP_RER	LCPI_RER	LGDPD_RER	LSRER	LNMGDP	LPRDVITY
With Constant	t-Statistic	-2.7700	-2.0915	-3.7640	-1.9335	-3.1788	-3.1264	-3.1710
	Prob.	***0.0687***	***0.2488***	***0.0057***	***0.3152***	***0.0260***	***0.0298***	***0.0265***
		*	n0	***	n0	**	**	**
With Constant & Trend	t-Statistic	-1.6411	-2.1642	-0.2778	-6.0396	-1.9408	-0.4106	-3.9873
	Prob.	***0.7646***	***0.5005***	***0.9894***	***0.0000***	***0.6215***	***0.9850***	***0.0140***
		n0	n0	n0	***	n0	n0	**
Without Constant & Trend	t-Statistic	1.3490	1.4969	0.9409	-0.2023	1.8626	3.8714	-0.7381
	Prob.	***0.9539***	***0.9656***	***0.9060***	***0.6094***	***0.9842***	***0.9999***	***0.3927***
		n0	n0	n0	n0	n0	n0	n0
	At First Difference							
		d(LTIMPT)	d(LIMP_RER)	d(LCPI_RER)	d(LGDPD_RER)	d(LSRER)	d(LNMGDP)	d(LPRDVITY)
With Constant	t-Statistic	-8.3324	-5.9608	-9.6521	-14.6578	-6.7416	-7.5563	-8.0987
	Prob.	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***
		***	***	***	***	***	***	***
With Constant & Trend	t-Statistic	-8.8672	-6.0174	-4.8051	-14.5068	-7.2716	-8.6300	-8.0252
	Prob.	***0.0000***	***0.0000***	***0.0015***	***0.0000***	***0.0000***	***0.0000***	***0.0000***
		***	***	***	***	***	***	***
Without Constant & Trend	t-Statistic	-3.4379	-5.7490	-9.6268	-14.7875	-6.4982	-1.7033	-8.1401
	Prob.	***0.0009***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0836***	***0.0000***
		***	***	***	***	***	*	***

N. Cointegration test

IMP-RER Model

Date: 06/06/23 Time: 19:52
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
Trend assumption: Linear deterministic trend
Series: LTIMPT LIMP_RER LNMGDP LPRDVITY
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.290255	53.03758	47.85613	0.0151
At most 1 *	0.267146	32.80948	29.79707	0.0218
At most 2	0.153589	14.47178	15.49471	0.0709
At most 3 *	0.075529	4.633488	3.841466	0.0313

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.290255	20.22810	27.58434	0.3256
At most 1	0.267146	18.33770	21.13162	0.1177
At most 2	0.153589	9.838294	14.26460	0.2228
At most 3 *	0.075529	4.633488	3.841466	0.0313

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CPI-RER Model

Date: 06/06/23 Time: 19:56
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
Trend assumption: Linear deterministic trend
Series: LTIMPT LCPI_RER LNMGDP LPRDVITY
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.419405	65.36469	47.85613	0.0005
At most 1 *	0.266397	33.28633	29.79707	0.0190
At most 2	0.150557	15.00885	15.49471	0.0591
At most 3 *	0.087176	5.381526	3.841466	0.0203

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.419405	32.07836	27.58434	0.0123
At most 1	0.266397	18.27748	21.13162	0.1198
At most 2	0.150557	9.627320	14.26460	0.2376
At most 3 *	0.087176	5.381526	3.841466	0.0203

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP Deflator-RER

Date: 06/06/23 Time: 19:59
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
Trend assumption: Linear deterministic trend
Series: LTIMPT LGDPD_RER LNMGDP LPRDVITY
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.337782	49.28410	47.85613	0.0365
At most 1	0.220640	24.96662	29.79707	0.1626
At most 2	0.096667	10.25894	15.49471	0.2613
At most 3 *	0.069670	4.260767	3.841466	0.0390

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.337782	24.31748	27.58434	0.1240
At most 1	0.220640	14.70768	21.13162	0.3099
At most 2	0.096667	5.998170	14.26460	0.6134
At most 3 *	0.069670	4.260767	3.841466	0.0390

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

Sectoral-RER Model

Date: 06/06/23 Time: 20:06
Sample (adjusted): 2006Q1 2020Q4
Included observations: 60 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: LTIMPT LSRER LNMGDP LPRDVITY
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.380965	56.46660	54.07904	0.0301
At most 1	0.263688	27.69097	35.19275	0.2554
At most 2	0.091643	9.324854	20.26184	0.7056
At most 3	0.057572	3.557768	9.164546	0.4820

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.380965	28.77563	28.58808	0.0473
At most 1	0.263688	18.36611	22.29962	0.1621
At most 2	0.091643	5.767086	15.89210	0.8135
At most 3	0.057572	3.557768	9.164546	0.4820

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

O. Error Correction Model (ECM) Results

IMP-RER Model

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 05/30/23 Time: 12:15
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.327058	0.223315	1.464560	0.1491
D(LIMP_RER)	-0.605501	0.902447	-0.670954	0.5052
D(LIMP_RER(-1))	0.990707	0.982483	1.008371	0.3179
D(LIMP_RER(-2))	2.135550	0.943578	2.263247	0.0278
D(LNMGDP)	0.958314	0.279966	3.422969	0.0012
D(LPRDVITY)	-0.386779	0.071499	-5.409591	0.0000
D(LPRDVITY(-1))	0.062908	0.121502	0.517758	0.6068
ECM_IMPR(-1)	-0.734064	0.258906	-2.835248	0.0065
C	-0.009523	0.013982	-0.681048	0.4989

R-squared	0.620907	Mean dependent var	0.020990
Adjusted R-squared	0.562585	S.D. dependent var	0.140683
S.E. of regression	0.093044	Akaike info criterion	-1.776042
Sum squared resid	0.450171	Schwarz criterion	-1.464602
Log likelihood	63.16928	Hannan-Quinn criter.	-1.653986
F-statistic	10.64618	Durbin-Watson stat	2.026481
Prob(F-statistic)	0.000000		

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

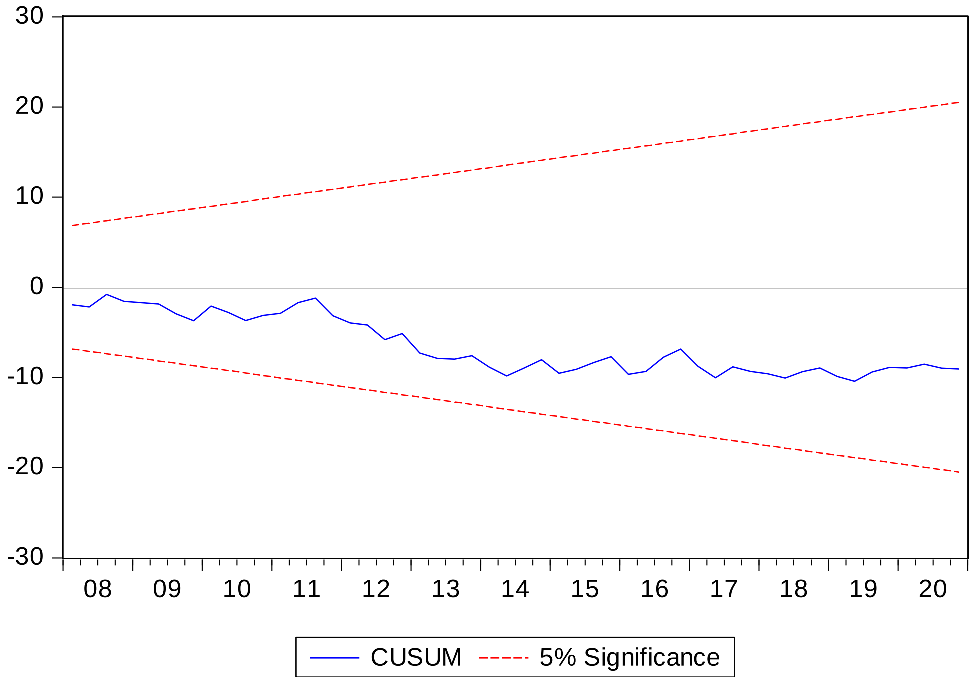
F-statistic	0.053568	Prob. F(1,51)	0.8179
Obs*R-squared	0.064005	Prob. Chi-Square(1)	0.8003

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/03/23 Time: 12:41
Sample: 2005Q4 2020Q4
Included observations: 61
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	-0.002028	0.225545	-0.008991	0.9929
D(LIMP_RER)	-0.028881	0.919282	-0.031417	0.9751
D(LIMP_RER(-1))	-7.80E-05	0.991548	-7.86E-05	0.9999
D(LIMP_RER(-2))	-0.001206	0.952298	-0.001266	0.9990
D(LNMGDP)	0.015550	0.290427	0.053544	0.9575
D(LPRDVITY)	-7.23E-05	0.072159	-0.001001	0.9992
D(LPRDVITY(-1))	-0.001605	0.122819	-0.013071	0.9896
ECM_IMPR(-1)	0.067446	0.391400	0.172320	0.8639
C	-6.09E-05	0.014114	-0.004318	0.9966
RESID(-1)	-0.078846	0.340664	-0.231448	0.8179

R-squared	0.001049	Mean dependent var	4.85E-18
Adjusted R-squared	-0.175236	S.D. dependent var	0.086619
S.E. of regression	0.093902	Akaike info criterion	-1.744305
Sum squared resid	0.449699	Schwarz criterion	-1.398260
Log likelihood	63.20130	Hannan-Quinn criter.	-1.608687
F-statistic	0.005952	Durbin-Watson stat	2.013904
Prob(F-statistic)	1.000000		

Stability Test



CPI-RER Model

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 06/04/23 Time: 17:11
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.138409	0.180711	0.765911	0.4472
D(LCPI_RER)	-3.649517	2.060999	-1.770751	0.0825
D(LCPI_RER(-1))	-3.575391	1.823363	-1.960877	0.0553
D(LCPI_RER(-2))	1.222877	1.122768	1.089163	0.2811
D(LNMGDP)	0.984511	0.280670	3.507715	0.0009
D(LNMGDP(-1))	0.170175	0.372423	0.456941	0.6496
D(LPRDVITY)	-0.358722	0.060977	-5.882896	0.0000
ECM_CPI(-1)	-0.502256	0.221541	-2.267104	0.0276
C	0.004885	0.013181	0.370640	0.7124

R-squared	0.666359	Mean dependent var	0.020990
Adjusted R-squared	0.615030	S.D. dependent var	0.140683
S.E. of regression	0.087288	Akaike info criterion	-1.903760
Sum squared resid	0.396197	Schwarz criterion	-1.592319
Log likelihood	67.06467	Hannan-Quinn criter.	-1.781703
F-statistic	12.98204	Durbin-Watson stat	2.153829
Prob(F-statistic)	0.000000		

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.063803	Prob. F(2,50)	0.3528
Obs*R-squared	2.489735	Prob. Chi-Square(2)	0.2880

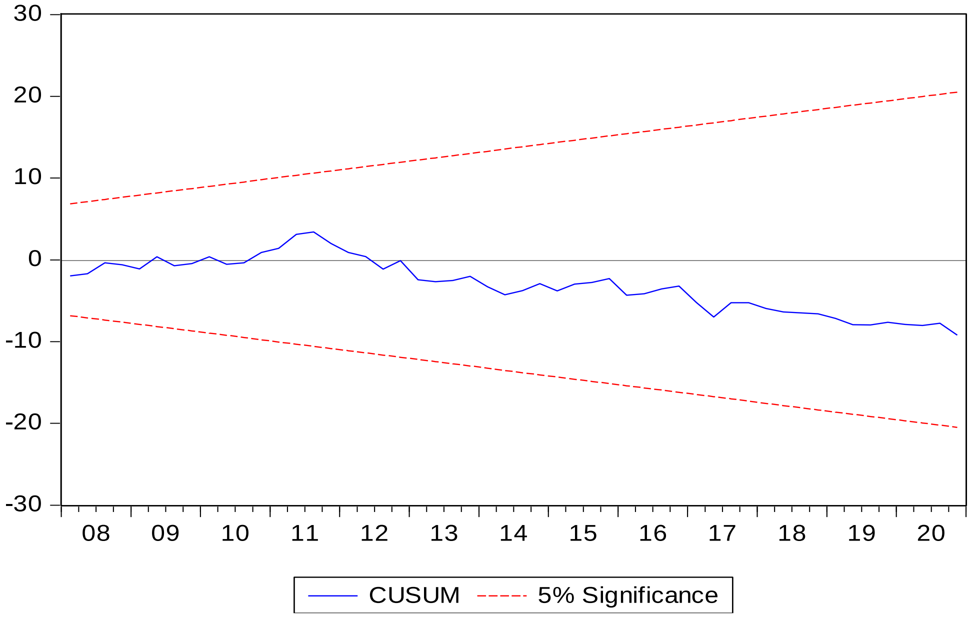
Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/03/23 Time: 12:44
Sample: 2005Q4 2020Q4
Included observations: 61
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	-0.024902	0.199501	-0.124820	0.9012
D(LCPI_RER)	0.593021	2.098244	0.282627	0.7786
D(LCPI_RER(-1))	0.111967	1.832843	0.061089	0.9515
D(LCPI_RER(-2))	-0.002696	1.135386	-0.002375	0.9981
D(LNMGDP)	-0.005212	0.280352	-0.018591	0.9852
D(LNMGDP(-1))	0.001965	0.389607	0.005044	0.9960
D(LPRDVITY)	-0.006322	0.064112	-0.098606	0.9218
ECM_CPI(-1)	0.279086	0.294714	0.946971	0.3482
C	0.000385	0.013169	0.029257	0.9768
RESID(-1)	-0.387919	0.272669	-1.422676	0.1610
RESID(-2)	-0.080481	0.171508	-0.469254	0.6409

R-squared	0.040815	Mean dependent var	7.05E-18
Adjusted R-squared	-0.151022	S.D. dependent var	0.081261
S.E. of regression	0.087181	Akaike info criterion	-1.879857

Sum squared resid	0.380026	Schwarz criterion	-1.499208
Log likelihood	68.33565	Hannan-Quinn criter.	-1.730677
F-statistic	0.212761	Durbin-Watson stat	1.923605
Prob(F-statistic)	0.994077		

Stability Test



GDP Deflator_RER Model

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 06/03/23 Time: 12:49
Sample (adjusted): 2005Q3 2020Q4
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.263474	0.145664	1.808786	0.0760
D(LGDPD_RER)	0.203259	0.271028	0.749957	0.4565
D(LGDPD_RER(-1))	0.470069	0.250266	1.878279	0.0656
D(LNMGDP)	1.217070	0.289798	4.199711	0.0001
D(LPRDVITY)	-0.309533	0.065545	-4.722445	0.0000
ECM_GDP(-1)	-0.600811	0.181725	-3.306149	0.0017
C	-0.003907	0.013124	-0.297679	0.7671

R-squared	0.586711	Mean dependent var	0.021969
Adjusted R-squared	0.541625	S.D. dependent var	0.139737
S.E. of regression	0.094607	Akaike info criterion	-1.772172
Sum squared resid	0.492274	Schwarz criterion	-1.532011
Log likelihood	61.93732	Hannan-Quinn criter.	-1.677879
F-statistic	13.01316	Durbin-Watson stat	2.222960
Prob(F-statistic)	0.000000		

Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

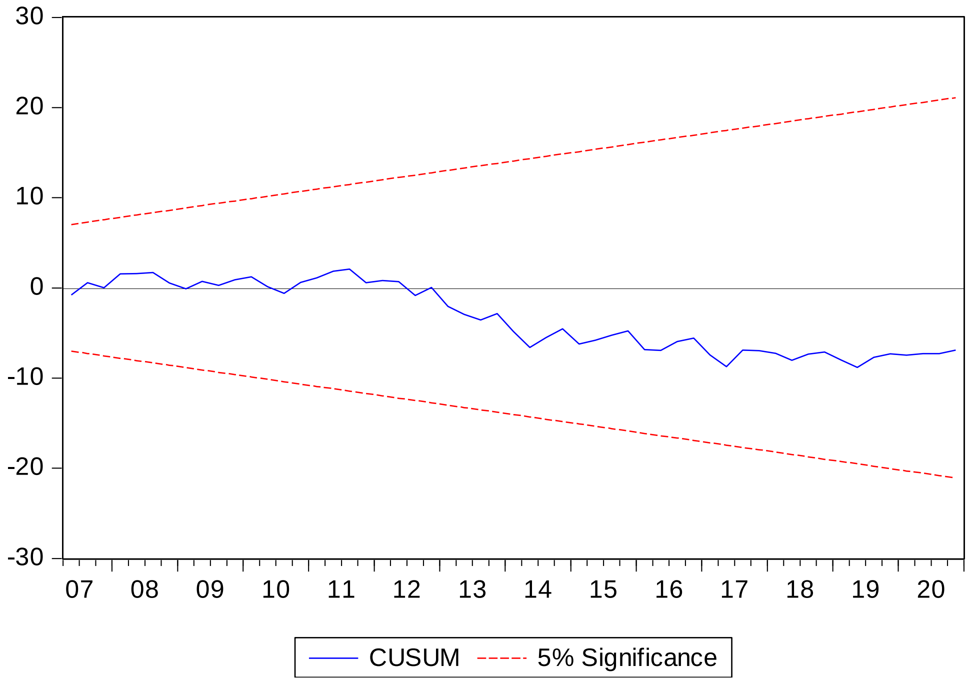
F-statistic	2.410523	Prob. F(1,54)	0.1264
Obs*R-squared	2.649371	Prob. Chi-Square(1)	0.1036

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/03/23 Time: 12:48
Sample: 2005Q3 2020Q4
Included observations: 62
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.006173	0.143886	0.042905	0.9659
D(LGDPD_RER)	-0.024904	0.268098	-0.092891	0.9263
D(LGDPD_RER(-1))	-0.023306	0.247573	-0.094138	0.9253
D(LNMGDP)	0.043756	0.287537	0.152174	0.8796
D(LPRDVITY)	-0.031167	0.067762	-0.459946	0.6474
ECM_GDP(-1)	0.246072	0.239412	1.027820	0.3086
C	-0.001355	0.012989	-0.104293	0.9173
RESID(-1)	-0.376219	0.242318	-1.552586	0.1264

R-squared	0.042732	Mean dependent var	-2.69E-18
Adjusted R-squared	-0.081359	S.D. dependent var	0.089834
S.E. of regression	0.093416	Akaike info criterion	-1.783585
Sum squared resid	0.471238	Schwarz criterion	-1.509116
Log likelihood	63.29114	Hannan-Quinn criter.	-1.675822
F-statistic	0.344360	Durbin-Watson stat	2.068857
Prob(F-statistic)	0.929665		

Stability Test



Sectoral_RER Model

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 05/30/23 Time: 12:44
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.256956	0.181315	1.417179	0.1624
D(LSRER)	-0.146915	0.732574	-0.200546	0.8418
D(LSRER(-1))	-0.436738	0.712602	-0.612878	0.5426
D(LSRER(-2))	1.647312	0.717030	2.297411	0.0257
D(LNMGDP)	1.046015	0.307891	3.397354	0.0013
D(LNMGDP(-1))	-0.123554	0.412255	-0.299704	0.7656
D(LPRDVITY)	-0.390914	0.067482	-5.792870	0.0000
ECM_STR(-1)	-0.632293	0.224506	-2.816376	0.0068
C	-0.006415	0.014692	-0.436610	0.6642

R-squared	0.593363	Mean dependent var	0.020990
Adjusted R-squared	0.530803	S.D. dependent var	0.140683
S.E. of regression	0.096365	Akaike info criterion	-1.705902
Sum squared resid	0.482880	Schwarz criterion	-1.394462
Log likelihood	61.03002	Hannan-Quinn criter.	-1.583846
F-statistic	9.484763	Durbin-Watson stat	2.059599
Prob(F-statistic)	0.000000		

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.079797	Prob. F(2,50)	0.3475
Obs*R-squared	2.525618	Prob. Chi-Square(2)	0.2829

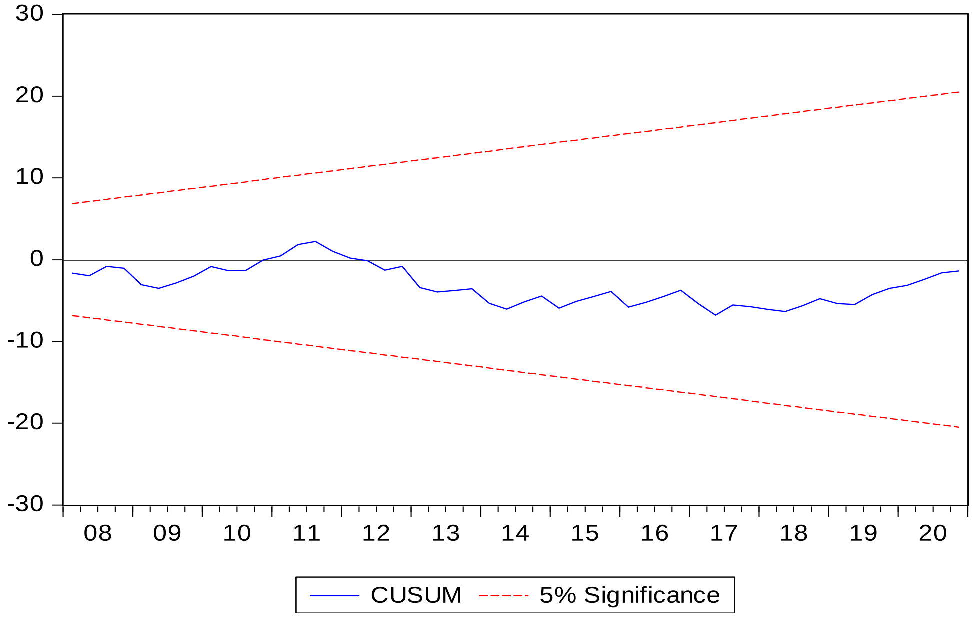
Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/03/23 Time: 19:28
Sample: 2005Q4 2020Q4
Included observations: 61
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	-0.232162	0.246660	-0.941226	0.3511
D(LSRER)	-0.073439	0.748039	-0.098176	0.9222
D(LSRER(-1))	0.006440	0.711587	0.009050	0.9928
D(LSRER(-2))	-0.051127	0.720401	-0.070970	0.9437
D(LNMGDP)	0.022040	0.309773	0.071150	0.9436
D(LNMGDP(-1))	0.372376	0.487523	0.763812	0.4486
D(LPRDVITY)	-0.002563	0.070332	-0.036438	0.9711
ECM_STR(-1)	0.561583	0.463910	1.210544	0.2318
C	-0.000259	0.014679	-0.017648	0.9860
RESID(-1)	-0.368575	0.352491	-1.045630	0.3008
RESID(-2)	-0.282139	0.205788	-1.371013	0.1765

R-squared	0.041404	Mean dependent var	-5.18E-18

Adjusted R-squared	-0.150316	S.D. dependent var	0.089711
S.E. of regression	0.096217	Akaike info criterion	-1.682614
Sum squared resid	0.462887	Schwarz criterion	-1.301964
Log likelihood	62.31972	Hannan-Quinn criter.	-1.533434
F-statistic	0.215959	Durbin-Watson stat	2.039887
Prob(F-statistic)	0.993713		

Stability Test



Robustness Check: Regression Output from the Current Account Balance Model

IMP-RER Model

Dependent Variable: D(LCURRENT_ACCNT)
Method: Least Squares
Date: 08/09/24 Time: 16:12
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCURRENT_ACCNT(-1))	-0.009724	0.123933	-0.078465	0.9378
D(LIMP_RER)	-7.708523	1.447476	-5.325494	0.0000
D(LIMP_RER(-1))	4.635184	1.846459	2.510310	0.0152
D(LIMP_RER(-2))	-3.392249	1.695345	-2.000919	0.0505
D(LNMGDP)	2.298213	0.687250	3.344070	0.0015
D(LPRDVITY)	0.244142	0.125556	1.944486	0.0572
ECM_IMPRER(-1)	-0.681446	0.170016	-4.008128	0.0002
C	-0.025104	0.025648	-0.978768	0.3321

R-squared	0.620671	Mean dependent var	-0.011074
Adjusted R-squared	0.570571	S.D. dependent var	0.256581
S.E. of regression	0.168139	Akaike info criterion	-0.606333
Sum squared resid	1.498357	Schwarz criterion	-0.329497
Log likelihood	26.49315	Hannan-Quinn criter.	-0.497838
F-statistic	12.38861	Durbin-Watson stat	2.007242
Prob(F-statistic)	0.000000	Wald F-statistic	18.90772
Prob(Wald F-statistic)	0.000000		

**Note: LIMP_RER is log of import-price RER, ECM_IMPRER is the error correction term, LNMGDP is the log of non-mining GDP, LPRDVITY is log of productivity. All the definitions are in the main document (chapter 5). According to the estimated results, a 1 percent appreciation in the import-price RER (upward movement) leads to a deterioration in Botswana's current account by 7.7 percent, holding other factors constant.*

CPI-RER Model

Dependent Variable: D(LCURRENT_ACCNT)
Method: Least Squares
Date: 08/09/24 Time: 16:36
Sample (adjusted): 2006Q2 2020Q4
Included observations: 59 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCURRENT_ACCNT(-1))	0.289108	0.237744	1.216049	0.2297
D(LCPI_RER)	-4.173843	4.024244	-1.037174	0.3046
D(LCPI_RER(-1))	4.765896	3.582050	1.330494	0.1894
D(LCPI_RER(-2))	-10.10336	4.277072	-2.362214	0.0221
D(LNMGDP)	2.681008	0.719528	3.726067	0.0005
D(LNMGDP(-1))	-1.552213	0.903112	-1.718738	0.0918
D(LPRDVITY)	0.318771	0.134533	2.369461	0.0217
ECM_CPIRER(-1)	-0.950990	0.230590	-4.124161	0.0001
C	-0.007462	0.028212	-0.264506	0.7925

R-squared	0.577580	Mean dependent var	-0.010230
Adjusted R-squared	0.509993	S.D. dependent var	0.260085
S.E. of regression	0.182061	Akaike info criterion	-0.429382

Sum squared resid	1.657306	Schwarz criterion	-0.112470
Log likelihood	21.66678	Hannan-Quinn criter.	-0.305673
F-statistic	8.545713	Durbin-Watson stat	2.330028
Prob(F-statistic)	0.000000	Wald F-statistic	19.32915
Prob(Wald F-statistic)	0.000000		

**Note: LCPI_RER is log of the headline CPI-derived CPI, ECM_CPIRER is the error correction term, and other variables are as defined above.*

GDP Deflator_RER Model

Dependent Variable: D(LCURRENT_ACCNT)
Method: Least Squares
Date: 08/09/24 Time: 16:28
Sample (adjusted): 2005Q3 2020Q4
Included observations: 62 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCURRENT_ACCNT(-1))	0.156640	0.148690	1.053467	0.2967
D(LGDPD_RER)	0.683489	0.532492	1.283567	0.2047
D(LGDPD_RER(-1))	-0.513579	0.602890	-0.851862	0.3980
D(LNMGDP)	2.236059	0.583893	3.829568	0.0003
D(LPRDVITY)	0.173535	0.122425	1.417477	0.1620
ECM_GDPRER(-1)	-0.774911	0.172287	-4.497786	0.0000
C	-0.038537	0.026266	-1.467195	0.1480

R-squared	0.523872	Mean dependent var	-0.005640
Adjusted R-squared	0.471930	S.D. dependent var	0.258041
S.E. of regression	0.187514	Akaike info criterion	-0.403922
Sum squared resid	1.933881	Schwarz criterion	-0.163762
Log likelihood	19.52158	Hannan-Quinn criter.	-0.309629
F-statistic	10.08584	Durbin-Watson stat	2.188700
Prob(F-statistic)	0.000000	Wald F-statistic	15.92727
Prob(Wald F-statistic)	0.000000		

**Note: LGDPD_RER is log of GDP deflator RER, ECM_GDPRER is the error correction term, and other variables are as defined above.*

Sectoral_RER Model

Dependent Variable: D(LCURRENT_ACCNT)
Method: Least Squares
Date: 08/09/24 Time: 15:57
Sample: 2006Q1 2020Q4
Included observations: 60
White heteroskedasticity-consistent standard errors & covariance

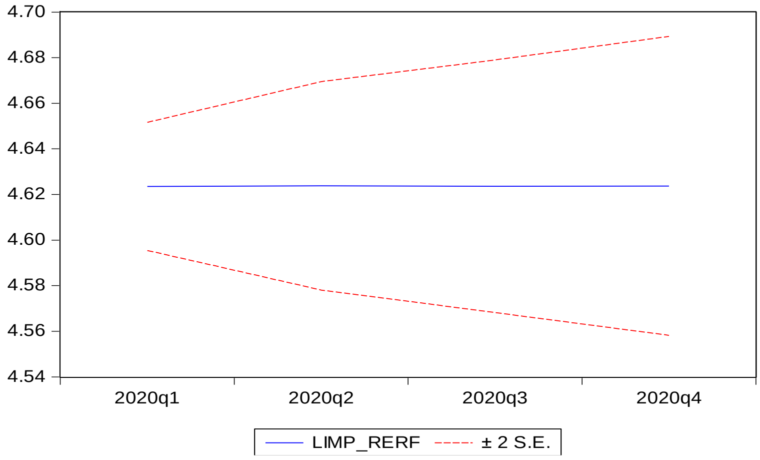
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCURRENT_ACCNT(-1))	0.171579	0.206957	0.829056	0.4109
D(LSRER)	-2.728292	1.901215	-1.435026	0.1573
D(LSRER(-1))	1.558786	2.242763	0.695029	0.4901
D(LSRER(-2))	-1.361288	1.627383	-0.836489	0.4067
D(LNMGDP(-1))	-2.323326	0.878741	-2.643927	0.0108
D(LPRDVITY)	0.128499	0.210047	0.611764	0.5434
ECM_SRER(-1)	-0.797034	0.246036	-3.239498	0.0021
C	0.037273	0.037264	1.000229	0.3218

R-squared	0.355733	Mean dependent var	-0.008782
Adjusted R-squared	0.269005	S.D. dependent var	0.258115
S.E. of regression	0.220684	Akaike info criterion	-0.060602
Sum squared resid	2.532479	Schwarz criterion	0.218644
Log likelihood	9.818060	Hannan-Quinn criter.	0.048626
F-statistic	4.101696	Durbin-Watson stat	2.046664
Prob(F-statistic)	0.001184	Wald F-statistic	6.256404
Prob(Wald F-statistic)	0.000024		

**Note: LSRER is log of sectoral RER, ECM_SRER is the error correction term, and other variables are as defined above.*

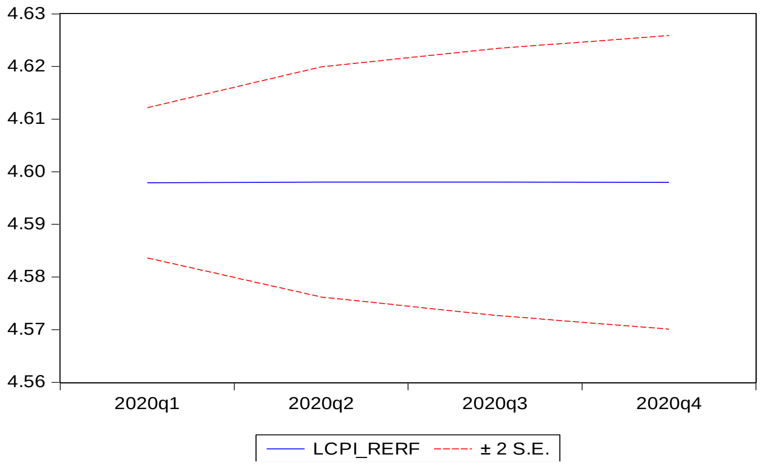
P. Real Exchange Rate ARIMA Forecast

IMP RER (2, 1, 1)



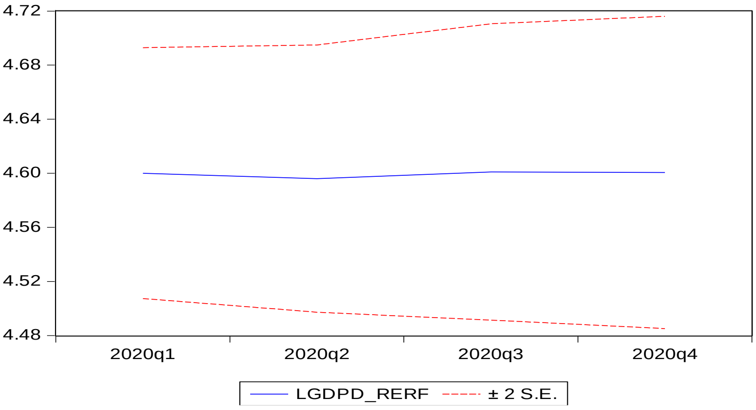
Forecast: LIMP_RERF	
Actual: LIMP_RER	
Forecast sample: 2020Q1 2020Q4	
Included observations: 4	
Root Mean Squared Error	0.015940
Mean Absolute Error	0.015694
Mean Abs. Percent Error	0.338250
Theil Inequality Coefficient	0.001721
Bias Proportion	0.969401
Variance Proportion	0.029323
Covariance Proportion	0.001276

CPI RER (2, 1, 2)



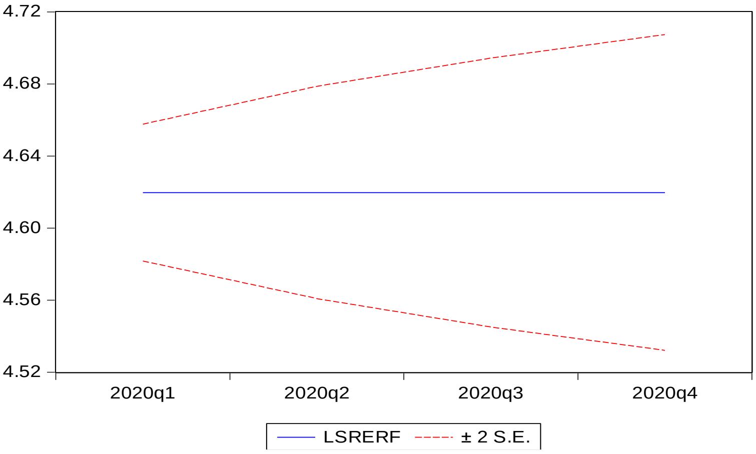
Forecast: LCPI_RERF	
Actual: LCPI_RER	
Forecast sample: 2020Q1 2020Q4	
Included observations: 4	
Root Mean Squared Error	0.018058
Mean Absolute Error	0.018031
Mean Abs. Percent Error	0.393693
Theil Inequality Coefficient	0.001968
Bias Proportion	0.996975
Variance Proportion	0.002819
Covariance Proportion	0.000206

GDP Deflator RER (2,1,1)



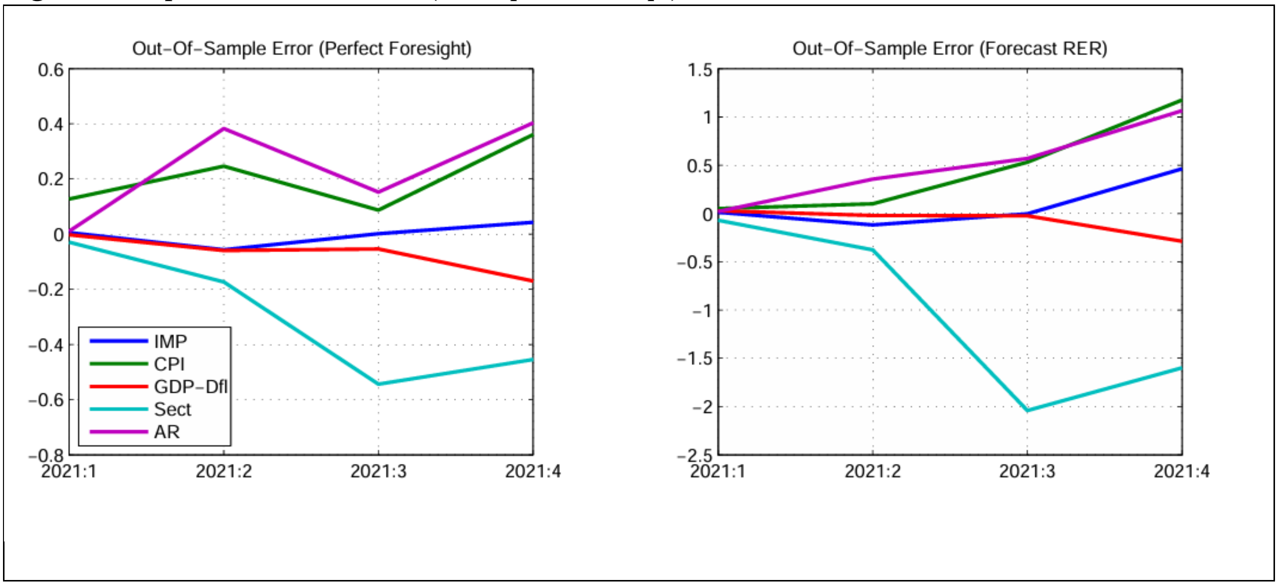
Forecast: LGDPD_RERF	
Actual: LGDPD_RER	
Forecast sample: 2020Q1 2020Q4	
Included observations: 4	
Root Mean Squared Error	0.077812
Mean Absolute Error	0.077774
Mean Abs. Percent Error	1.720043
Theil Inequality Coefficient	0.008531
Bias Proportion	0.999016
Variance Proportion	0.000183
Covariance Proportion	0.000802

Sectoral RER (2, 1, 1)



Forecast: LSRERF	
Actual: LSRER	
Forecast sample: 2020Q1 2020Q4	
Included observations: 4	
Root Mean Squared Error	0.005134
Mean Absolute Error	0.004657
Mean Abs. Percent Error	0.100685
Theil Inequality Coefficient	0.000555
Bias Proportion	0.822809
Variance Proportion	0.176526
Covariance Proportion	0.000665

Figure P: Import Flow Forecasts (2021q1 to 2021q4)



Note: The import flow forecast are based on; IMP (import-price RER), CPI (headline CPI-derived RER), GDP-Dfl (GDP-deflator RER), Sect (Sectoral disaggregation RER), and AR is a simple autoregressive based forecast of import flow.

Q. Non-nested Model Tests

IMP-RER vs CPI-RER

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 05/30/23 Time: 13:14
Sample (adjusted): 2005Q4 2020Q2
Included observations: 59 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.165656	0.175119	0.945962	0.3490
D(LIMP_RER)	-0.941344	0.791873	-1.188755	0.2405
D(LIMP_RER(-1))	0.184106	0.869910	0.211638	0.8333
D(LIMP_RER(-2))	2.277609	0.822238	2.770013	0.0080
D(LCPI_RER)	-4.414360	1.856273	-2.378077	0.0215
D(LCPI_RER(-1))	-2.929812	1.846055	-1.587067	0.1192
D(LCPI_RER(-2))	1.218172	1.034532	1.177511	0.2449
D(LPRDVITY)	-0.387785	0.063049	-6.150573	0.0000
D(LPRDVITY(-1))	-0.026576	0.084763	-0.313527	0.7553
D(LNMGDP)	1.031382	0.269345	3.829218	0.0004
ECM_WALDCPI(-1)	-0.704216	0.208500	-3.377533	0.0015
C	0.005181	0.012316	0.420712	0.6759

R-squared	0.721397	Mean dependent var	0.014253
Adjusted R-squared	0.656192	S.D. dependent var	0.136624
S.E. of regression	0.080110	Akaike info criterion	-2.031444
Sum squared resid	0.301627	Schwarz criterion	-1.608894
Log likelihood	71.92760	Hannan-Quinn criter.	-1.866498
F-statistic	11.06351	Durbin-Watson stat	2.021453
Prob(F-statistic)	0.000000		

IMP-RER vs GDP deflator-RER

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 05/30/23 Time: 13:27
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.345434	0.221923	1.556548	0.1259
D(LIMP_RER)	-0.547651	0.935821	-0.585209	0.5610
D(LIMP_RER(-1))	1.132439	1.005765	1.125949	0.2656
D(LIMP_RER(-2))	1.846093	0.970528	1.902154	0.0629
D(LGDPD_RER)	0.161013	0.280826	0.573354	0.5690
D(LGDPD_RER(-1))	0.444901	0.276914	1.606642	0.1144
D(LNMGDP)	1.084124	0.286487	3.784198	0.0004
D(LPRDVITY)	-0.343755	0.074659	-4.604339	0.0000
D(LPRDVITY(-1))	0.086901	0.121829	0.713299	0.4790
ECM_WALDGDP(-1)	-0.746055	0.256877	-2.904330	0.0055
C	-0.010600	0.013917	-0.761665	0.4498

R-squared	0.638475	Mean dependent var	0.020990
Adjusted R-squared	0.566170	S.D. dependent var	0.140683
S.E. of regression	0.092662	Akaike info criterion	-1.757919

Sum squared resid	0.429309	Schwarz criterion	-1.377269
Log likelihood	64.61653	Hannan-Quinn criter.	-1.608739
F-statistic	8.830302	Durbin-Watson stat	2.148807
Prob(F-statistic)	0.000000		

IMP-RER vs Sectoral-RER

Dependent Variable: D(LTIMPT)
Method: Least Squares
Date: 06/05/23 Time: 14:24
Sample (adjusted): 2005Q4 2020Q4
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LTIMPT(-1))	0.298537	0.215352	1.386273	0.1718
D(LSRER)	0.287289	0.828078	0.346934	0.7301
D(LSRER(-1))	-0.591685	0.905431	-0.653485	0.5164
D(LIMP_RER)	-0.465916	1.158859	-0.402047	0.6894
D(LIMP_RER(-1))	0.743587	1.145702	0.649023	0.5193
D(LIMP_RER(-2))	2.333159	0.965827	2.415712	0.0194
D(LNMGDP)	0.932225	0.290327	3.210943	0.0023
D(LPRDVITY)	-0.390556	0.076162	-5.127940	0.0000
D(LPRDVITY(-1))	0.045992	0.120722	0.380975	0.7048
ECM_WALSECT(-1)	-0.718912	0.253567	-2.835197	0.0066
C	-0.007708	0.014083	-0.547333	0.5866

R-squared	0.625603	Mean dependent var	0.020990
Adjusted R-squared	0.550724	S.D. dependent var	0.140683
S.E. of regression	0.094297	Akaike info criterion	-1.722934
Sum squared resid	0.444595	Schwarz criterion	-1.342284
Log likelihood	63.54948	Hannan-Quinn criter.	-1.573754
F-statistic	8.354812	Durbin-Watson stat	1.993596
Prob(F-statistic)	0.000000		