Arms Race, Military Expenditure and Economic Growth in India

By

Na Hou

A thesis submitted to

University of Birmingham

For the degree of

DOCTOR OF PHILOSOPHY

Department of Economics

Business School

The University of Birmingham

October 2009

To my parents

Abstract

This thesis aims to study the causes and effects of military expenditure on economic growth in India. Three aspects of this subject are concentrated which link well with the core stylised facts of the Indian defence effort and its developmental problems: the ‘security dilemma’ in terms of its relationship with its neighbour, Pakistan; the core factors that motivate the demand for defence; the economic impact of militarization and the effect of defence on development.

First, the arms race between India and Pakistan is analyzed by using a Richardson action-reaction model and cointegration techniques. The empirical results provide robust evidence to support the existence of an enduring arms race between India and Pakistan, even after taking into account a structural break. Second, the results indicate that India’s military expenditure is mainly determined by income, political status, the perceived threat from Pakistan and the external wars both in the long-run and in the short-run. Third, the relationship between military expenditure and economic growth is studied in India and in a broader context, i.e. in a cross-sectional and panel data study of 36 developing countries. The significant and negative effect of defence on economic growth is confirmed in both cases.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

2SLS	Two Stage Least Square
3SLS	Three Stage Least Square
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AO	the Additive Outlier
AR	Auto-correlation
ARDL	Autoregressive Distributed Lag
CEL	Caselli, Esquivel and Lefort
CGE	Central Government Expenditure
DBI	Defence Burdens of India
DF	Dickey-Fuller
DGP	the Data-Generating Process
DOLS	Dynamic Ordinary Least Square
ECM	Error Correction Model
FEM	Fixed-Effect Model
FGLS	Feasible Generalized Least Squares
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GNP	Gross National Income
HCA	Housing and Community Amenities
IO	the Innovational Outlier
J&K	Jammu and Kashmir

KPSS	Kwiatkowski, Phillips, Schmidt, and Shin
LDCs	Less Developed Countries
LM	Lagrange Multiplier
LP	Lumsdaine and Papell
LR	Likelihood ratio
LSDV	Least Squares with Dummy Variables
MEI	Military Expenditure of India
MEP	Military Expenditure of Pakistan
MRW	Mankiw, Romer and Weil
NATO	North Atlantic Treaty Organization
OLS	Ordinary Least Square
PPP	Purchasing Power Parity
PWT	Penny World Table
R&D	Research and Development
SEM	Simultaneous Equation Model
SIC	Schwarz Information Criterion
SIPRI	Stockholm International Peace Research Institute
SOP	the Standard Operating Procedure
UN	United Nation
VAR	Vector Autoregressive
WDI	World Development Indicator
WMD	Weapons of Mass Destruction
ZA	Zivot and Andrews

Acknowledgements

I would like to thank Professor Sen Somnath and Mr. Richard Barrett for their excellent supervision, support and patient at all times, which have been invaluable on both an academic and a personal level. I am grateful to Professor Keith Hartley and Dr. Saadet Deger for their helpful comments on my research. I am glad to acknowledgement the advice and support of Dr. Brendan Burns. I also wish to express my gratitude to the Department of Economics.

I wish to thank my parents and my sister for their hearty support and understanding which made this study possible.

Finally, I am grateful to my friends, Leilei Huang, Xiaopeng Zhang, Li Guan and Lu Han for their support, understanding and encouragement.

Chapter 1 Introduction

1.1 Introduction

According to SIPRI Yearbook 2009, India's military expenditure in 2008 was US$ 24,716 million, in constant 2005 price which ranks among the top 10 in the world. However, it is still among the poorest countries and the per capita PPP-adjusted gross national income for India was international $ 2,960 which is 155th among 210 countries (World Development Indicator Database, 2009) in the world in the same year. Thus on the one hand, India is still facing many problems such as poverty, poor I nfrastructure and poor health status, even though it has been one of the fastest-growing economies since the 1990s. On the other hand, India does spend a huge amount on military expenditure which might use scarce resources and crowd out growth-leading expenditures such as health and education expenditures and also might stimulate economic growth by spin-off effects. In particular since the trade-off takes place first and primarily at the government budgetary level, military spending may crowd out other types of government expenditure which has direct and bigger productivity effects. Thus, there is a potential problem and trade-off between military security and human security.

Of course, it is simplistic to claim that the impact of military spending in the case of India is always negative. There is a large literature since the work of Emile Benoit in the early 1970s which shows that there are positive effects of higher defence spending on economic growth particularly in developing countries. We review this literature later and check whether these positive channels are strong enough to compensate for the negative (crowding-out) effects. In addition, national security and protection of property rights are the *sine qua non* of economic development and without them no institutions can transform a poor country into a developed one. Another point is worth mentioning; this is derived from the recent literature on the success of 'large' economies in achieving high rates of growth in the era of globalisation. Alesina and Spolare (2008) claim the following: "There are economies of scale in the production of public goods. The per capita cost of many public goods is lower in larger countries, where taxpayers pay for them." Think, for instance, of defence: a larger country (both in terms of population and national product) is less subject to foreign aggression. Thus, safety is a public good that increases with country size. Also, and related to the size of government argument above, smaller countries may have to spend proportionately more for defence than larger countries given economies of scale in defence spending. Thus, according to these authors a large country may derive economies of scale from expenditures which protects itself and provides security. This may be one explanatory factor behind the recent growth successes of large developing countries (often termed BRICS, Brazil, Russia, India, China, and South Africa). Yet, India seems to have suffered due to high military expenditures which have been a substantial part of overall government spending which in turn has depleted resources from government spending on health, education and infrastructure.

Most important, we need to understand the causes of military expenditure i.e. ask and answer the question as to what are the factors behind the demand for defence spending in countries like India. Stylised facts tell us that there is a long-standing arms race between the India and its neighbour Pakistan and therefore we should be able to identify the parameters of this relationship. On the other hand, defence spending is also affected in the short run by various temporary economic and political factors. How the long run and short run relations are related to each other is an obvious issue for discussion. Arms races are often a product of a 'security dilemma' as discussed in the international relations literature. On the other hand, the adverse impact of defence spending is analysed as a 'developmental failure'. We, therefore, need to understand India's defence expenditure issues as trying to reconcile the twin claims of security and development.

The motivations that drive India's military expenditure are not only the security considerations but also the constraints, which are imposed by economic factors such as per capita income and balance of payment. All these facts make India a very important and interesting case study as an example for investigating the broader question of military expenditure and economic growth in developing countries.

1.2 Research Questions and Hypothesis

This study investigates the causes and effects of military expenditure in India. The three core research questions are as following:

1. ***In there an enduring arms race between India and Pakistan?***

Since the creation as separate states in 1947, India began its rivalry relationship with its neighbouring country Pakistan. Over the last six decades, India and Pakistan have been in conflict with each other constantly and have at least four major wars and many small scale armed conflicts. Their conflicts mainly due to internal religious differences and the ongoing external political hostility lead to an arms race. The arms race implies that India's military expenditure is determined in an action-reaction framework with Pakistan's military expenditure in the long run. Hence, the first hypothesis is that there is a long-run arms race between India and Pakistan.

2. *What factors drive India's military expenditure?*

The complexity of India's economic, political and security environments determines that there are many factors would determine military expenditure of India. Those determinant factors include economic variables (such as income, population, central government expenditure, and trade balance), external and internal security considerations (such as defence burden of Pakistan, average defence burden of countries in India's security web, domestic riots and external wars) and the political environment (such as democracy and autocracy). Thus, the second hypothesis is that economic, security and political variables are all driving India's military expenditure.

3. *What is the effect of military expenditure on economic growth in India?*

Military expenditure would have both positive and negative effects on economic growth in developing countries. Those effects could be direct and indirect. For example, military expenditure might stimulate India's economic growth directly by the spin-off from defence to other sectors in the economy. India's military expenditure also might reduce economic growth indirectly by depressing the saving ratio. Some major problems of India's economic development such as a low saving ratio, severe balance of payment deficits and lack of public expenditures on health might be deteriorated by the high military expenditure. So the third hypothesis is that India's military expenditure has a net negative effect on economic growth by taking both direct and indirect effects together.

Furthermore, as a complementary study for single-country analysis, the effect of military expenditure on economic growth in developing countries is explored in both cross-section and panel data frameworks. After adding military expenditure variable into the Augmented Solow growth model, it is predicated that a decrease in military expenditure would stimulate economic growth in developing countries. We also hypothesize the existence of a peace dividend in developing countries.

1.3 Structure of the Thesis

The rest of this thesis is organized as follows.

Chapter 2 examines the arms race between India and Pakistan during the period 1960-2007. The existing literature on theoretical arms race model and on empirical studies of India-Pakistan arms race is reviewed. Then based on literature review and analysis of India's military expenditure and its conflict history with Pakistan, the Richardson arms race model is employed to investigate the relationship between India and Pakistan's military expenditures. The focus of Chapter 2 is not the specific arms race model but the empirical analysis of the long-run relationship between India and Pakistan's real military expenditure. Thus, different empirical methodologies on unit root tests and cointegration tests are assessed and applied in this chapter.

Chapter 3 explores the demand for military expenditure in India between 1960 and 2006. This chapter starts by reviewing the literature on theoretical models of the demand for military expenditure. Then empirical studies of the determinants of military expenditure in developing countries are reviewed. Those determinants are grouped into the following categories: military activities, economic and geo-strategic factors, the political environment and other related factors (e.g. population and the lagged military expenditure). After investigating India's military expenditure history and its security considerations both internal and external, the demand model for India's military expenditure is specified and estimated by employing a recent econometric method, the autoregressive distributed lag (ARDL) approach to cointegration. Chapter 3 argues that the demand for India's military is determined by economic, political and security variables.

Chapter 4 aims to investigate the defence-growth nexus and to provide evidence to support the existence of a peace dividend in developing countries. Firstly, it provides an explicit literature review on the theoretical models and empirical studies on the defence-growth relationship. The reviewed literature is divided into seven groups: Benoit (1978)'s work, demand side models, supply side models, Deger-type models, Barro models, Solow models and Granger causality analysis. Then Chapter 4 gives a single country study of the effects of military expenditure on economic growth in India for the period 1970-2003. Whilst Chapter 4 examines the long-run and short-run impact of military expenditure on economic growth based on cross-sectional and panel analyses for 36 developing countries during 1975-2004.

Finally, Chapter 5 provides concluding remarks and some possible directions for further research.

Chapter 2 Military Expenditure and Arms Race: the Case of India and Pakistan

2.1 Introduction

Arms race, by definition, is the competitive, resource-constrained, dynamic process of interaction between two states or coalitions of states in their acquisition of weapons (Brito and Intriligator, 1995). After the Cold War, the United States and the Soviet Union's arms race no longer dominates the whole world politics and regional antagonisms become the focus. For example, arms races exist between Greece and Turkey, Iran and Iraq, North and South Korean, India and Pakistan.

In the case of the arms race between India and Pakistan, it is well known that India and Pakistan's rivalry relationship began at the same time as their creation as separate states in August 1947. Now more than 60 years after their independence, India and Pakistan have made significant economic, social and political developments. But they have been in conflict with each other constantly and have had at least four major wars and many small scale armed conflicts. We believe the conflicts which mainly due to internal religious differences and the ongoing external political hostility led to an arms race, although both governments deny that.

India and Pakistan are still two of the poorest countries in the world based on GDP per capita PPP. In 2008, the per capita PPP-adjusted gross national income for India (international $ 2,960) was the 155th among 210 countries in the world and it was the 156th for Pakistan (international $ 2,700). But they both devote a substantial portion of their resources to defend against each other. While military expenditure declined in most of industrial countries after the Cold War (for the period 1990-2005), military expenditure in India and Pakistan has increased significantly. Thus, the problem of limitation of resources available for development is worsening. So the question of the existence of an arms race between India and Pakistan which might hinder the economic development of both countries is still important and worrying

This chapter aims to find out whether or not there is an arms race between India and Pakistan. A Richardson type action-reaction model and a vector autoregressive method are employed for the time period 1960-2007. Furthermore, we examine the existence of unit root, structural breaks and a cointegrating relationship for real military expenditure in India and Pakistan. Due to the importance of these empirical analyses, the related econometric issues are presented carefully and critically. The structure of this chapter is as follows: Section 2.2 lays out a brief literature review of theoretical models of the arms race; empirical studies on the

India-Pakistan arms race are also reviewed. Section 2.3 outlines the conflict history of India and Pakistan. Section 2.4 provides the framework of the Richardson arms race model. Section 2.5 gives data description and empirical methodologies. The empirical results are presented in section 2.6 and section 2.7 concludes.

2.2 Literature Review

2.2.1 Theoretical Models of the Arms Race[1]

There are various arms models. In this section, key elements of some representations are discussed to provide a brief review of arms race models. The starting point of arms race models is the analysis of the arms race phenomenon put forward by Richardson (1960). Based on this model, extensions have been developed in many subsequent studies. However, the Richardson arms race model and its variants tend to treat the arms race as a simply action-reaction process and the rival's military expenditures are the main determinant of a nation's military expenditure. Other models suggest that arms races are influenced by various internal and external factors which are very complex and might interact with each other. Therefore, we present a brief survey of diverse arms race models in this section, which include the

[1] This section leans on Sandler and Hartley (1995, Chapter 4) and Isard and Anderton (1988).

classic Richardson arms race model and its variants, the Intriligator and Brito Strategic Deterrence-Attack Model and other related arms race models.

2.2.1.1 The Richardson Model and Its Variants

Lewis F. Richardson presents a mathematical model of an arms race in his seminal study in 1960 which became one of the most influential models of the arms race. In this classical Richardson model, two opposing countries, labelled 1 and 2, are involved in a dynamic process of interaction with each other in their acquisitions of weapons. Each country is treated as a single unified actor and there is a single homogeneous weapon. The model can be summarized by two differential equations:

$$\frac{dM_1}{dt} = kM_2 - \alpha M_1 + g, (k, \alpha > 0) \tag{2.1}$$

$$\frac{dM_2}{dt} = lM_1 - \beta M_2 + h, (l, \beta > 0) \tag{2.2}$$

where M_i, i=1,2, denotes the stock of military weapons or military expenditure of country i. k and l are reaction coefficients, α and β are fatigue coefficients and g and h are grievance terms.

In the Equations (2.1) and (2.2), the change in military stock or expenditure of one country is linearly related to its rival's military stock or expenditure, its own accumulation of weapons or military expenditure and a grievance term. k and l are positive where the accumulation of weapons or military expenditure is influenced positively by the military stock or expenditure of the rival. α and β are positive where the accumulation of weapons or military expenditure is influenced negatively by one's own military stock or expenditure. The fatigue effects are caused by the economic and administrative burden of the arms race. g and h could be negative or positive, which reflect amicable relations and hostility between the two countries, respectively.

Based on the Richardson model, Wolfson (1968) introduce the emulative model of the arms race in which the rivals aim to emulate one another's military stock or expenditure. The model can be written as:

$$\frac{dM_1}{dt} = k(M_2 - M_1) - \alpha M_1 + g \quad (2.3)$$

$$\frac{dM_2}{dt} = l(M_1 - M_2) - \beta M_2 + h \quad (2.4)$$

In Equations (2.3) and (2.4), the change in military stock or expenditure is dependent on the difference between own military stock or expenditure and that of the rival, a fatigue and a grievance term. The emulation assumption is based on achieving parity rather than dominance and thus the terms, $-kM_1$ and $-lM_2$ could serve as additional fatigue factors.

Wolfson (1968, 1990) formulates another arms race model which is called the rivalry model. The model considers the characteristics of the United States (country 1) and the Soviet Union (country 2) during the Cold War period. In this model, country 2 is winning the arms race and its success is measured by the difference between the two country's military stocks in the previous period. The equations in discrete form are:

$$M_1(t) = k[M_2(t-1) - M_1(t-1)] + \alpha M_1(t-1) + k' M_2(t-1) \qquad (2.5)$$

$$M_2(t) = l[M_2(t-1) - M_1(t-1)] + \beta M_2(t-1) + l' M_2(t-1) \qquad (2.6)$$

The United States and the Soviet Union are not treated symmetrically where the Soviet Union is seen as trying to dominate the United States while the United States is trying to resist the Soviet Union. There are no grievance terms in the rivalry model and neither assured stability.

Another variant of the Richardson model is the submissiveness model (Isard and Anderton, 1988) in which the equation for country 1 is:

$$\frac{dM_1}{dt} = k[1 - w(M_2 - M_1)]M_2 - \alpha M_1 + g \qquad (2.7)$$

If $M_2 > M_1$ where country 2 has the advantage, the difference between M_2 and M_1 will have a negative effect on the change in M_1. The larger is M_2 relative to M_1, the greater the negative effect on dM_1/dt, also the larger the value of *w*, the greater this effect. This model highlights the asymmetries between the two countries and how these asymmetries can promote stability by decreasing the value of reaction terms. But if country 1 has the advantage, that difference will have a positive effect on the change in M_1 and country 1 will be more aggressive than in the classical model. When $M_1 = M_2$, $w(M_2 - M_1) = 0$, the equation is equivalent to the Richardson equation. α and g denote the fatigue and grievance terms, respectively. An equation for country 2 will be analogous.

Rattinger (1975) develops a model to incorporate the bureaucratic influences in a country's military establishment. The bureaucratic model provides an equation as follows:

$$m_1(t) - M_1(t) = k'[M_2(t-1) - m_2(t-1)] + g \quad (2.8)$$

where m_i , $i = 1,2$, is the desired defence budget in country i and M_i, $i = 1,2$, is the actual defence budget. The difference between a country's actual and desired defence budget in the current period (t) is dependent on the difference between the rival's actual and desired defence budget in the previous period (t-1). g is the grievance term. A similar expression can be applied to country 2.

Public choice and opinion also influence a country's military spending decisions. Hartley and Russett (1992) apply a model which bases defence spending decisions on public opinion. In that model, the changes in public opinion have a lagged effect on policy-making. An increase in the public's support for military expenditure is expected to be followed by an increase in the national defence budget. While if the public's opposition increases, the defence budget will tend to decrease.

McGuire (1965) introduces the utility-maximization assumption, resource constraints and strategic considerations (deterrence and retaliatory threat) into arms race models. In his study, each country is motivated to maximize its citizens' social welfare, W, which is taken to depend on its security and civilian consumption (resources allocated to the production of civilian goods and services). It is noted that the resource allocation is static in McGuire's model. Welfare is maximized subject to a linear resource constraint. Security is a function of $\overline{M}_1$ and $\overline{M}_2$, where:

$\overline{M}_1$= the minimum (assured) number of country 1's missiles from its stockpile, M_1, that survives an attack by country 2;

$\overline{M}_2$= the maximum (assured) number of country 2's missiles from its stockpile, M_2, that is not destroyed during an attack by country 1.

Here, "assured" refers to an acceptable probability (percent of total stockpile). $\overline{M}_1$ and $\overline{M}_2$represent country 1's and country 2's deterrence potential, respectively. At the same time, $\overline{M}_1$ and $\overline{M}_2$ are themselves a function of missile stocks and other strategic factors. Civilian output is $Y_i, i = 1,2$. Thus, social welfare in country 1 is:

$$W_1 = W_1[\bar{M}_1(M_1, M_2), \bar{M}_2(M_1, M_2), Y_1] \tag{2.9}$$

Subject to the resource constraint, social welfare is maximized when marginal cost of M_1 equals the sum of two marginal benefits which are derived from M_1. The two marginal benefits are from the increase in country 1's deterrence and from the decrease in the retaliatory threat from abroad. However, the McGuire's model does not have an adequate measure of national welfare or an appropriate way of proceeding from individual preferences to social preferences (Isard and Anderton, 1988).

In Richardson type models, the reaction factor could apply not only to the level of military expenditure but also to military stocks. These two representations are assumed to be interchangeable. For example, Isard and Anderton (1988) write the military stock in the form:

$$\frac{dS_1}{dt} = M_1/p - \delta S_1 \tag{2.10}$$

where S_1 denotes current military stock in country 1, M_1 is military expenditure and δS_1 is depreciation of military stock in that period. p is in terms of dollars per unit stock. So p translates dollar expenditure, M_1, into military stock and could be seen as the cost of a "composite" unit of stock. Then the basic behavioural equation for country 1 (M_1 may be taken to replace $\dot{M}_1$) can be written as:

$$M_1 = kS_2 - \alpha M_1 + g \qquad (2.11)$$

In Equation (2.11), the level of country 1's military expenditure is related to the opponent's stock, a fatigue and a grievance factor. Hence, by substitution of the value M_1 from Equation (2.11) to Equation (2.10), it is obtained: $dS_1/dt = [(kS_2 - \alpha M_1 + g)/p] - \delta S_1$. A similar expression can be applied to country 2.

Additionally, levels of military stocks or expenditure in ratio form (i.e. M_1/M_2 or S_1/S_2) and their inverses could be used in arms race models. The use of ratio form permits the establishment of ratio goals (Wallace and Wilson, 1978). If the fatigue and grievance terms are absent, the model could be related to the rivalry model. Furthermore, alternative lag structures could be employed in variants of the Richardson model. In those models, one country reacts to the rival country's military stocks or expenditure in one or more previous time periods. Because the reaction is to the previous military expenditure and the armaments produced by the expenditure are properly depreciated, this reaction could be seen as a reaction to the accumulated stocks of its rival country (Isard and Anderton, 1988).

The Richardson model and some representative models of its variants which are reviewed in this section are presented in Table 2.1. The key elements of the variants include emulation, rivalry, submissiveness, bureaucracy, public opinion and social welfare maximization. We also consider stock variables, ratio forms and lag structures which could be applied in arms race models as well.

It is well known that the classical Richardson model has some problems. There are no explicit objectives, no decision-making process, no explicit economic constraints and no strategic considerations. The Richardson model does not include other important variables such as foreign aid and social factors (e.g. the political system). The model is static and does not allow the coefficients to change with time or experience (Sandler and Hartley, 1995). Furthermore, the assumption of positive reaction coefficients is invalid and they could indeed be negative. When the action-reaction process is absent between two countries, one country might decrease its military expenditure regardless of the increase of its opponent's armaments. Hence, the variants reviewed above attempt to extend and amend the Richardson model and make contributions by adding related factors, using accumulation variables, and applying resource constraints and maximizing behaviour. However, most of these models still do not have an explicit framework and do not overcome the limitations of the classical Richardson model.

Table 2. 1 the Richardson Arms Race Model and its Variants

Authors	*Models*
Richardson (1960)	Classical Richardson Model
Wolfson (1968)	Emulative Model
Wolfson (1968, 1990)	Rivalry Model
Isard and Anderton (1988)	Submissiveness Model
Rattinger (1975)	Bureaucratic Model
Hartley and Russett (1992)	Public Opinion Model
McGuire (1965)	Social Welfare Maximization Model

2.2.1.2 Intriligator and Brito Strategic Deterrence-Attack Model

In this section, we will review the Strategic Deterrence-Attack Model which is developed by Intriligator and Brito (1976, 1984). Different with the Richardson-type arms race model, the Strategic Deterrence-Attack Model focuses on the potential of arms use and its effect on arms production. Thus, this model considers the strategic factors in the arms race. The use of arms has two purposes: attack (war) or deterrence (peace), and these strategic considerations which are perceived by defence planners are connected to the arms race in the Intriligator and Brito model. In their basic model, there are two countries, 1 and 2 (superpowers), that confront each other with their missile stockpiles. The defence planners seek to justify their budgetary requests for missile stocks, $z_i (t)$, and their current inventories of missiles, $m_i (t)$, in terms of national security considerations. The security considerations are the two countries' potential for deterrence or attack. Intriligator and Brito set up a hypothetical missile war which could be used to calculate this potential in a computer simulation.

The time path for missiles and casualties in the two countries can be used to describe the simulation of a missile war. A dynamic model representation of the simulated missile war is shown in the following equations:

$$\dot{m}_1 = -\alpha m_1 - \beta' \beta m_2 f_2 \tag{2.12}$$

$$\dot{m}_2 = -\beta m_2 - \alpha' \alpha m_1 f_1 \tag{2.13}$$

$$\dot{c}_1 = (1 - \beta')\beta m_2 v_2 \tag{2.14}$$

$$\dot{c}_2 = (1 - \alpha')\alpha m_1 v_1 \tag{2.15}$$

where:

$m_i(t)$ = stock of missiles at time *t* in country *i*, *i*=1, 2.

$\dot{m}_i(t)$ = change in stock of missiles at time *t* in country *i*.

$c_i(t)$ = casualties at time *t* in country *i*.

$\dot{c}_i(t)$ = change in casualties at time *t* in country *i*.

$\alpha(t), \beta(t)$ = rates at which countries 1 and 2 fire their missiles at time t.

$\alpha'(t), \beta'(t)$ = proportion of missiles targeted counterforce by countries 1 and 2.

f_1 = the number of 2's missiles destroyed by one of 1's missiles.

f_2 = the number of 1's missiles destroyed by one of 2's missiles.

v_1 = the number of 2's casualties caused by one of 1's missiles.

v_2 = the number of 1's casualties caused by one of 2's missiles.

In Equation (2.12), country 1's stock of missiles declines for two reasons. First, due to its own firing decisions, country 1 fires its missiles by αm_1. Second, due to country 2's counterforce attack, country 1 missiles are destroyed by $\beta'\beta m_2 f_2$. The remaining country 2 missiles $(1 - \beta')\beta m_2$ which are launched at time t are aimed at country 1's cities and lead to casualties of country 1 by $(1 - \beta')\beta m_2 v_2$. A similar interpretation holds for country 2 given in Equations (2.13) and (2.15). Thus, the above four equations describe the evolution of the simulated war which is dependent on the initial missile stocks, the strategic decisions (over time) on rates of fire and targets, and the effectiveness of missiles against rival missiles and against rival cities (Brito and Intriligator, 1995).

In the case of war initiation, it is assumed that country 1 starts a war and then it chooses a maximum rate of firing, $\alpha = \bar{\alpha}$, aiming at country 2's missiles and thus α'=1. This first strike is supposed to last t_A minutes during which time there is no response from the targeted country 2, so that $\beta = 0$.The time span is $0 \leq t \leq t_A$. By these assumptions, it is found that at the stage of war initiation:

$$m_1(t_A) = m_1^0 \exp(-\bar{\alpha} t_A) \quad (2.16)$$

$$m_2(t_A) = m_2^0 - f_1[1 - \exp(-\bar{\alpha} t_A)]m_1^0 \quad (2.17)$$

The remaining missiles stock of country 1 is $m_1^0 \exp(-\bar{\alpha} t_A)$ and it uses $m_1^0[1 - \exp(-\bar{\alpha} t_A)]$ to destroy $f_1[1 - \exp(-\bar{\alpha} t_A)]m_1^0$ of country 2's missiles. So country 2 is left with a missile stock of $m_2^0 - f_1[1 - \exp(-\bar{\alpha} t_A)]m_1^0$.

During the retaliatory phase, country 2, as aiming at tit-for-tat, chooses its maximum rate of countervalue attack, targeting country 1's cities, so that $\beta = \bar{\beta}$ and $\beta' = 0$. Assume that the time span for retaliatory attack is from $t = t_A$ to $t = t_A + t_B$, and during this phase $\alpha = 0$ without country 1's response. The number of casualties in country 1 at the end of country 2's retaliatory attack is given as:

$$c_1(t_A + t_B) = v_2\{m_2^0 - f_1[1 - \exp(-\bar{\alpha} t_A)]m_1^0\}[1 - \exp(-\bar{\beta} t_B)] \quad (2.18)$$

If country 2 starts the war, an analogous analysis would be applied.

If the objectives of the defence planners in both country 1 and country 2 are to be fulfilled to deter, each must possess sufficient missile stocks to absorb an all-out first-strike and still respond with a second strike which inflicts unacceptable casualties. Intriligator (1975) solved the deterrence conditions for countries 1 and 2 as shown in following equations:

$$m_1 = f_2[1 - \exp(-\bar{\beta} t_B)]m_2 + \bar{c}_2/\{v_1[1 - \exp(-\bar{\alpha}\psi_A)]\} \qquad (2.19)$$

$$m_2 = f_1[1 - \exp(-\bar{\alpha} t_A)]m_1 + \bar{c}_1/\{v_2[1 - \exp(-\bar{\beta}\psi_B)]\} \qquad (2.20)$$

where:

$\bar{\alpha}(t), \bar{\beta}(t)$ = maximum rates at which country 1 and 2 fire missiles at time t.

$\bar{c}_1$ = country 2's recognition of the minimum unacceptable civilian casualties in country 1.

$\bar{c}_2$ = country 1's recognition of the minimum unacceptable civilian casualties in country 2.

t_A, t_B= time interval of country 1 and 2's first strike, respectively.

ψ_A, ψ_B = time interval of country 1 and 2's second strike, respectively.

In Equation (2.19), country 1 believes that the minimum unacceptable casualties to country 2 are $\bar{c}_2$. It must have sufficient missiles to inflict these casualties in a second strike. Thus the amount of country 1's missiles which are needed to deter country 2 is a function of the number of country 2's missiles. A similar interpretation holds for country 2 in Equation (2.20). In fact, Equations (2.19) and (2.20) are Richardson-type reaction functions, which could be written as:

$$m_1 = b_2^{'} m_2 + \bar{c}_2/b_4^{'} \qquad (2.21)$$

$$m_2 = b_1^{'} m_1 + \bar{c}_1/b_3^{'} \qquad (2.22)$$

where:

$$b_1^{'} = f_1[1 - \exp(-\bar{\alpha} t_A)], \quad b_2^{'} = f_2[1 - \exp(-\beta t_B)]$$

$$b_3^{'} = v_2\left[1 - \exp\left(-\bar{\beta}\psi_B\right)\right],\ b_4^{'} = v_1[1 - \exp(-\bar{\alpha}\psi_A)]$$

$b_1^{'}$ and $b_2^{'}$ are the normalized defence terms. $\bar{c}_2/b_4^{'}$ and $\bar{c}_1/b_3^{'}$ are the grievance terms. Because the grievance terms are positive, there exists a stable equilibrium when $b_1^{'}b_2^{'} < 1$. The equilibrium point is:

$$m_1^e = \frac{b_2^{'}\bar{c}_1/v_2b_3^{'} + \bar{c}_2/v_1b_4^{'}}{1 - b_1{'}b_2{'}} \tag{2.23}$$

$$m_2^e = \frac{b_1^{'}\bar{c}_2/v_1b_4^{'} + \bar{c}_1/v_2b_3^{'}}{1 - b_1{'}b_2{'}} \tag{2.24}$$

According to Sandler and Hartley (1995), in a simplified analysis the firing interval can be assumed to be long enough and thus $\exp(.)$ could be replaced by zero in Equations (2.19) and (2.20)[2]. This leads to the following equations:

$$m_1 = f_2m_2 + \bar{c}_2/v_2 \tag{2.25}$$

$$m_2 = f_1m_1 + \bar{c}_1/v_1 \tag{2.26}$$

Now the stable condition becomes $f_1f_2 < 1$. Intriligator (1975) indicates that the “hardness” condition that more than one missile is needed to destroy one rival missile is a sufficient condition (but not necessary) for stability.

[2] Set $c_1 = \bar{c}_1, m_1 = m_1^0, m_2 = m_2^0$.

If country 2 attacks, a similar analysis and corresponding notation can be applied as above. As the aggressor, country 2 would need to have sufficient missiles to damage country 1's missiles and thus country 1 would not have enough missiles left to inflict many casualties during its retaliatory strike. The maximum acceptable casualty level for country 2 is set by $\hat{c}_2$. Thus, the level of missiles country 2 needed for an attack can be solved and written as:

$$m_2 = m_1/f_2 - (\hat{c}_2/f_2 v_1) \quad (2.27)$$

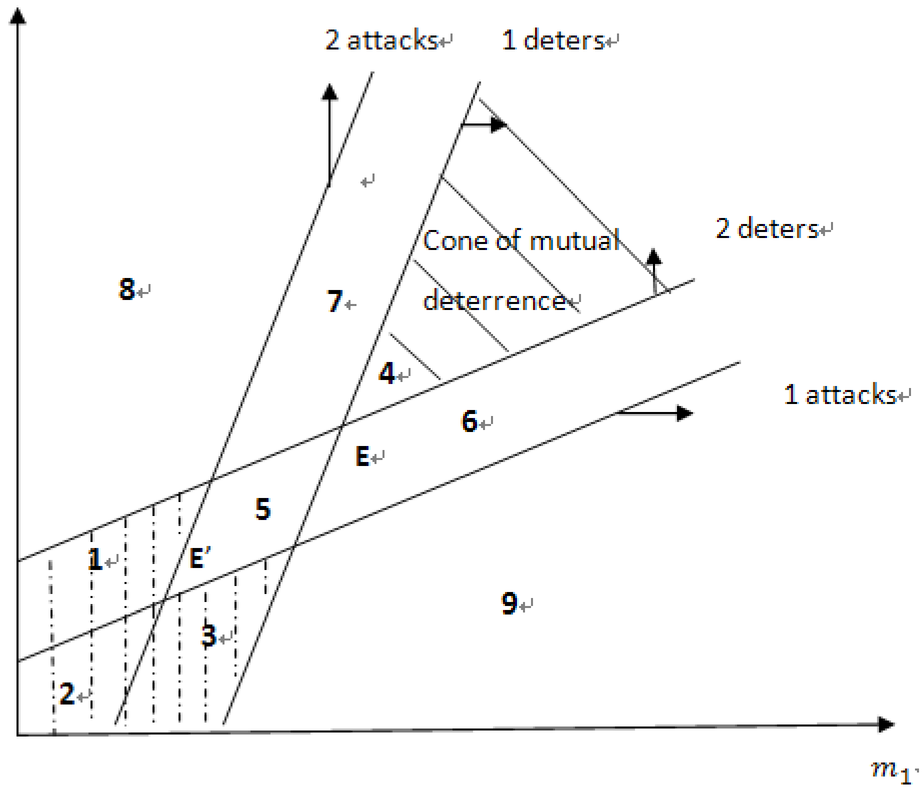
Similarly, the level of missiles country 1 required for an attack is:

$$m_1 = m_2/f_1 - (\hat{c}_1/f_1 v_2) \quad (2.28)$$

If the "hardness" condition holds, $1/f_1 f_2$ must exceed unity and the equilibrium described by Equations (2.27) and (2.28) simultaneously is unstable.

Equations (2.25)-(2.28) are presented in Figure 2.1. Because $\hat{c}_i < \bar{c}_i, i = 1,2,$ the intercept of the attack line is smaller than the corresponding deter line. In (m_1, m_2) space, Equation (2.26) and (2.28) have the same slope and so that the country 1 attack line is parallel to the country 2 deter line; Equations (2.25) and (2.27) have the same slope so that the country 1 deter line is parallel to the country 2 attack line.

Figure 2.1 Cone of Mutual Deterrence



In Figure 2.1, there are nine regions. In region 1, country 2 has enough missiles to attack country 1 but not to deter and country 1 has inadequate missiles to attack or deter. Thus, country 2 is forced to attack as it has sufficient missiles for a first strike but not sufficient for a second strike (Intriligator, 1975). Region 3 is the reverse case. In region 2, both countries can attack the other but neither can deter the other. So regions1-3 are called *the regions of war initiation* by Intriligator. In region 4, both countries have sufficient missiles to deter the other and the region is known as *the cone of mutual deterrence*. Within this cone, both countries could decrease their missile stocks while maintaining stability and peace, and equilibrium E is stable.

In region 5, neither country has adequate missiles to attack or deter. In region 6, country 1 has enough missiles to deter but not enough to attack country 2 while the status is reversed in region 7. Anderton (1992) suggests that regions 5-7 could be called *the cone of mutual attack avoidance.* Equilibrium E' is unstable since upward spiralling arms races might occur in regions 5-7 (Sandler and Hartley, 1995). In region 8, country 2 can attack or deter country 1 and has the advantage, but country 1 can do neither. In region 9, country 1 has the power advantage instead.

According to Intriligator (1975) and Intriligator and Brito (1986), large missile stockpiles could have a deterring effect as shown in the cone of mutual deterrence. Thus, heavily armed countries in an arms race would not tend to initiate war since the casualties and damages would be huge and unacceptable. However, when two countries have low levels of armaments and at the beginning of an arms race, the risk of war will be high.

The Intriligator and Brito model involves the deterrence-attack strategy, effectiveness coefficients, rates of fire, and time intervals for firing. These factors are important in influencing the cone of deterrence and provide policy implications for arms control. The model also presents possible peace equilibrium and the possible outbreak of war under different conditions. However, the Intriligator and Brito model has a similar reaction framework to the Richardson model and also has some limitations. For example, one country starts an attack which is counterforce and its rival will then have a retaliatory strike which is countervalue, but there is no theoretical evidence to support these predetermined counterforce and countervalue attacks. Furthermore, the impact of the quality of armaments on the modern arms race becomes more and more important rather than the quantity of weapons in the Intriligator and Brito model.

2.2.1.3 Other Related Models[3]

Luterbacher (1976) applies a disaggregated Richardson type arms race model which distinguishes between conventional and strategic weapons. Both countries would have two equations, one for the change in conventional weaponry and one for the change in strategic weaponry. Other elements are also considered in different arms race models. For example, the

---

[3] More details see Isard and Anderton (1988, p43-51).

effect of uncertainty on military expenditure is examined by Liossatos (1980) and Cusack and Ward (1981). Uncertainty, secrecy and the intelligence effort, international tensions and some psychological factors (e.g. insecurity, fear and distrust) are also introduced into arms models.

Siljak (1977) developes an n-nation system in which the change in each country's defence spending is a linear function of the defence spending of every other country in the system. Choucri and North (1975) and Bremer (1986) set up a framework for the operation and functioning of the world system. In addition to military expenditure, other key endogenous variables are included into their models, such as the military expenditure of alliances and non-alliances, intensity of intersections and violent behaviour toward other nations.

2.2.2 Empirical Studies of Arms Race between India and Pakistan

Various models and estimate methods have been used to study the arms race phenomenon in different countries: for example, arms races between Greece and Turkey, South & North Korea. In this section, we focus on empirical studies of an arms race between India and Pakistan (see Table 2.3). The empirical results are not conclusive. Hollist (1977) provides empirical analysis of a competitive arms process in India and Pakistan for the period 1949-1973. Different variants of Richardson-type arms race models are employed and assessed which consider the effects of submissiveness, explicit cost constraints, and technology factors. However, the results show that the estimated coefficients of reaction factor are less than clear for India and Pakistan. Furthermore, the estimated sign of reaction factor is negative in most models and inconsistent with the hypothesis of the Richardson type models. Thus Hollist (1977) suggests that internal factors play a comparably greater role than the rival's military expenditure (reaction factor) and military expenditure processes are influenced by both external and internal factors.

Deger and Sen (1990) empirically analyze the military expenditure process of India and Pakistan during 1960-1985. The Richardson arms race model is applied and its differential equations form is written as:

$$\dot{M}_1 = aM_1 + bM_2 + X_1 + Z_1 \tag{2.29}$$

$$\dot{M}_2 = cM_1 + dM_2 + X_1 + Z_2 \tag{2.30}$$

where M_1 and M_2 are the military expenditure of India and Pakistan, respectively. The Zs are vectors of environmental and dummy variables. The coefficients b and c are reaction terms while the coefficients a and d are fatigue terms. The constants, *Xs* are grievance terms. The authors consider the unequal size between India and Pakistan, where India can be characterized as the large country and Pakistan is the small one. The unequal size might imply that those two countries' military reaction functions, threat perceptions and economic costs are asymmetric. Furthermore, some variables are added into the arms race model to represent the effects of economic environmental factors on military expenditure. National income (GDP), the ratio of central government expenditure to GDP (CGESH), arms imports (AIMP) and arms productions (APROD) are chosen.

Based on model specifications and diagnostic tests, the regression equations are chosen and the estimating results (OLS) for India and Pakistan are presented in Table 2.2. Regarding the military expenditure process of India and Pakistan, empirical results provide the analysis of three issues which include: the relative importance of military and economic variables, the existence of an India-Pakistan arms race and the asymmetric behaviour.

Table 2.2 Empirical Estimates of Military Expenditures of India and Pakistan

	constant	$M_1(-1)$	$M_2(-1)$	*AIMP*	*APROD*	*GDP*	*CGSH*	R^2
M_1	-289	0.52*	0.06	0.06	-1.13	2.66*	--	0.935
	(-0.67)	(2.73)	(0.09)	(0.18)	(-1.17)	(2.64)	--	
M_2	-623*	0.08*	0.62*	0.27*	--	--	41.4*	
	(-2.07)	(2.25)	(5.55)	(1.66)	--	--	(1.86)	0.970

Notes:

1) t-values are in parentheses.

2) $M_i(-1), i = 1,2$ is the military expenditure in previous year.

3) 10 per cent significance levels are used and denoted by *.

4) Results are from Deger and Sen (1990).

For India, the Pakistan previous year's military expenditure has no statistically significant effect on military expenditure in India. The influences from arms import and arms production are insignificant as well. But GDP is found to be an important determinant for military expenditure. For Pakistan, Indian threat and arms import both play an important role in the military expenditure process. The impact of the ratio of central government expenditure in GDP reflects the role of the government in the politico-economic structure of Pakistan. This impact is statistically significant and indicates the positive impact on defence allocation. On the other hand, economic variables, such as GDP seem to have little impact on military expenditure.

Thus, the strategic relationship between India and Pakistan seems to be asymmetric where Pakistan is relatively more response to Indian military expenditure. However, that direct effect from Indian military expenditure to the one of Pakistan is weak. Thus, the question as to the existence of an arms race is hard to give a clear answer. Deger and Sen (1990, p214) provide their conclusion that India-Pakistan arms race might probably "more a matter of political rhetoric than an empirically supported description of the military expenditure process".

Oren (1994) analyzes the India-Pakistan arms competition where each country's military expenditure responds not only to the rival country's military expenditure but also to its intentions. According to the intentions, the rival's bellicose acts would be more threatening when its military power is weaker (i.e. smaller military expenditure). The regression equations for India and Pakistan, respectively, can be written as follows:

$$\ln\left(\frac{M_i}{N_i}\right) = \alpha_i + (f_i - g_i)\ln(M_p) + g_i \ln(X_p) + \mu_i \quad (2.31)$$

$$\ln\left(\frac{M_p}{N_p}\right) = \alpha_p + (f_p - g_p)\ln(M_i) + g_p \ln(X_i) + \mu_p \quad (2.32)$$

where subscript i refers to Indian and p denotes Pakistan. M_i and M_p are the military expenditure, N_i and N_p are non-military output (GDP minus military expenditure), f_i and g_i ($f_p$andg_p) are the relative weights that India (Pakistan) assign to Pakistan (India)'s military expenditure and intentions, respectively. X_i and X_p are the belligerent behaviour of India and Pakistan, respectively. The empirical analysis of Indo-Pakistani relations for the period 1947-1990 shows that both countries respond positively to the rival's belligerent behaviour. However, both India and Pakistan react to increases in each other's military expenditure by decreasing their own expenditure and thus the estimated arms-reaction coefficients are found to be negative. Based on his empirical finding, Oren (1994) suggests that perceived intentions are more important that military expenditure (power) as the determinants of India and Pakistan's armament levels.

Using a second order VAR framework, Dunne, Nikolaidou and Smith (1999) examine the existence of Richardson-type arms race in India and Pakistan for the period 1962-1996. The basic VAR model is set up which included two variables: real military expenditure of India and Pakistan. The Johansen estimating technique is applied and the results presented the cointegration vector as:

$$Z_t = I_t - 2.008P_t \tag{2.33}$$

where I_t and P_t are the level of military expenditure in India and Pakistan at time *t*, respectively. Thus, they suggest that there is a long run relationship between India and Pakistan's military expenditure where the level of India's military expenditure is about twice the level of Pakistan's military expenditure and there exists an action-reaction arms race between India and Pakistan during 1962-1996. Additional, the Granger causality tests indicates there is a bi-directional causality between the level of India and Pakistan's military expenditure.

Dunne and Smith (2007) update the data for India and Pakistan's real military expenditure to 1960-2003 by using revised SIPRI data. They re-estimate the VAR framework for the same time period 1962-1996 as in Dunne, Nikolaidou and Smith (1999)'s study. Comparing with the previous finding, $Z_t = I_t - 2.008P_t$, the new result is slightly different where $Z_t = I_t - 2.51P_t$. Then the revised data are extended to 1962-2003, less evidence is found to support the existence of long-run relationship between India and Pakistan's real military expenditure. So the authors investigate the difference between these two estimating periods: 1962-1996 and 1962-2003 and they add dummy variables into the cointegrating vector. The dummies are used to allow a break in the intercept in 1996 and also to allow a trend starting from 1996. The cointegrating vector includes a dummy, D_t which is equal to one after 1996 and a trend, DT which started from 1996. The cointegrating vector is found to be:

$$Z_t = \mathrm{I_t} - 2.51\mathrm{P_t} - 921\mathrm{D} - 272\mathrm{DT} \quad (2.34)$$

The estimating results show that the dummies are both statistically significant. Comparing with the earlier equilibrium, Indian military expenditure is steadily increasing after 1996. The dummies are believed to be related with India and Pakistan's preparations for nuclear weapons tests (Both countries had their own nuclear test in 1998). However, the adding of these dummies in the cointegrating vector is *ad hoc* and has no theoretical explanation.

Using a smooth transition-type non-linear model, Öcal (2003) investigates the India-Pakistan arms race and the possibility of asymmetric effects of those two countries' military expenditures during the period 1949-1999. In his analysis, the level of each country's military expenditure is a function of the lagged values of its own and the rival's military expenditure and the transition variables. The empirical finding for Pakistan provides evidences to support the possible non-linear dynamics between India and Pakistan's military expenditure. The specification of the non-linearity is corresponding to the dynamic of Pakistan military expenditure from the 1960's to the middle of 1980's when the tension between India and Pakistan is high. Öcal (2003) also finds that when the past level of Pakistan military expenditure is high, the effect of Indian military expenditure on Pakistan military expenditure seems to become greater.

Yildirim and Öcal (2006) investigate the causality between the military expenditure of India and Pakistan for the time period 1949-2003. A multivariate VAR model is employed to allow for both economic and political factors, which include military burden (*MB*), income (*Y*), defence burden of the rival country (*THR*), population (*POP*) and the trade balance. In a seemingly unrelated regression form, the regression system is represented as follows:

$$\begin{bmatrix} MB_{it} \\ Y_{it} \\ THR_{it} \\ POP_{it} \\ TB_{it} \end{bmatrix} = A_0 + A_1 \begin{bmatrix} MB_{it-1} \\ Y_{it-1} \\ THR_{it-1} \\ POP_{it-1} \\ TB_{it-1} \end{bmatrix} + \cdots + A_p \begin{bmatrix} MB_{it-p} \\ Y_{it-p} \\ THR_{it-p} \\ POP_{it-p} \\ TB_{it-p} \end{bmatrix} + A_2 \begin{bmatrix} \varepsilon_{MB_i} \\ \varepsilon_{Y_i} \\ \varepsilon_{THR_i} \\ \varepsilon_{POP_i} \\ \varepsilon_{TB_i} \end{bmatrix} \quad (2.35)$$

where subscript *i* denotes India and Pakistan and *t* refers to time. *p* is the total number of lags which is equal to 3 in their analysis. Then the Granger causality tests[4] are carried out to examine the causality relationship between India and Pakistan's military spending. When *i*

[4] Toda and Yamamoto (1995) approach was employed to test the Granger causality.

denote India, the hypothesis that the military spending of Pakistan Granger cause the military spending of India can be tested by:

:

$$H_0: \alpha_1^{13} = \alpha_2^{13} = \cdots = \alpha_p^{13} = 0 \qquad (2.36)$$

where α_j^{13}, *j=1,.., p,* are the parameters of $THR_{it}, THR_{it-1}, \dots, THR_{it-p}$ in the first equation of the system (Equation (2.35)). The similar tests can be held for the Granger causality from India to Pakistan. The empirical results show that there exists a bi-directional causality between the military spending of India and Pakistan which confirm the finding of Dunne, Nikolaidou and Smith (1999).

The summary of empirical studies of the arms race between India and Pakistan reviewed above are presented in Table 2.3. Different regression equations and different econometric methods have been applied to investigate the Indo-Pakistani arms race or the long run relationship between real military expenditures of India and Pakistan. However, the empirical findings of these studies are inconclusive either on the suitable regression equations or on the empirical analyzing methodologies. The inconclusive results indicate that the empirical analysis of India and Pakistan's arms race should based on the examining of their conflict history and the dynamics of their military expenditures which will be analyzed in the following sections.

Table 2.3 Review of Empirical Literature of India-Pakistan Arms Race

Author(s)	*Period*	*Remarks*	*Main Conclusion*
1. Hollist (1977)	1949-1973	Different variants of Richardson -type arms race model.	The estimated coefficients of reaction factor are unclear for India and Pakistan. The estimated sign of reaction factor is negative in most models.
2. Deger and Sen (1990)	1960-1985	Richardson arms race model with additional considerations of the effects of economic environmental factors.	Asymmetric arms race where Pakistan is relatively more response to Indian military expenditure.
3. Oren (1994)	1947-1990	The effects of military expenditure, intentions and belligerent behaviour of India and Pakistan on each other's levels of armament.	Negative arms-reaction coefficients and thus perceived intentions are more important that military expenditure (power) as the determinants of India and Pakistan's armament levels.
4. Dunne, Nikolaidou and Smith (1999)	1962-1996	Bivariate VAR model and cointegration analysis of military expenditures in India and Pakistan.	There existed an action-reaction arms race between India and Pakistan and their military expenditures Granger caused each other.
5. Dunne and Smith (2007)	1962-2003	Bivariate VAR model and cointegration analysis of military expenditures in India and Pakistan which allowing for a break in the intercept and a trend in 1996.	There existed a long-run relationship between India and Pakistan's military expenditures. India and Pakistan's preparations for nuclear weapons tests had an effect on the long-run relationship where comparing with the earlier equilibrium (1962-1996), Indian military expenditure is steadily increasing after 1996.
6. Öcal (2003)	1949-1999	Smooth transition-type non-linear models.	There is a non-linear dynamics between India and Pakistan's military expenditures. When the past level of Pakistan military expenditure is high, the effect of Indian military expenditure on Pakistan military expenditure seemed to become greater.
7. Yildirim and Öcal (2006)	1949-2003	Multivariate VAR model which considered both economic and political factors.	There is a bi-directional causality between the military spending of India and Pakistan.

2.3 Military Expenditure and Conflicts in India and Pakistan

2.3.1 India and Pakistan Conflict History

After 300 years of Imperial rule and the partition of sub-continent into Hindu-majority India and Muslim-majority Pakistan in 1947, these two new countries not only gained independence but also started their long-running conflicts. India and Pakistan have much in common such as state institutions, budgetary mechanisms and government macroeconomic policies but at the same time, they are different in foreign policies, religions and security strategies. So India and Pakistan could be characterized as 'diversity in unity'. These characteristics are believed to have considerable influence on the two neighbouring countries' relationship and military expenditure dynamics.

The creation of the two independent countries began the hostility and conflicts between India and Pakistan. The partition and independence in 1947 caused severe riots, communal violence and population movements. In the partitioned provinces of Punjab and Bengal, Muslims, Sikhs and Hindus all tried to move to the right sides (where Muslims moved to Pakistani side and Sikhs and Hindus moved to Indian side). During these movements, an estimated half a million people were killed in communal violence and a million people became homeless. India and Pakistan were separated but the dispute in the territory of Jammu and Kashmir has remained and is seen as a root of the Indo-Pakistani animosity. Generally, India tends to claim the entire erstwhile princely state of Jammu and Kashmir while Pakistan claims all areas of the erstwhile state except for those claimed by China. The dispute areas between India and China are located in the Shaksam Valley and Aksai Chin . The dispute areas are shown in Figure 2.2.

Table 2.2 Major Conflicts Between India and Pakistan, 1947-2008

Year	Conflicts	Place
1947-1948	First Indo-Pakistani War	Northern Kashmir
1965	Second Indo-Pakistani War	Punjab and Sind
1971	Third Indo-Pakistani War	East Pakistan
1999	Kargil War	India-held Kashmir around Kargil

These two countries have come to four large scale armed conflagrations, which are presented in Table 2.4 and countless border skirmishes since independence. The first Indo-Pakistani war took place in October, 1947 after Pakistan troops supported a Muslim insurgency in the disputed territory in Kashmir and according to the request from Kashmir's Maharaja, the Indian government provided armed assistance. The war ended in January 1949 and a ceasefire line, later known as the Line of Control, was established. During the war, each side suffered 1500 battlefield fatalities.

Over the Kashmir issue, the two countries clashed again on 5th August, 1965 in the Rann of Kutch. Pakistan launched a covet offensive across the West Pakistan-India border and the fighting broke out. India retaliated by crossing the international border at Lahore and the fighting spread to Kashmir and the Punjab. In September, both countries' troops crossed the partition line between them and air assaults on each other's cities were launched. In this war, 3000 Indian soldiers died while the Pakistan side lost 3800. By 22nd September both sides decided to adopt UN mandated ceasefire resolution. But the suspicion and hostility between India and Pakistan was enhanced and the disputes over Kashmir remained.

Figure 2.2 the Disputed Area of Jammu and Kashmir

Source: The University of Texas at Austin, PCL Map Collection. Accessed 08/2009,

http://www.lib.utexas.edu/maps/middle_east_and_asia/kashmir_disputed_2002.jpg

Although the Eastern wing of Pakistan was more populous than the Western one, political power rested with the Western elite since independence. This caused East Pakistanis resentment and demanding autonomy. In 1971, civil war erupted in Pakistan which pitted the West Pakistan army against East Pakistanis. Entire East Pakistan was in revolt and an estimated 10 million East Pakistani civilians were forced to flee to India. In December, 1971 India invaded East Pakistan in support of the East Pakistani people. The relationship between India and Pakistan deteriorated again and the third Indo-Pakistani war was fought. Pakistan attacked Indian airfield in Kashmir while India attacked both East and West Pakistan. The Pakistani army surrendered at Dhaka and East Pakistan became the independent country of Bangladesh on 6th December 1971. It was a humiliating and major military defeat for Pakistan with loss its Eastern wing, 15% in territory and 60% in population.

The tension between the rivals escalated dramatically in the 1990s and both sides conducted nuclear tests in the same year 1998. In 1999, Pakistan's army captured strategic heights in India-held Kashmir around Kargil. India responded with launching air strikes against Pakistan troops and recaptured a majority of the positions which were infiltrated by the Pakistani troops and militants. With international diplomatic support, the Pakistani forces were forced to leave Kargil. During the 73 day Kargil conflict, it was reported that more than 30,000 people were forced to leave their homes on the Pakistani side of the Line of Control and about 20,000 people became refugees on the Indian side. The Kargil war was the most recent ground war between two countries both possessing nuclear weapons and led to a heightened tension between India and Pakistan.

During 2001-2002, one million troops had squared off menacingly along the Indo-Pakistan border and actual war was in a near state. However, there were some improvement in the India-Pakistani relationships since April 2003 and the two neighbors took steps to restore diplomatic relations and resume flight, bus service, and cricket matches between them. Recently, the mutual suspicion governed the India-Pakistani relations again after the 2007 Samjhauta Express Bombings[5], and the 2008 Mumbai Terrorist Attacks[6] by a group of Pakistani people. Nowadays, the two governments have made clear that they want to a peaceful and beneficial resolution to the issues that they both concerned, such as Kashmir, conventional and nuclear arms, terrorism and economic cooperation. Whether India and Pakistan can capitalize on the desire for peace and cooperation, or whether the long hostilities will destroy any such initiative remains to be seen.

2.3.2 India and Pakistan's Military Expenditure Dynamics

Military expenditures in India and Pakistan have been influence by their conflict history and the enduring hostility with each other. The competitive arms race was born almost at the same time as the two countries' independence. After the partition, most of the ordnance factories were located in India and thus at the beginning India had the prevailing advantage in the military industrial base over Pakistan. Then Pakistan was forced to 'catch up' through increasing military expenditure and arms importation. To compete with India's military industry and partly due to the first Indo-Pakistani war in 1948, Pakistan believed it was

[5] The 2007 Samjhauta Express bombings were a terrorist attack that occurred around midnight on 18 February 2007 on the Samjhauta Express, a twice-weekly train service connecting Delhi, India, and Lahore, Pakistan. Sixty-eight people were killed in the ensuing fire and dozens more were injured.

[6] The 2008 Mumbai attacks were more than ten coordinated shooting and bombing attacks across Mumbai. The Mumbai attacks were planned and directed by Lashkar-e-Taiba militants inside Pakistan At least 164 victims (civilians and security personnel) and 9 attackers were killed in the attacks.

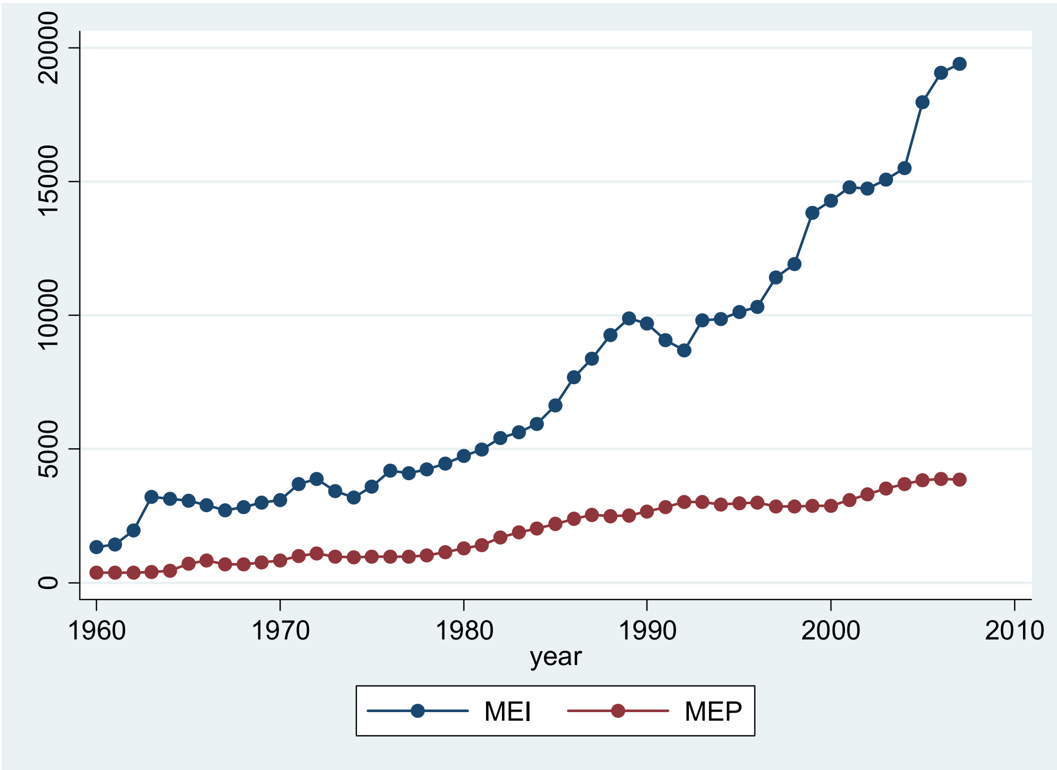
necessary to have a modest domestic arms production and raised its military spending which included all categories, from procurement to operations and maintenance to R&D.

During the 1950s, as a member of various US-sponsored Treaty Organizations (for example, the Central Treaty Organization[7]), Pakistan acquired arms through imports and military aid from the United States. The arms in Pakistan were thus being bolstered by sophisticated arms imports and US military aid. On the other hand, India kept its policy of the self-sufficient import substitution industrialization and expanded its military industries. Thus, India's military expenditure and domestic arms production experienced a rapid expansion partly to offset the high foreign exchange costs of imports and partly to keep the advantage over Pakistan whose armaments were improved during that period.

In the start of 1960s, India expanded its military expenditure dramatically due to the defeat in the Sino-Indian war in 1962. A dispute arose over disagreements regarding to the border in the Rann of Kutch between India and Pakistan in 1965 and the Second Indo-Pakistani war broke out. Then the traditional rival relationship between these two neighbouring countries continued, and culminated in the Third Indo-Pakistani war in 1971. Pakistan lost its Eastern wing and the state of Bangladesh was created in that year. Both sides kept building up their armaments. The levels of India's military expenditure (MEI) and Pakistan's military expenditure (MEP) for the period 1960-2007 are illustrated in Figure 2.3.

[7]Mutual-security organization originally composed of Turkey, Iran, Iraq, Pakistan, and Britain. It was formed in 1955, at the urging of the U.S. and Britain, to counter the threat of Soviet expansion into the Middle East. It was dissolved in 1979.

Figure 2 3 India and Pakistan's Military Expenditure (Constant 2000 Millions US$), 1960-2007



Data sources: SIPRI Yearbooks

In the 1980s, Russia invaded Afghanistan and Pakistan acted as the principal channel through which assistance from the United States was provided to Afghan freedom fighters. Pakistan also provided access to its military bases to use against the Soviet Union. Thus, Pakistan received financial and military aid from the U.S. during the period with the supply of F-16 fighters and other weaponry. In response to the sizeable arsenal built up by Pakistan, India imported armaments from the Soviet Union and speeded up the process of defence industrialization. In the late 1980s both countries expanded their military spending and were concerned about the sophistication of warfare and missile programmes.

The expansion of military expenditure continued in both India and Pakistan due to the escalated tension between the rivals in the 1990s. The new menace of arms rivalry was brought to the South Asia continent by nuclear weapons tests of both countries in 1998. The Kargil war of 1999 was also seen as a factor driving up the two rivals' military spending. In the 2000s, military expenditures in both countries had shown continuing rises which were fuelled by rapid economic growth, especially in India.

This brief conflict history of India and Pakistan and their military expenditure dynamics indicates that, although other actors (China, Russia and the United Sates) have been present in the interaction between India and Pakistan's arms acquisition process, in many ways they have been driven by the arms race with each other which could be characterized by an action-reaction model. Hence it would be simplistic to believe that this was the predominant reason for India and Pakistan's respective military expenditures (Barrett and Sen, 2009).

2.4 Theoretical Model and Specification

Based on the analysis in section 2.3, it is known that India and Pakistan's arms race could be characterized by an action-reaction model. Thus, this study employs the Richardson action-reaction model. Dunne and Smith (2007) indicate that a recent and advanced econometric technique can be used to estimate long-run arms race relationships and their method is applied in this study to examine the possible arms race relationship between India and Pakistan. Based on Lewis F. Richardson's (1960) seminal study, the standard framework is summarized by two differential equations describing the change over time of weapon stocks in each of the two countries as a function of the weapon stocks or military expenditure of each side. Focusing on a two-country model, the process is as follows:

$$dm_1/dt = a_1 + b_1 m_2 - c_1 m_1 \qquad (2.37)$$

$$dm_2/dt = a_2 + b_2 m_1 - c_2 m_2 \qquad (2.38)$$

For two rival countries with weapon level or military expenditure m_1 and m_2, the rate of change in one country's weapon levels or military expenditure, m_1, is influenced positively by the increases in the other country's weapon levels or military expenditure, m_2.

For empirical analyses, the 'structural form' of the Richardson model can be given in discrete time with the addition of a stochastic error term:

$$\Delta m_{1t} = a_1 + b_1 m_{2t} - c_1 m_{1t-1} + \varepsilon_{1t} \qquad (2.39)$$

$$\Delta m_{2t} = a_2 + b_2 m_{1t} - c_2 m_{2t-1} + \varepsilon_{2t} \qquad (2.40)$$

We assume that: $E(\varepsilon_{it}) = 0$, $E(\varepsilon^2_{it}) = \sigma^2_i$, $E(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$, $E(\varepsilon_{it}\varepsilon_{jt-s}) = 0$, where $s \neq 0$ and $i, j = 1,2$ and as explained by Dunne and Smith (2007), the structural shocks ε_{it} are not expected to be independent.

The 'reduced form' of the equations which are in term of predetermined and lagged variables as a first order Vector Auto-regression (VAR) model can be written as:

$$\Delta m_{1t} = \frac{a_1 + b_1 a_2}{1 - b_1 b_2} + \frac{c_1 + b_1 b_2}{1 - b_1 b_2} m_{1t-1} + \frac{b_1(1 + c_2)}{1 - b_1 b_2} m_{2t-1} + \frac{\varepsilon_{1t} + b_1 \varepsilon_{2t}}{1 - b_1 b_2}$$

$$\Delta m_{2t} = \frac{a_2 + b_2 a_1}{1 - b_1 b_2} + \frac{c_2 + b_1 b_2}{1 - b_1 b_2} m_{1t-1} + \frac{b_2(1 + c_1)}{1 - b_1 b_2} m_{2t-1} + \frac{b_2 \varepsilon_{1t} + \varepsilon_{2t}}{1 - b_1 b_2}$$

or

$$\Delta m_{1t} = \delta_{11} + \delta_{12} m_{1\,t-1} + \delta_{13} m_{2t-1} + \mu_{1\,t}$$

$$\Delta m_{2t} = \delta_{21} + \delta_{22} m_{1\,t-1} + \delta_{23} m_{2t-1} + \mu_{2\,t} \qquad (2.41)$$

Where $E(\mu_{it}) = 0$, $E(\mu^2_{it})=\omega^2_i$, $E(\mu_{it}\,\mu_{jt})= \omega_{ij}$, $E(\mu_{it}\,\mu_{jt-s})= 0$, where $s\neq0$ and i, j=1,2.

If there is a long run relationship between variables m_{1t} and m_{2t}, which might be non-stationary, the Vector Error Correction Model (VECM) can be written in the form:

$$\Delta m_{1t} = \pi_{10} + \alpha_1 Z_{t-1} + \mu_{1t}$$
$$\Delta m_{2t} = \pi_{20} + \alpha_2 Z_{t-1} + \mu_{2t} \qquad (2.42)$$

where Z denotes the long run relationship between m_{1t} and m_{2t}, i.e. the cointegrating vector.

Before using VAR techniques to empirically test the Richardson type arms race between India and Pakistan, two things need to be noticed. Firstly, despite the popularity of the Richardson model, it has a number of weaknesses. For the model itself, it is a descriptive rather than normative model as discussed in section 2.2. Secondly, when applied to the data, the empirical results of these models have been disappointing (Hartley and Sandler, 1995). Smith *et al*. (2000) analyse the problems when applying the Richardson model: these problems include measurements of m, a stochastic specification for ε, a theoretical interpretation and an estimation method. Furthermore, the quality and reliability of the data also make the application of the model questionable. Thus, our empirical analysis of India-Pakistan arms race in the following sections not only employs conventional cointegration techniques but also applies recently developed methodologies to examine the existence of a long-run relationship between these two neighbour countries' real military expenditure.

2.5 Methodologies of Empirical Analysis

During the past decade, the methods of estimation of unit root, structural breaks and cointegration have been developed at a fast pace. In particular, it is now widely accepted that many macro time series are non-stationary which have substantial implications for empirical analyses. Most econometric analyses are based on the variance and covariance among variables. For instance, the method of estimating a standard regression model, Ordinary Least Square (OLS), assumes that means and variances of the variables being tested are constant over time. But non-stationary variables have means and variances which change over time. Thus, if the regression contains these non-stationary variables, OLS technique is invalid and could lead to spurious regression results - i.e. if two variables are trending over time, they can be highly correlated even if the increments in each variable are uncorrelated at all. However, if variables are cointegrated (i.e. there exist co-movements among these trending variables), regressions could be exploited to test for the existence of long-run equilibrium relationships within a dynamic specification framework (Engle and Granger, 1987).

Furthermore, the cointegration relationship has the long-run property which implies that the testing time series cover long periods. Thus, it is more likely that there exist structural breaks in those time series. In the presence of structural breaks, the standard tests for unit root and cointegration are biased (Perron, 1989; Gregory and Hansen, 1996). Structural breaks may reflect large economic shocks, changes in economic policies and changes in institutional arrangements. For example, India and Pakistan's arms race relationship might change when both of them had nuclear tests in 1998 (i.e. there is a possible structural break around 1998.). So it is very important to take into account structural breaks in empirical analyses. If the cointegration relationship is not distorted with structural breaks, Stock and Watson (1993)'s Dynamic OLS (DOLS) method could be applied to test the long-run relationship and to be compared with other related cointegration analyses which are applied in our empirical studies.

The objective of this section is to provide the empirical methodologies for testing the existence of the long run relationship (arms race) between military expenditure of India and Pakistan. Since unit root tests are the preconditions to test of the existence of cointegration relationship, unit root tests of military expenditures of India and Pakistan are firstly discussed. Given the fast development and importance of unit root tests, a brief review of unit root tests are provided and five different methodologies are applied which include the conventional Augmented Dickey-Fuller (ADF) test, Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test, Zivot-Andrews unit root test, Clemente *et al.* (1998) unit root tests and the Minimum LM Unit Root test (Lee and Strazicich, 2003, 2004). The results from these five unit root tests will be summarized and the robust conclusion could be made based on the comprehensive analysis.

Then the Engle-Granger Cointegration tests (Engle and Granger, 1987) and Vector Autoregressive procedure (Johansen, 1991, 1995; Johansen and Juselius, 1990) are provided to estimate the cointegrating relationship without structural breaks. In the case of existence of structural breaks, the Gregory Hansen (1996) test is employed to allow for a single unknown structural break in the cointegration relationship. This test captures one structural break and identifies the break-point empirically. Finally, the Stock-Watson DOLS technique with the structural break (captured by earlier tests) is employed and provides more robust results in the small sample. The results of the long-run relationship reported by different tests are compared and summarized as well.

2.5.1 Unit Root Tests without Structural Breaks: The ADF Test and KPSS Test

2.5.1.1 The ADF Test

The conventional methods to test for the presence of unit roots are developed by Dickey and Fuller (1979), and Said and Dickey (1984). The standard Dickey-Fuller (DF) test is carried out as follows.

Consider a simple Autoregressive (AR) (1) process:

$$y_t = \rho y_{t-1} + x_t{}'\delta + \varepsilon_t \tag{2.43}$$

where x_t are optional exogenous regressors which may include a constant, or a constant and a trend, ρ and δ are parameters to be estimated, and ε_t are white noise. After subtracting y_{t-1} from both sides of the equation, we get

$$\Delta y_t = \alpha y_{t-1} + x_t{}'\delta + \varepsilon_t \tag{2.44}$$

where $\alpha = \rho$-1. y is non-stationary if α is zero. If the series is an AR(1) process, the simple DF unit root test is valid.

However, if the series is correlated at higher order, the white noise assumption of ε_t will be violated. By assuming that y series follows an AR(p) process and adding p lagged difference terms of the dependent variable y to the right-hand side of the regression equation, the ADF test constructs a parametric correction for higher order correlation as following:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \cdots + \beta_p \Delta y_{t-p} + \nu_t \tag{2.45}$$

The information criterions such as Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) are used to determine the optimal lag length p.

The null and alternative hypotheses can be written as:

$$H_0: \alpha = 0$$
$$H_1: \alpha < 0 \tag{2.46}$$

Non rejection of the null hypothesis implies that the series is non-stationary,(i.e. exhibits unit root); whereas the rejection of the null hypothesis implies that the series is stationary.

However, it need to be concerned that the ADF test tends to have low power and cannot reject the unit root hypothesis when the series is stationary. As argued by Perron (1989), structural breaks in time series can influence the results of unit root test. The ADF test could rarely reject the null of unit root where in fact the series is a stationary process with a broken trend.

2.5.1.2 The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

The KPSS (1992) test differs from the ADF unit root test. Under the null of KPSS test, the series y_t is assumed to be stationary. Its statistics is based on the residuals from the OLS regression of y_t on the exogenous variables x_t:

$$y_t = x_t'\delta + u_t \tag{2.47}$$

The Lagrange Multiplier (LM) statistic is defined as:

$$LM = \sum_t S(t)^2 /(T^2 f_0) \tag{2.48}$$

Where f_0 is an estimator of the residual spectrum at frequency zero and $S(t)$ is a cumulative residual function:

$$S(t) = \sum_{r=1}^{t} \hat{u}_r \tag{2.49}$$

Where $\hat{u}_t = y_t - x_t'\hat{\delta}(0)$. So the KPSS test is a stationary test, while the ADF test is a non-stationary test.

2.5.2 Unit Root Tests with Structural Breaks

2.5.2.1 The Zivot-Andrews Unit Root Test with a Single Structural Break

The Perron (1989) unit root test assumes that the structural break date is uncorrelated with the data and known *ex ante* by economic information: for example, the 1973 oil price shock. However, according to Christiano (1988), the Perron (1989)'s assumption of exogenous breaks has been criticized and considered inappropriate. Due to problems associated with "pre-testing", Perron's methodology invalidates the distribution theory of conventional testing and will tend to over reject the null of unit root. Instead, Zivot and Andrews (1992, hereafter ZA) treat the selection of the break points as the outcome of an estimation procedure. They transform Perron (1989)'s test into an unconditional unit root test which allows endogenously determined break points in the intercept and/or the trend function.

Following Perron(1989)'s notation, ZA test the null of unit root against the alternative of a one-time structural break with three models: Model A allows a one-time change in the level of the series, Model B permits a one-time change in the slope of the trend function of the series and Model C admits both changes. The regression equations corresponding to these three models are as following.

Model A

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \theta DU_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2.50}$$

Model B

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \gamma DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2.51}$$

Model C

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \theta DU_t + \gamma DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2.52}$$

where DU_t and DT_t are break dummy variables for a mean shift and a trend shift,respectively. The shift occurs at each possible break point T_B ($1 < T_B < T$). Formally:

$$DU_t = \begin{cases} 1\ if\ t > T_B \\ 0\ otherwise \end{cases}\ and\ DT_t = \begin{cases} t - T_B\ if\ t > T_B \\ 0\ otherwise \end{cases} \tag{2.53}$$

where k is the number of lags determined for each possible break point by one of information criteria.

The null hypothesis is α=0, which implies that the series exhibits a unit root with a drift and excludes any structural break points. The alternative hypothesis is α<0, which implies that the series is a trend-stationary with an unknown one-time break. So Equations (2.50), (2.51) and (2.52) are sequentially estimated and T_B is chosen so as to minimize the one–sided t-statistics for testing $\hat{\alpha} = 0$. Following the same method, Lumsdaine and Papell (1997, hereafter LP) extend the ZA minimum unit root test and include two structural breaks. The null hypothesis is also unit root with no break against the alternative stationary with breaks hypothesis.

2.5.2.2 The Clemente, Montanes and Reyes (1998) Unit Root Test with Double Structural Breaks

Since some variables exhibit multiple break points, Clemente, Montanes and Reyes (1998, hereafter CLEM) extend the Perron and Vogelsang (1992) tests to allow for two structural breaks in the mean of a series. There are two different forms of those structural breaks: the Additive Outlier (AO) and Innovational Outlier (IO) models. They test the null hypothesis H_0 against the alternative hypothesis H_1:

$$H_0: y_t = y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + \mu_t \tag{2.54}$$

$$H_1: y_t = \mu + d_1 DU_{1t} + d_2 DTB_{2t} + e_t \tag{2.55}$$

In these equations DTB_{it} is a pulse variable that takes the value one if $t = TB_i + 1$ (i=1, 2) and zero otherwise, $DU_{it} = 1$ if $t > TB_i$ (i=1, 2) and zero otherwise. TB_1 and TB_2 represent time periods when the shifts in the mean occur. For the sake of simplicity, suppose that $TB_i = \lambda_i T$ (i=1, 2) where $0 < \lambda_i < 1$ and $\lambda_2 > \lambda_1$ (Clemente Montanes and Reyes, 1998).

For the case the two breaks belong to the IO, the estimating regression can be written as:

$$y_t = \mu + \alpha y_{t-1} + \beta t + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \tag{2.56}$$

Equation (2.56) is then sequentially estimated and the null hypothesis of unit root is tested by obtaining the minimum value of the t-statistic for the hypothesis $\alpha = 1$ for all break time combinations.

2.5.2.3 The Lee and Strazicich (2003, 2004) Minimum LM Unit Root Test

Lee and Strazicich (2003, 2004) provide evidences that assuming no break under the null in above endogenous break(s) tests cause the test statistic to diverge and lead to significant rejections of the unit root null. In fact, the data-generating process (DGP) is a unit root with break(s). Based on these unit root tests such as ZA and LP tests, the rejection of the null does not indicate the rejection of a unit root per se, but would indicate the rejection of a unit root without break(s). Thus, the above unit root tests with endogenous break(s) will exhibit size distortions and will reject the null hypothesis of unit root too often.

Lee and Strazicich (2003, 2004) develop a one- and two-break minimum Lagrange multiplier unit root test which is a remedy to the problem noted above. Their LM unit root test allows for break(s) under both the null and alternative hypotheses. As a result, rejection of the null hypothesis unambiguously implies trend stationarity.

Following the notation of Lee and Strazicich (2003), the LM unit root test with two structural breaks can be obtained from the regression:

$$\Delta y_t = d'\Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta \tilde{S}_{t-i} + \mu_t, t = 1, \dots, T \qquad (2.57)$$

where Z_t contains a vector of exogenous variables, $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$ and $\tilde{\psi}_x = y_1 - Z_1\tilde{\delta}$. $\tilde{\delta}$ are the coefficients in the regression of Δy_t on ΔZ_t. The lagged terms $\Delta \tilde{S}_{t-i}$ are included as required to correct for serial correlation. The number of lagged augmentation terms is determined by following the general-to-specific procedure which is suggested in Ng and Perron (1995).

There are two forms of models. Model A allows for two shifts in level and is defined by $Z_t = [1, t, D_{1t}, D_{2t}]'$, where D_{jt}=1 for $t \geq T_{Bj}, j = 1,2$ and 0 otherwise. T_{Bj} denotes the points at which breaks occur. Model C includes two breaks in level and trend and is defined by $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$, where $DT_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1, j = 1,2$ and 0 otherwise. The unit root null hypothesis $\phi = 0$ is then tested via the t-statistic being denoted as $\tilde{\tau}$. The break points are determined endogenously to be where the test statistic is minimized over the interval [0.1T, 0.9T] (to eliminate endpoints). The break fractions are denoted as $\lambda_j (= TB_j/T)$ and the LM test statistic LM_τ is given by:

$$LM_\tau = \underset{\lambda}{Inf}\, \tilde{\tau}(\lambda) \tag{2.58}$$

2.5.3 Cointegration Tests

2.5.3.1 The Engle-Granger Cointegration Test

Engle and Granger (1987) propose a theoretical representation for estimating and modeling cointegration relationship among non-stationary time-series variables. They propose that a linear combination of two or more non-stationary series may be stationary. This stationary linear combination is called the cointegration equation and could be interpreted as a long run equilibrium relationship among the series.

As the most well known cointegration test, Engel and Granger provide a formal framework for testing the existence of long run equilibrium relationship and avoid spurious regression problems. Consider the set of (k+1) variables y_t which are I(1). If there exists a vector θ such that $\theta' y_t$ is I(0), then θ is the cointegration vector. In a simple two-variable case, the residual-based test considers the equation:

$$y_{1t} = \beta y_{2t} + \mu_t \quad (2.59)$$

If μ_t is I(0), then $y_{1t} - \beta y_{2t}$ is a cointegrating relationship. If μ_t has a unit root, then y_{1t} and y_{2t} are not cointegrated. Thus, a test for a unit root in μ_t is a test that y_{1t} and y_{2t} are not cointegrated. The ADF test and Phillips-Perron Z_α and Z_t tests could be applied to the estimated residuals, $\hat{u}_t$. Since the linear combination $y_{1t} - \beta y_{2t}$ is stationary, an error correction model (ECM) could be written as following:

$$\Delta y_{1t} = \alpha \Delta y_{2t} + \lambda(y_{1t-1} - \beta y_{2t-1}) + \nu_t \quad (2.60)$$

where all of these transformed variables are I(0) and could be estimated. So it provides both long- and short-run information. Engle and Granger (1987) suggest a two stage procedure. In the first step, all dynamics are ignored and estimate the static cointegrating relationship in Equation (2.59) by the OLS. If the estimated residuals, $\widehat{\mu_t}$, are stationary, y_{1t} and y_{2t} are cointegrated. So the test of the unit root null implies the test of null hypothesis that y_{1t} and y_{2t} are not cointegrated. If y_{1t} and y_{2t} are cointegrated, a long-run equilibrium relationship exists and the short run disequilibrium relation can always be represented by an ECM. In the second step, since y_{1t} and y_{2t} are cointegrated, we could get $\hat{\beta}$ from estimating $y_{1t} = \beta y_{2t} + \mu_t$. Then the ECM could be estimated in the form: $\Delta y_{1t} = \alpha \Delta y_{2t} + \lambda\left(y_{1t-1} - \hat{\beta} y_{2t-1}\right) + \nu_t$. Thus, the Engle-Granger two steps test provides a model incorporating both the static long-run and the dynamic short-run components.

The Engle-Granger is easy to apply and OLS estimates can provide super-consistent coefficients of a long-run model (Stock, 1987). But it has some weaknesses. For example, firstly, it is only suitable for bivariate model and rules out multiple cointegration vectors between more than two variables. Secondly, standard significance tests on the long-run model (cointegration vector) coefficients are invalid because standard errors are unreliable. Thirdly, it suffers from small sample bias. Fourthly, independent variables are assumed exogenous and it may violate weak exogeneity. Fifthly, it is not invariant with the choice of dependent variable and has the normalization problem. Finally, it is likely to have lower power against alternative tests, such as Engle-Granger-Yoo (1991) 3-step approach and Johansen cointegration test (1990).

2.5.3.2 The Johansen Cointegration Test

Another commonly employed cointegration test is developed by Johansen and Juselius (1990). Based on a vector autoregressive (VAR) model, Johansen and Juselius's methodology is widely used to test whether a group of non-stationary series are cointegrated or not. The Johansen cointegration test can test a number of cointegration relations. All variables are assumed endogenous and then the test is insensitive to the choice of dependent variables and the variable being normalized. Here a VAR model treats every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system.

Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \varepsilon_t \tag{2.61}$$

where y_t is a k-vector of non-stationary I(1) variables, i.e. integrated with order 1, x_t is a d-vector of deterministic variables, and ε_t is a vector of innovations. It may be rewritten as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \tag{2.62}$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I,\ \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{2.63}$$

If the coefficient matrix Π has reduced rank $r < k$, there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0), i.e. stationary. So r is the number of cointegration relations and each column of β is the cointegration vector, and the elements of α are the adjustment parameters which measure the speed of adjustment coefficient of particular variable to a disturbance in the long-run equilibrium relationship. By applying trace or maximum eigenvalue statistics, Johansen's methodology is to estimate the matrix Π based on an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

For the lag length of the unrestricted VAR, Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) and the Long Run sequential modified LR statistics (LR) are adopted to determine the lag length. However, it is important to avoid too many lags in the VAR since the number of parameters grows very fast with the lag length (Johansen, 1995). In the case of small samples, it is the best choice to use a rather small lag length.

The cointegrating equations may have intercepts and deterministic trends. The asymptotic distribution of the Likelihood ratio (LR) test statistic for cointegration depends on the assumption made with respect to deterministic trends including in the cointegration relations. Johansen (1995) specifies five general models of deterministic trends cases. One could make an appropriate assumption regarding the trend underlying the data. The choice of the appropriate specification could rely on the so-called “Pantula principle” (Johansen, 1992) by proceeding from the most restrictive model, (i.e. no deterministic components), to the least restrictive model. The model which accepts cointegration first will be the preferred one.

There are three main weaknesses of the Johansen approach. The first one is the interpretation problems. The symmetrical treatment of all variables in the VAR system and the possibility of multiple cointegration relations both cause the interpretation problematic. The second one is the sensitivity to variables selection and number of lags included. The last weakness is that the Johansen cointegration test does not perform well in small samples. Maddala and Kim (1998) suggested that by comparison, the least squares methods are more robust.

2.5.3.3 The Gregory and Hansen Cointegration Test

The conventional approach to cointegration assumes that cointegration vectors are time-invariant. When there is a structural break in the cointegration relationship, the power of the Engle-Granger (1987) test of the null of no cointegration will be substantially reduced. Denoting the standard cointegration between two series $\{ y_{1t}, y_{2t}\}$ as:

Model1: Standard cointegration

$$y_{1t} = \mu + \alpha^T y_{2t} + e_t , \qquad t = 1, \dots, n \tag{2.64}$$

If Model 1 captures a long-run relationship, the parameters α and μ are expected to be time-invariant. But in some applications, due to structural changes it may be desirable to consider a shift in the relationship, (i.e. the cointegration holds over some period of time), and then shifts to a new equilibrium relationship. One important point to bear in mind is that the test needs to use time series covering long period for capturing long-run relationships.

Gregory and Hansen (1996) develop Engle-Granger's single-equation regression models and allow for cointegration with a structural change in either the intercept or the intercept and trend at an unknown time. Allowing different forms of structural change in the cointegration relationship, three models are specified and denoted as follows:

Model 2: Level shift (C)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha^T y_{2t} + e_t, \qquad t = 1, \dots, n \tag{2.65}$$

There is a level shift in the cointegrating relationship in Model 2. μ_1 denotes the intercept before the shift, and μ_2 denotes the change in the intercept at time of the shift.

Model 3: Level shift with trend (C/T)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha^T y_{2t} + e_t, \qquad t = 1, \dots, n \tag{2.66}$$

This model introduces a time trend into the level shift model.

Model 4: Regime shift (C/S)

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} \varphi_{t\tau} + e_t, \qquad t = 1, \dots, n \tag{2.67}$$

Allowing both the intercept and slope to shift, Model 4 permits the cointegrating relationship to shift parallel as well as rotate. μ_1 and μ_2 are as Model 2. $\propto_1$ represents the cointegrating slope coefficients before the regime shift and $\propto_2$ represents the change in the slope coefficients.

Structural change via the dummy variable $\varphi_{t\tau}$ in the above models is defined as:

$$\varphi_{t\tau} = \begin{cases} 0 \; if \; t \leq [n\tau] \\ 1 \; if \; t > [n\tau] \end{cases} \tag{2.68}$$

Where the unknown parameter $\tau \in (0,1)$ denotes the timing of the break point, and [ ] denotes integer part.

To detect cointegration relationship with a possible shift, Gregory and Hansen (1996) suggest three tests: $Z_\alpha^*(\tau), Z_t^*(\tau)$, and ADF^*. The first two are modified Phillips (1987) test statistics and the third one is based on the ADF statistic. These three statistics can be used alternatively. By computing the cointegrating test statistics for each possible regime shift $\tau \in T$, the smallest values of the above statistics are taken to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration with shifts.

2.5.3.4 The Stock-Watson Dynamic OLS

Stock and Watson (1993) propose a technique to estimate long-run relationship via dynamic OLS which is a more robust approach, particularly in small sample. By the inclusion of lags and leads of the change in the regressors, the potential of simultaneity bias and small sample bias among the regressors are eliminated. Stock-Watson DOLS presents efficient estimators of cointegrating vectors and statistical inferences (for example, normal t-statistics) on the parameters of the cointegrating vectors.

Given that two or more series are non-stationary, test the following regression by OLS,

$$y_t = \beta_0 + \sum_{i=1}^{n} \beta_i x_{it} + \sum_{i=1}^{n} \sum_{j=-k1}^{+k2} \gamma_{ij} \Delta x_{it-j} + \varepsilon_t \qquad (2.69)$$

where $k_1,$ and k_2 denote leads (future) and lags (past), respectively. Using information criteria (AIC and SIC), the values of $k_1,$ and k_2 are selected and usually set $k_1, = k_2$. The resulting DOLS estimators are asymptotically equivalent to the Johansen estimator and have been proved that they perform well relative to the other asymptotically efficient estimators (Stock and Watson, 1993).

2.6. Data and Empirical Results

2.6.1 Data

The section uses SIPRI data on India and Pakistan's (nominal) military expenditures. The data on price index and interest rates are from World Development Indicators by World Bank. Then real military expenditure data are derived at constant 2000 price US$ (Data on real military expenditure, defence burden of India and Pakistan, 1960-2007, are listed in Table A1 and A2, respectively in the Appendix; data on military personnel of India and Pakistan, 1985-2005 are listed in Table A3 in the Appendix). The testing period covers 1960-2007 for both countries. Real military expenditure variables are employed by the logarithm forms of series, in order to overcome some statistic problems in the regression: for example unequal variation. Many macroeconomic time series are non-stationary and contain a unit root. Thus, real military expenditure data would be non-stationary as well and unit root tests need to be carried out. The following section will use different unit root tests outlined previously to examine the existence of a unit root in India and Pakistan's real military expenditure data.

2.6.2 Unit root Tests

First, the ADF test is used to test for unit root without allowing for any breaks. The variables tested are the logarithm of the real military expenditure of India (LNMEI) and the one of Pakistan (LNMEP). Table 2.5 shows the results from the ADF test. The ADF test for unit root in levels indicates that both series are non-stationary. After taking the first difference of the series, the results indicate stationarity. So LNMEI and LNMEP exhibit unit root.

Another conventional unit root test is the KPSS test. The null hypothesis is different with the ADF test which is stationary. The rejection of the null indicates the series is non-stationary. Table 2.6 presents the results of KPSS test. We can reject the null of stationary in levels but cannot reject it after taking the first difference of the series. The results also indicate that both LNMEI and LNMEP have unit root.

Table 2.4 Augmented Dickey-Fuller Unit Root Test

	Level		First Difference	
	K	ADF	K	ADF
LNMEI	0	-1.590	1	-5.605***
LNMEP	1	-1.847	0	-4.862***

Notes:

1) Estimation with constant for the level and the first difference.

2) Lag order is determined by using SIC with a maximum of 8 lags allowed.

3) Significance levels: *** at 1%, ** at 5% and * at 10%.

4) K denotes the lag length.

Table 2.5 KPSS Stationary Test

	Level	*First Difference*
	LM statistic	LM statistic
LNMEI	0.9232***	0.1434
LNMEP	0.8799***	0.2261

Notes:

1) Estimation with constant for the level and the first difference.

2) Critical value: 1% 0.739, 5% 0.463 and 10% 0.347

3) Significance levels: *** at 1%, ** at 5% and * at 10%.

The criticism against the conventional unit root tests is that they tend to have low power and cannot reject the unit root hypothesis due to without allowing for structural breaks. Then we continue to perform the Zivot-Andrews unit root test with a single structural break and the Clemente, Montanes and Reyes (1998) unit root test with double structural breaks. The results are shown in Table 2.7 and Table 2.8, respectively.

Table 2.6 Zivot-Andrews Unit Root Test with a single structural break

	Intercept		*Trend*		*Both*	
	K	t-statistic	K	t-statistic	K	t-statistic
LNMEI	1	-7.662***	1	-6.708***	1	-7.767***
LNMEP	2	-3.574	2	-3.302	2	-4.081

Notes:

1) Lag length is determined by using AIC and TTEST.

2) Estimation with 0.15 trimmed.

3) Significance levels: *** at 1%, ** at 5% and * at 10%.

4) K denotes the lag length.

Table 2.7 The Clemente, Montanes and Reyes Unit Root Test

	Additive Outliers			*Innovative Outliers*		
	Breaks	K	t-statistic	Breaks	K	t-statistic
LNMEI	1	0	-2.878	1	1	-2.955
	2	0	-3.861	2	0	-3.702
LNMEP	1	0	-2.674	1	6	-3.622
	2	1	-4.710	2	7	-3.529

Notes:

1) Maximum lags allowed 8.

2) Significance levels: *** at 1%, ** at 5% and * at 10%.

3) K denotes the lag length.

The results of Zivot and Andrew unit root test indicate that LNMEI is trend-stationary with a one-time break and reject the null hypothesis of unit root. But for series LNMP, we cannot reject the null of unit root. By allowing for one and two structural breaks of two forms (AO and IO), all the test statistics from Clemente, Montanes and Reyes unit root test cannot reject the null hypothesis of unit root. LNMEI and LNMEP are non-stationary which are coinciding with the finding of ADF test.

Table 2.8 The LM Unit Root Test

	Crash (Model A)			*Break (Model C)*		
	Breaks	K	t-statistic	Breaks	K	t-statistic
LNMEI	1	0	-3.3295	1	1	-3.8258
	2	0	-3.7795	2	4	-4.9543
LNMEP	1	5	-1.5235	1	5	-3.3544
	2	5	-1.7277	2	5	-5.3275

Notes:

1) Lag order is determined by using general to specific with a maximum of 5 lags allowed.
2) Critical value from Lee and Strazicich (2003, 2004).
3) Significance levels: *** at 1%, ** at 5% and * at 10%.
4) K denotes the lag length.

Finally, the LM unit root tests are adopted to test the null hypothesis of unit roots against the alternative hypothesis of stationarity. As discussed above, those tests are different with Zivot and Andrew and Clemente, Montanes and Reyes unit root test by allowing for one or two endogenous breaks under both hypotheses. The test results are presented in Table 2.9. With one or two breaks, all the test statistics are unable to reject the null hypothesis of unit root with one or two breaks which indicate that LNMEI and LNMEP both contain unit root. As discussed by Lee and Strazicich (2003, 2004), LM unit root test statistic will not spuriously reject the unit root null hypothesis. So those tests tend to provide more accurate results.

Table 2.9 The Summary of Unit Root Tests

Variables	*Without Breaks*		*With One or Two Breaks*		
	ADF	KPSS	Zivot and Andrews*	Clemente et al.*	Lee and Strazicish**
LNMEI	unit root	unit root	Stationary	unit root	unit root
LNMEP	unit root	unit root	unit root	unit root	unit root

Notes:

1) *Assume no break(s) under the unit root null hypothesis

**Assume break(s) under both the null and the alternative hypothesis

As shown in Table 2.10, it is the time to make a conclusion of our unit root tests. Using five different methodologies, we perform unit root tests for real military expenditure of India and Pakistan. Except ZA test indicates LNMEI is trend-stationary with a one-time break, all other results find the existence of unit root. Because ZA test has size distortions problem and tend to reject the null of unit root when in fact the series has a unit root with break(s). So we have strong evidence to conclude that both LNMEI and LNMEP are non-stationary I(1) series.

Furthermore, the aim of this section is to find out whether the testing series are stationary or not, which is the pre-condition for the following cointegration tests. Hence the break points in the Zivot and Andrews test, CLEM and LM tests are not reported. These break points are based on tests of the univariate models, while the break points concerned by this section should relate with both series. Rather than the univariate frameworks which have been examined above, the break point will be tested by a multivariate model in the following section. The multivariate model is based on the cointegration test with one break which is proposed by Gregory and Hansen (1996).

2.6.3 Cointegration Test

2.6.3.1 The Engel-Granger Cointegration Test

Given the above non-stationary results (two variables LNMEI and LNMEP both have unit root), we assume there exists a long run relationship (cointegration) between LNMEI and LNMEP. By OLS regression, the residuals are provided. Then it can be tested by the ADF test. The augmented lags length is chosen by information criteria as before. The ADF test results are presented in Table 2.11 and the null hypothesis of unit root is rejected. Thus, it implies that LNMEI and LNMEP are cointegrated.

Table 2. 10 The Engle-Granger Cointegration Test

	ADF test statistic	Critical Value			Conclusion
		1%	5%	10%	
Residuals	-4.136**	-4.14	-3.47	-3.14	stationary

Notes:

1) Lag order is determined by SC with a maximum of 8 lags allowed.

2) Critical values for t-test are from MacKinnon (1991).

3) Significance levels: *** at 1%, ** at 5% and * at 10%.

2.6.3.2 The Johansen Cointegration Test

Charemza and Deadman (1992) suggests that Johansen cointegration test may be used as a confirmation test of the Engle-Granger single equation test. Thus, Johansen cointegration test is also employed to confirm the Engle-Granger method.

Using AIC, SC and LR test, the information criteria indicate that a second order VAR. Given that the variables, LNMEI and LNMEP are both I(1), we could move on to test cointegration relationship between them. The Johansen cointegration test provides the results in Table 2.12. Estimating with constant and no trend in the cointegration space, the results shows that the two variables are cointegrated and a long-run relationship exists between them. But due to the existence of two cointegration equations, there is an interpretation problem of the long-run relationship. It is hard to decide which one is the proper cointegrating equation depending on the empirical results. The results are consistent with the finding of Engle-Granger test.

Table 2.11 The Johansen Cointegration Test

Hypothesized No. of CE(s)	Trace Statistic	Max-Eigen Statistic
None *	19.521(15.495)	15.513(14.265)
At most 1 *	4.008(3.841)	4.008(3.842)

Notes:

1) * denotes rejection of the hypothesis at the 0.05 level.

2) ‘CE(s)’ is the Cointegrating Equation(s).

3) 5% critical values are shown in parentheses

2.6.3.3 The Gregory and Hansen Test

By extending the conventional cointegration tests to allow for the possibilities of one structural break in the cointegration relationship, the Gregory-Hanson residual based test is postulated. The results in Table 2.13 provide the empirical evidence for the presence of a long-run relationship between LNMEI and LNMEP. In particular, the level shift model indicates that the cointegration is present with a break at 1997. Adding a trend, the model C/T indicates that the cointegration is present with a break at 1970. By taking into consideration the simultaneous presence of both a mean break and a slope break, the regime shift model indicates that the cointegration with a regime shift at 1997.

Table 2.12 The Gregory-Hansen Cointegration Test

Model	*Break Time*	*GH Test Statistic*	*1% Critical Value*
Level Shift(C)	1997	-6.496***	-5.440
Level Shift with Trend(C/T)	1970	-7.022***	-5.800
Regime Shift(C/S)	1997	-6.704***	-5.970

Notes:

1) Reported statistics are obtained using 1 lags for all tests.
2) *** indicates the rejection of the null hypothesis at 1% level.
3) Fraction of data range to skip at either end when examining possible break points [.15].

We have examined the possible cointegration between real military expenditure of India and Pakistan over the period 1960 to 2007. The empirical results are based on not only the commonly employed Engle-Granger and Johansen cointegration tests but also the Gregory and Hansen test which accounts for one endogenous structural break in the cointegration relationship. All the three tests provide evidences in favour of a long-run relationship. It can therefore be concluded that for India and Pakistan over the sample period, these two countries' real military expenditures are cointegrated and there is an arms race between them. Another finding is that the long run relationship might experience a break in 1997. Both India and Pakistan had their own nuclear tests in 1998. The preparation of nuclear tests might change the relationship between MEI and MEP and thus, a break could exist in 1997.

2.6.3.4 The Stock-Watson DOLS Test

Given the existence of a cointegration vector (with and without one structural break) and the small sample size, the Stock-Watson DOLS test is applied to estimate the long-run relationship between the real military expenditure of India and Pakistan. One lag and one lead of the first difference of the regressors are used. The likely breaks captured by the Gregory and Hansen test are adding to the regression equation by the intercept and slope dummies. The corresponding breaks are in 1970 and 1997. The regression equation could be written as:

$$\begin{aligned} lnmei_t = & \propto_0 + \propto_1 lnmep_t + \propto_2 D_1 + \propto_3 (D_2 lnmep_t) \\ & + \propto_4 \Delta lnmep_t + \propto_5 \Delta lnmep_t(-1) \\ & + \propto_6 \Delta lnmep_t(1) + \mu_t \end{aligned} \quad (2.70)$$

where $\Delta lnmep_t(-1)$ and $\Delta lnmep_t(1)$ are leads and lags of the first difference of $\Delta lnmep_t$ respectively. D_1 is the dummies for the break in the intercept which equal 0 up to 1970 and equal 1 thereafter. D_2 is the dummies for the break in the slope which equal 0 up to 1997 and equal 1 thereafter.

The results are given in Table 2.14. The t-statistics of DOLS indicate that the intercept dummies are insignificant and slope dummies are statistically significant at the 1% level. The positive coefficient of slope dummies also indicates that the shift in 1997 is an upward one. The slope coefficient measures the elasticity of real military expenditure of India with respect to real military expenditure of Pakistan. Thus, before the regime shift in 1997, real military expenditure of India would increase 0.830 percent given one percent increase in real military expenditure of Pakistan. But after 1997, the increasing percentage will change from 0.830 to 0.876. So with respect to the increase in real military expenditure of Pakistan, real military expenditure of India will increase more after 1997 comparing with the period before 1997. Even taking into account the regime shift, there exists a long-run relationship between these two countries real military expenditure which implies the existence of enduring arms race.

Table 2.13 The Stock-Watson DOLS Test

Coefficient	$\propto_1$	$\propto_2$	$\propto_3$
	0.830***	-0.090	0.046***
	(0.061)	(0.114)	(0.007)

Notes:

1) Newey-West HAC Standard Errors & Covariance are used in t-tests.

2) Significance levels: *** at 1%, ** at 5% and * at 10%.

Table 2.14 The Long-Run Relationship between *lnmei* and *lnmep*

Model	*Slope Coefficient*	
Engle-Granger	0.931	
Johansen	1.002	
Gregory-Hansen (C/S)	0.836	0.883*
Stock-Watson DOLS	0.830	0.876*

Notes:

1) Dependent variable is *lnmei.*

2) The slope coefficient measures the elasticity of *lnmei* with respect to *lnmep*.

3) * denotes the value of slope coefficient after regime shift.

In the end the long-run relationship captured by different cointegration tests can be compared and summarized in Table 2.15. All tests imply that there exists a long-run relationship between the real military expenditure of India and Pakistan. The slope coefficients are ranging from 0.830 to 1.002. Thus the increase percentages in real military expenditures of India and Pakistan are similar which are responding to each other. The tests provide robust evidences to support the conclusion that there was an enduring arms race between India and Pakistan in the period 1960-2007.

2.7 Conclusion

This chapter has surveyed the confrontation between India and Pakistan since their creation as separate countries in 1947. After more than 60 years independence, India and Pakistan have been in long-running conflict with each other. The rival relationship and the Indo-Pakistani arms race are always concerned by both defence economists and political scientists. After reviewing the literature of the theoretical arms race models and empirical studies of the arms race between India and Pakistan, the Richardson action-reaction model was employed to investigate the existence of an arms race between India and Pakistan. By reviewing India and Pakistan's conflict history and their military expenditures dynamics, it shows that these two neighbor countries represent a classic arms race and structural breaks exist for the long-term arms race relationship.

By applying VAR frameworks, empirical analyses are carried out to find out the possible long-run relationship between India and Pakistan's real military expenditure for the period 1960-2007. Due to the importance of estimation of unit root and structural breaks in time-series analysis, both traditional and recent developed approaches are employed to investigate this long-run relationship. The results of unit root tests show that both LNMEI and LNMEP are non-stationary I(1) series. The empirical results of different cointegration tests all indicate the existence of a cointegrating relationship between these two counties' real military expenditure, even after taking into account a structural break. Thus, it can be concluded that there is quite strong evidence to support the existence of an enduring arms race between India and Pakistan. Furthermore, there is a regime shift (structural break) in 1997. Compared with the period before 1997, real military expenditure of India increases by a bigger per cent after 1997, with respect to the increase in real military expenditure of Pakistan. A possible reason for that change is the preparation of nuclear tests by both countries.

Compared with the previous empirical studies reviewed in this chapter, our results were based on the analysis of India and Pakistan's conflict history and the dynamics of their military expenditures. Both conventional and advanced econometric techniques were employed which all indicated the existence of a long-run relationship between India and Pakistan's real military expenditure for the period 1960-2007. Especially, a structural break was examined and estimated in our long-run relationship analysis which shed light on the current empirical studies of India and Pakistan's arms race.

Thus, Chapter 2 provided empirical studies of the long-standing arms race between the India and Pakistan and the parameters of this relationship were identified. For example, the parameter was 0.876 after 1997 by applying the Stock-Watson DOLS method, i.e. when Pakistan's real military expenditure increases by 1 per cent, India's real military expenditure would increase by 0.876 per cent. Thus, on the one hand, it provided the evidence of the existence of the long-run arms race which these two series were responded with each other. On the other hand, compared with the amount of Pakistan's real military expenditure, India's amount was huge and about 4.6 times (average) as high as Pakistan's. So the responding increase was huge as well and when Pakistan's real military increased US$1, India's would increase US$4.03. From India's point of view, the level of Pakistan's real military expenditure was relatively small compared with her own spending. However, as shown in Table A2, Pakistan's defence burden was much higher than India's. Thus, India would concern Pakistan's defence burden which indicates the priority of Pakistan's government expenditures and provides a proxy of Pakistan's military threats faced by India.

Stylised facts and the empirical results of this chapter indicated that there is a long-standing India-Pakistan arms race. On the other hand, defence spending is also affected in by various economic and political factors. How these arms race factor, various economic and political factors are related to each other to determine India's defence spending is an obvious issue for discussion. Thus, the demand for military expenditure in India will be examined in the next chapter which will consider not only its rival-Pakistan’s military expenditure but also other related factors such as its economic and political environments.

Chapter 3 the Demand for Military Expenditure in India

3.1 Introduction

Although a number of studies have concerned the demand for military expenditure in developing countries, there are few such studies for India. The goal of this chapter is attempt to fill the gap and examines the determinants of military expenditure in India. There are several reasons which make India a valuable case for such a study. Firstly, India is strategically located in South Asia which has witnessed a high level of insecurity. It is claimed by many economists that there is an arms race between India and its neighbor-Pakistan due to the ongoing political hostility and religious differences. Our empirical analysis in chapter 2 provides a robust evidence to support the existence of the India-Pakistan arms race. But the effect of arms race on India's military expenditure is not conclusive and the natural of the determinants of military expenditure of India is not clearly investigated.

Secondly, security environments are of great concern to many. For India, since the Sino-Indian border war in 1962, India's conflicts with China have been acknowledged and as two of the largest and most powerful nations, their relationship becomes more and more important and influences the whole world's political environment. India's strategies to assert its regional power in South Asia and global power status influence its security policy and military expenditures. Thirdly, the nuclear explosions which were carried out by both India and Pakistan in 1998 have increased the uncertainty and complication of the stability in South Asia. Finally, even though India is still among the poorest countries in the world, it devotes a substantial portion of their resources for defence. In 2008, military expenditure of India was US$24,716 (SIPRI 2009: in constant 2005 prices), ranking as 10^{th} in the world.

Thus, India's military expenditure is determined not only by its rival-Pakistan's military expenditure which has been confirmed in Chapter 2 but also by other related factors such as its economic and political environments. This chapter adds to the defence economics literature by applying the autoregressive distributed lag (ARDL) approach to cointegration to investigate these determinants for military expenditure in India. The structure of this chapter is as follows. Section 3.2 provides theoretical models of the demand for military expenditure. Section 3.3 reviews the relevant empirical literature. Section 3.4 describes the brief background of military expenditure and security concerns in India. Section 3.5 provides the model specification and data description. The econometric model and the estimation method used by this study are given in section 3.6. In section 3.7, empirical results are presented for India. Section 3.8 concludes.

3.2 The Theoretical Models of the Demand for Military Expenditure

Over the years, the study of the demand for military expenditure has been carried out using a variety of different approaches. It has attempted to identify strategic, political, economic and other related factors that influence the evolution of military burden or military expenditure. Broadly, the demand models of military expenditure could be grouped into three groups: organizational politics models, arms race models and neoclassical models which are reviewed as follows.

3.2.1 Organizational Politics Models

Some models are focus on the defence budgetary process where interest groups including bureaucrats, politicians and arms industry are struggling for power and trying to optimize their separate objectives. The level of defence budget or military expenditures is the result of such struggle, competition and optimization. These models are called "organizational politics" models and are basic for the short-run determinants of military expenditure, and types and scope of weapon development (Isard and Anderton, 1988).

The simplest organizational type model is proposed by Lucier (1979). In Lucier's model, future defence budget decisions are based on small revision of past spending levels and can be written as:

$$M_t = qM_{t-1} \tag{3.1}$$

where M_t is the military expenditure at time t and q is the parameter which refers to policy-making rule. The model is focusing on the change of the parameter, q, which is based on two propositions. First, if there is a revision of the armament standard operating procedure (SOP), the value of parameter, q, will usually change in the following year. Second, if there is a deadline, a dramatic domestic or international event with manifest implications for armaments, or a replacement of decision-makers, the value of parameter, q, will change in the following year. Thus, the level of military expenditure is dependent on the past level of military expenditure and the value of parameter, q, in Lucier's model.

Majeski (1983) constructs an organizational politics model to analyze the decision-making process of the United States' military expenditure. There are four policy-making groups playing a role in deciding the level of military expenditures:

1. the Defence Services Agencies with a request for a defence budget, M_1;
2. the President, who follows with his/her request, M_2 and might focus on the next election and the expected federal deficit;

3. the Congress, which then makes an appropriation, M_3 and might focus on the electorate as well as the expected federal deficit;
4. the Department of Defence, which then spends the appropriation, M_4 and requests a supplementary appropriation when necessary.

Each group has its own set of objectives and could state its desired level of military expenditure. Thus the level of military expenditure will be determined by the interactions of those four policy-making groups.

There exist other organizational politics models which focus on different factors of the policy-making process. For example, Rattinger (1975) develops a model to examine the relationship between bureaucratic behaviours and military expenditure and investigates the effects of bureaucratic momentum and international tensions on the military expenditure. Ostrom and Marra (1986) provide a model which presents and synthesizes two distinct perspectives on the policy-making process: an organizational process and bureaucratic politics. Their model reveals the U.S. multi-step of the defence expenditure policy-making process where Soviet defence spending (new estimated) and the U.S. public opinion are the major influencing factors of U.S. defence spending.

As suggested by Isard and Anderton (1988), organizational politics models have significance for the short run, in particular for a given year or the following year's military expenditure. However, the long run is after all a sequence of the short runs and the cumulating of the factors and status of each short run can have a major influence on the long run. Thus, the short run and organizational politics cannot be ignored.

3.2.2 Arms Race Models

Another type models are based on the Richardson type arms race models which are more suitable for situations where countries are in conflicts. As reviewed in Chapter 2, in arms race type models, the level of rival country's military expenditure is the major determinant of one country military spending. The decision of military expenditure is characterized by an action-reaction process. The details were presented in chapter 2.

3.2.3 The Neoclassical Models

The neoclassical models of the demand for military expenditures focus upon military, economic and political determinants of military expenditure. The formal models which are developed from the neoclassical approaches consider the country or state as maximising a social welfare function. The framework of the neoclassical model is based on Smith (1980, 1995). In the standard neoclassical model of the demand for military expenditure, it is assumed that a country maximizes welfare, W, and W is a function of security S, economic factors such as total consumption, C, population, N and other factors, ZW:

$$W = W(S, C, N, ZW). \quad (3.2)$$

Security can be regarded as a subjective peace of mind which is based on perceptions from threats of attacks. However, security is unobservable and thus can be replaced by some set of quantifiable variables. For example, it could be produced by military expenditure of the country and other countries, conditional on the strategic variables, ZS. Thus the security function can be written as:

$$S = S(M, M_1, \dots, M_n, ZS) \quad (3.3)$$

where $M_1, \dots, M_n$ are the military expenditure of other countries which can be grouped into two types: allies and rivals. Allies' military expenditure could raise the country's security while rivals' military expenditure could pose a threat to the country's security.

The maximization is subject to the security function and a budget constraint. The simplest budget constraint is:

$$Y = p_c C + p_m M \tag{3.4}$$

where *Y* is nominal aggregate income. p_m and p_c are the prices of real military expenditure, *M* and consumption, *C*. A derived demand for the level of military expenditure can be written as:

$$M = M(p_m/p_c\,, Y, N, M_1, \dots, M_n, ZW, ZS) \tag{3.5}$$

To be more specific, we can use a simple example by ignoring N, ZW, and ZS.

As follows, some assumptions are required to estimate the model. The welfare function is given by:

$$W = \alpha \log(C) + (1-\alpha)\log(S) \tag{3.6}$$

and it is supposed that the country is not aggressive but has a rival neighbouring country which has the military expenditure, M_1. There are no allies. Hence the security function is assumed to be:

$$S = M - M^* = M - (\beta_0 + \beta_1 M_1) \tag{3.7}$$

where M^* is the level of military forces or expenditure the country requires to resist its rival neighbour's attack. M^* is determined by two factors: one factor is denoted by β_0 which is the fixed element and unrelated to the rival's military forces or expenditure. For example, β_0 would be negative if the rival's defence strategies are natural, but β_0 would be positive if the neighbour country could gain an advantage from a surprise attack. Another factor is denoted by $\beta_1 M_1$, the size of the rival' military forces or expenditure with β_1 where β_1 is the relative effectiveness of M_1.

The Lagrangean subject to the above budget constraint is then given by:

$$L = \alpha \log(C) + (1-\alpha)\log(M - M^*) + \lambda(Y - p_c C - p_m M) \qquad (3.8)$$

The first order conditions are:

$$\frac{\partial L}{\partial C} = \frac{\alpha}{C} - \lambda p_c = 0; i.e. C = \frac{\alpha}{\lambda p_c}, \qquad (3.9)$$

$$\frac{\partial L}{\partial M} = \frac{1-\alpha}{M - M^*} - \lambda p_m = 0; i.e. M = \frac{1-\alpha}{\lambda p_m} + M^*, \qquad (3.10)$$

$$\frac{\partial L}{\partial \lambda} = Y - p_c C - p_m M = 0. \qquad (3.11)$$

Then we get:

$$Y - p_c \frac{\alpha}{\lambda p_c} - p_m(\frac{1-\alpha}{\lambda p_m} + M^*) = 0$$

Thus the Lagrange multiplier can be eliminated by using

$$\frac{1}{\lambda} = Y - p_m M^* \qquad (3.12)$$

We get two linear demand equations:

$$M = \frac{1-\alpha}{\lambda p_m} Y + \alpha(\beta_0 + \beta_1 M_1), \qquad (3.13)$$

$$C = \frac{\alpha}{p_c}[Y - p_m(\beta_0 + \beta_1 M_1)]. \qquad (3.14)$$

In these two demand equations, real consumption and military expenditure are a function of income (Y), relative prices (p_c, p_m), preference parameters (α), strategic parameters (β_0, β_1) and the rival country's military expenditure.

Furthermore, Smith (1995) provides a range of theoretical considerations. For example, security might depend on stocks of military forces rather than flows of military spending and thus dynamics could be introduced into the demand model. Bureaucratic and political factors such as governmental choice, public opinion and incrementalism can also influence the decision of the level of military expenditures. The budget constraint, the welfare and security functions have different forms. For example, Smith (1980) uses a constant elasticity of substitution welfare function and a Cobb-Douglas security function.

Hence, the neoclassical models of demand for military expenditure can incorporate quite complex considerations including not only income, prices, preferences and other country's strategy and military expenditure but also other related bureaucratic, political and strategic factors. On the other hand, the bureaucratic and politics models narrowly focus on bureaucratic and politics environments while arms race models only focus on the rival's military forces or expenditure. It can be suggested that the neoclassical models provide a relatively comprehensive approach to investigate the demand for military expenditure in a country and get more satisfactory empirical results which are presented in the following review of the empirical literature.

3.3 Review of Empirical Literature

Many researchers have studied the demand for military expenditure in developing countries. Some studies are based on cross-country regression models; others provide time-series individual case studies. Broadly the factors that determine the military expenditure in developing countries can be grouped into the following categories: military activities, economic and geo-strategic factors, the political environment and other related factors such as the lagged military expenditure and population. Table 3.1 gives a summary of the determining factors from the selected literature reviewed in this chapter. In this section, we review the empirical literature on the demand for military expenditure in developing countries following the above categories.

3.3.1 Military Activity (Security Considerations)

Military expenditure is chosen by governments in the light of a multitude of specific circumstances and influences. The most important output of military expenditure is national security. Under these considerations, the governments will focus on military activity and make perceptions of threats. In general, these considerations of military activities include external wars, civil wars, security web and related country's military activities.

External wars (inter-state war) will affect governments' ability to secure land, economic returns and property rights. Many studies find that external wars result in increased military expenditure. Furthermore, if a country experiences external war, it will not only be responding to the threat of the other country's military force, but will need to replenish stocks of arms and ammunitions used up in the fighting (Dunne and Perlo-Freeman, 2003a).

Hewitt (1996) investigates the determinants of military expenditures in 125 countries for the period 1972-1990. For developing countries, the empirical results indicate that the impact of international war on military burden is significant and positive. Security improvements are likely playing a role for decreased military expenditure by countries at war. Batchelor, *et al.* (2002) provide an analysis of the demand for military expenditure in South Africa during 1963-1997. The dummy for involvement in Angolan War (1977-1993) has a significant and positive effect on South Africa's military burden. Dunne and Perlo-Freeman (2003a and 2003b) estimate the demand functions for developing countries during the Cold War (1981-89) and Post Cold War period (1990-1997). The empirical results of static and dynamic panel models reveal a posive effect from external wars on the military burden. Tambudzai (2005) empirically tests the effect of external wars on Zimbabwe's military expenditure from 1980-2003. Zimbabwe has external wars with Mozambican between 1983 and 1993 and with the Democratic Republic of Congo from 1998 to 2002. These external wars had a significant and positive effect on its military expenditure in the long run.

Civil wars often have significant security implications in developing countries. Ball (1988) argues threats to internal security outweigh external security considerations for developing countries. The main task of defence forces is to protect the regime in power against its citizens. Both civilian and military governments make use of military expenditure budgets in order to placate the armed forces. Dunne and Mohammed (1995) examine military spending in 13 Sub-Saharan African countries during the period 1967-1985 and they find a significant and positive effect of civil war dummies on the military burden. Collier and

Hoeffler (2002) measure internal threats by estimating the probability of a civil war breaking out. The variable has a more significant effect on military expenditure than international wars in developing countries between 1960 and 1999. Dunne and Perlo-Freeman (2003a) suggest that the effects of civil war on military spending are of comparable magnitude. Collier *et al* (2003) find out that in peacetime, the average developing country allocates 2.8 percent of GDP to military spending, while during civil war, this average rises to 5 percent.

Rosh (1988) introduces a broader conception of the security issues facing a country, called the 'security web'. Rosh defines country X's security web to be all other countries capable of significantly affecting country X's security. This includes neighbouring countries and regional powers capable of projecting their influence beyond their immediate land and sea borders. To measure the level of threat a country faces, Rosh uses the average military burden (military expenditure/GDP) of countries in the security web. In his study for military expenditure in 63 LDCs during 1969-78, security web variables play an important role to determine the third world's military burden.

Dunne and Perlo Freeman (2003a, 2003b) and Dunne, Perlo Freeman and Smith (2008) use security web variables in their recent studies to estimate demand functions for developing countries for the period 1981-97. Furthermore, they divide the countries in a country's security web in to Enemies, Potential Enemies and others. The effects of military expenditure by allies, enemies and neutral countries are distinguished. Great power enemy is also included to take account of countries' relations with superpowers. In their studies, enemies and potential enemies' military burden influence the country's military burden in most cases while the empirical results for security web variables are mixed and the results for Great power enemies variables are generally insignificant. Other studies also show the significant and positive effect of enemies' military burden or expenditure on the country's military spending. For instance, Sun and Yu (1999) find Japanese military expenditure influenced Chinese military expenditure positively for the period 1965-93. Tambudzai (2005) reveals that South African military expenditure has a significant and positive impact on Zimbabwe's military expenditure during 1980-2003.

3.3.2 Internal and External Economic Factors

There are a number of economic influences to be considered. The overall economic environment may pose a constraint on military burden over time. Looney (1989) suggests that at the national level, economic factors such as the level of economic development (urbanization and inequalities in wealth and income), real income growth, the size of the budget, and the influence of the military-industrial complex are considered important determinants of military expenditure. In a general way, national income can be viewed as the most important determinant of the level of military expenditure. Many studies have used per capita income and real income/ GDP or GNP to capture income constraints on military expenditure. There exist other internal economic constraints to military expenditure (e.g. central government expenditure or non-defence government expenditure: opportunity cost of defence) and arms industry.

In the empirical analysis of military expenditure in developing countries during 1972-1990, Hewitt (1996) suggests that GDP level will clearly affect the level of military burden. However, the relationship might be convex, the estimated coefficient on log of GDP is negative and the estimated coefficient on log of GDP squared is positive. Tambudzai (2007) investigates the military burden determinants in 12 Southern African countries during 1997-2004. His cross-sectional and panel results both confirm the importance of GDP per capita in the determination of the level of military burden in South Africa.

In the studies of single country's demand for military expenditures, income variables tend to have significant and positive effects on military expenditure. For example, Batchelor, *et al*. (2002) provides an investigation of the demand for military spending in South Africa for the period 1963-97. Their empirical results give the evidence to support the important role of income in determining military burden. Sun and Yu (1999) also find that China's military expenditure is positively related to its GNP. In the empirical study of Taiwan's military spending, Yu (2002) shows the significant and positive impact of Taiwan's GNP on its military expenditure during the period 1966-1992.

Central government expenditure provides the size of state budget for determination of military spending. Dommen and Maizels (1988) use the ratio of central government expenditure to GDP as one factor of internal economic linkages. For 72 LDCs, 1978-1980, their cross-sectional analysis shows that the estimated coefficient of the ratio of central government expenditure to GDP is significant and positive. Furthermore, they also estimate the effect of non-defence government expenditure on the military burden. However, the estimated coefficient is insignificant. Hewitt (1996)'s finding for determinants of military burden in developing countries provides similar results for the positive effect of the ratio of central government expenditure to GDP on the level of military burden. Yildirim and Sezgin (2005) estimate the effect of the government consumption on military burden by using panel data techniques for 92 countries during 1987-1997. Their empirical results also reveal that central government expenditure has a significant and positive impact on military burden. Those empirical results show that defence spending or military burden is generally positively related with central government expenditure.

Deger and Sen (1990) investigate the military expenditure process of India during 1960-85. Because India has possible the largest arms industry among LDCs, the arms production variable is included in the demand function of military expenditure. However, their empirical results show that the estimated coefficient of arms production is insignificant.

At the global level, Maizels and Nissanke (1986) consider the growth of foreign exchange, the influence of foreign capital and major aid donors to be important determinants of military spending. Dommen and Maizels (1988) find the growth of foreign exchange (positively) and the foreign investor concentrations (negatively) are very significant for the Asian region. In addition, foreign arms production is a positive determinant of military expenditure and superpowers influence non-arms producing countries in terms of their purchases. Arms suppliers can influence governments to purchase military weapons well in excess of need.

Rosh (1988) hypothesize that countries that are highly integrated in the global economy would find it easier to access finance for arms purchases, leading to a higher military expenditure. His empirical results prove the hypothesis that trade has a significant and positive effect on military burden for developing countries. Dunne and Perlo Freeman

(2003b) and Dunne, Perlo Freeman and Smith (2008) use a total trade variable, imports plus exports, to capture this effect. They also find a significant and positive trade effect on military burden in developing countries during 1981-97. However, Dunne and Mohammed (1995) show that the trade effect on military burden in Sub-Saharan Africa for 1967-85 is statistically insignificant.

3.3.3 Political Factors

Some studies find that political factors such as regime type (democracy, dictatorship, military rule, etc) and political changes should be incorporated into the demand function of military spending in developing countries. It is widely found that democratic countries spend less on the military than non-democracies. Autocratic states are more likely to rely, at least partly, on the military to retain their grip on power, along with a culture and ideology of militarism to justify their rule.

Dommen and Maizels (1988) examine determinants of military burden in 72 LDCs during 1978-80. They find that of the 72 sample countries, nearly two-thirds have military governments which included two-fifths officially use violence against the public frequently. The empirical results of their cross sectional estimations provide the evidence for the role of military government in determining the level of military spending. Hewitt (1996) also shows the significant and positive effect of military governments on military burden in developing countries during 1972-90.

On the other hand, democratic countries are generally governed by the rule of law where the allocation decisions of military spending are debated openly by elected representatives and more constrained by competing demand of alternative priorities. Thus, the coefficient of democracy variable is expected to have a negative sign in demand functions of military expenditure. Dunne and Perlo Freeman (2003a, 2003b and 2007) examine the demand for military spending in developing countries for the period 1981-97 by using different econometric methodologies. The democracy data from the POLITY98 database are used to reflect the degree of democracy in a country. Their empirical results show that the democracy variable has a significant and negative effect on military burden in developing countries.

Political changes and political shocks influence the level of military expenditures in some countries. For example, Sun and Yu (1999) illustrate the effect of the political change in China where the Chinese leadership's top priority changed from war preparing to economic development after 1979. The empirical analysis shows that the change has a negative impact on the level of Chinese military expenditure during the period 1965-93. In the study of military spending demand in South Africa during 1963-97, Batchelor, *et al.* (2002) use a political dummy to reflect the regime change from 1994 to 1997 when the new South African government stated the commitment to development and prioritized social spending. The time-series results indicate that the political dummy is negatively related with the level of military spending in South Africa. Yu (2002) provides an interesting analysis of Taiwan's military expenditure. The volatility in US-China conflict relationship and major political shocks during 1966-92 are incorporated into the demand function of Taiwan's military expenditure. The empirical finding shows that both the volatility and political shocks influence the level of military expenditure in Taiwan.

3.3.4 Other Considerations

Population can be included into the demand function to capture possible size effects. It may be seen as giving some intrinsic security, reducing the need for military expenditure, or may reduce costs by allowing reliance on a large army rather than hi-technology equipments. On the other hand, 'public good' theory would suggest that a large population makes military expenditure more effective, as it benefits a large number of people as a 'pure public good' (Dunne and Perlo-Freeman, 2003a).

Hewitt (1996) estimates the population effect on military burden in the demand function for developing countries and the estimated coefficient on population is found to be significant and positive. He provides the possible explanations for the positive effect: a larger population can enable a country to have a large army and thus enhance a country's military potential. Unlike the study of Hewitt (1996), Dunne and Perlo Freeman (2003a, 2003b) and Dunne, Perlo Freeman and Smith (2008) all find that population has a negative and significant impact on military burden. They suggest that large population can be considered to provide autonomous security in itself. For small countries, they cannot rely on a large army and thus have to spend more on high technology armaments. Another possible explanation is that larger populations need greater extra civilian consumption demand than security need.

Some studies add military participation ratio variable into the demand function which is expected to be positively related with external threats. Weede (1986) shows that South Korea has very high military participation ratio which is more than four times as high as Brazilian one and reflects the seriousness of external threats during the 1970s. Looney

(1989) examines the effect of military participation ratio-armed forces per 1000 population on Third world military expenditures during 1970-82 and the effect is found to be significant and positive. Dunne and Mohammed (1995) use the proportion of armed forces in the population to estimate the effect of military participation ratio on military burden in 13 Sub-Saharan African countries for 1967-85 and confirm the positive impact from the effect of military participation ratio to military burden. Similarly, Yildirim and Sezgin (2005) provide an empirical analysis based on the data for 92 countries during 1987-97 and their panel estimating results suggest that higher ratio of armed forces per 1000 population is associated with higher levels of military expenditure.

Last year's military spending or military burden is one of the best pointers of current military spending. To capture the concept of inertia, many econometric studies have included a lagged military expenditure variable among the explanatory variables. Dunne and Mohammed (1995) find that among the determinants of military burden in Sub-Saharan African countries during 1967-85, the dominant effect is the lagged dependent variable-military burden which reflects the inertia or hangover in military expenditure. Sun and Yu (1999) also show the highly significant and positive effect of the lagged Chinese military expenditure in determining China's military expenditure for 1965-93. Batchelor, *et al.* (2002)'s study of the demand for military spending in South Africa illustrate the similar inertia in South African military spending for the period 1963-97.

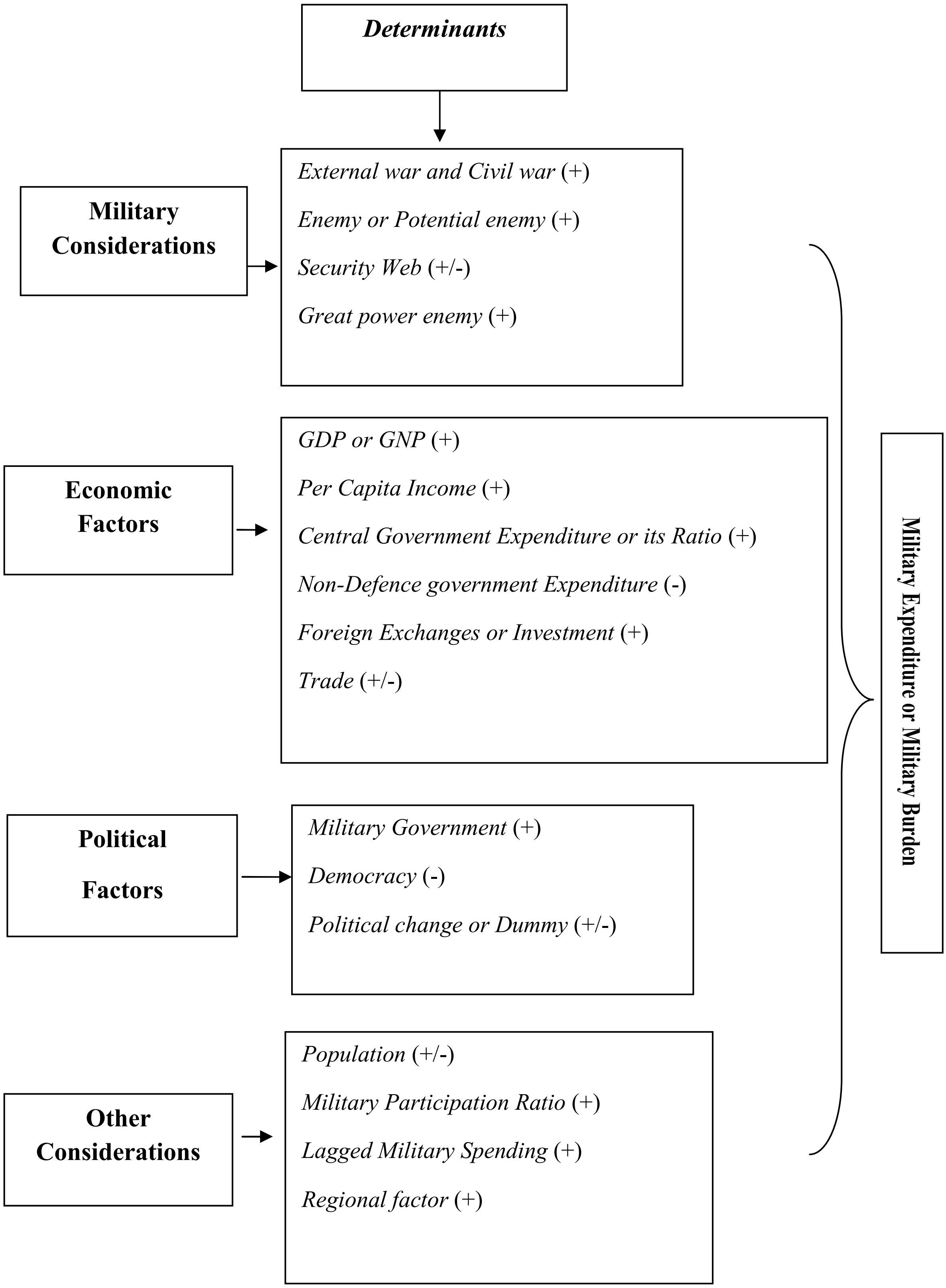
In some cross-sectional and panel studies, regional factor is included for Middle East countries to allow for the 'bad neighbourhood' or 'contagion' effect. For example, Dommen and Maizels (1988) and Dunne and Perlo-Freeman (2003a) estimate the regional factor of Middle East by adding Middle East dummy to the determinants of military spending in developing countries. Both studies reveal highly significant estimated coefficients on the Middle East dummies which reflect a strong ‘contagion’ effect for all countries in this region with various conflicts.

Insofar, empirical literature of the demand for military expenditure in developing countries has been reviewed and different determinants factors are described in Table 3.1. Figure 3.1 provides a summary of main determinants and their expected sign in demand functions of military spending.

Table 3.1 Determinants of Military Expenditure in Developing Countries

Authors	Model	Country	Determinants Factors																			R-sq
			Military					***Economics***							***Political***			***Others***				R-sq
			External War	Civil War	Enemy (or potential)	Security Web	Great power enemy	GDP or GNP	Growth Rate	Per capita income	Foreign exchange or investment	Trade	CGE or CGE ratio	Non-defence GE	Democracy	Military government	Political dummy	Population	Lag Milex	military participation	Regional factor	
1. Rosh 1988	Pooled time series models	63 LDCs 1969-78			0.28	0.47						0.002			-0.006						n.s.	0.6
2.Dommen and Maizels 1988	Cross section regression	72 LDCs 1978-80		1.74							2.4		0.17	n.s.		0.66		n.s.			3.33	0.67
3.Dunne and Mohanmmed 1995	Pooled method	Sub-Saharan Africa 1967-85		0.3						-0.29		n.s.	n.s.		n.s.	n.s.			0.6	0.1		0.91
4.Hewitt 1996	TSLS	125 countries 1972-90	1.3	1.13				-0.59			0.88		0.7			0.6		0.14				0.76
5.Sun and Yu 1999	Time series OLS	China 1965-93			0.45			0.11									-0.1		0.41			0.88
6.Batchelor et al 2002	Time series OLS	South Africa 1963-97	0.17			n.s.		1.07							-0.24		0.26		0.71			0.91
7.Yu 2002	Time series ECM	Taiwan 1966-92					1.46	0.003			93.1											0.94
8. Dunne and Perlo-Freeman 2003a	Cross section regression	LDCs																				
		1981-88	0.58	0.09	0.08	0.06	n.s.	n.s.							-0.03			-0.2			0.7	0.66
		1990-97	n.s.	0.26	0.05	0.05	n.s.	n.s.							-0.04			-0.1			0.46	0.61
9. Dunne and Perlo-Freeman 2003b	Dynamic panel analysis	LDCS																				
		1981-89	n.s.	-0.03	0.02	n.s.	n.s.	-0.17				n.s.			n.s.			n.s.				
		1990-97	0.58	0.11	n.s.	n.s.	1.04	n.s.				0.16			-0.01			-1				
10. Tambudzai 2005	Time series ARDL	Zimbabwe 1980-2003	0.14		0.96	-0.38		n.s.											n.s.			0.62
11. Tambudzai 2007	Cross section& panel analysis	Southern Africa 1996-2005	0.36							0.018			n.s.		n.s.				0.44			0.99
12. Dunne et al. 2008	Dynamic panel analysis	LDCs 1981-97	0.57	0.11	0.04.	-0.03	0.16	-0.14				0.09			-0.014			-0.2				0.24

Figure 3.1 the Summary of Determinants of Military Expenditure in Developing Countries



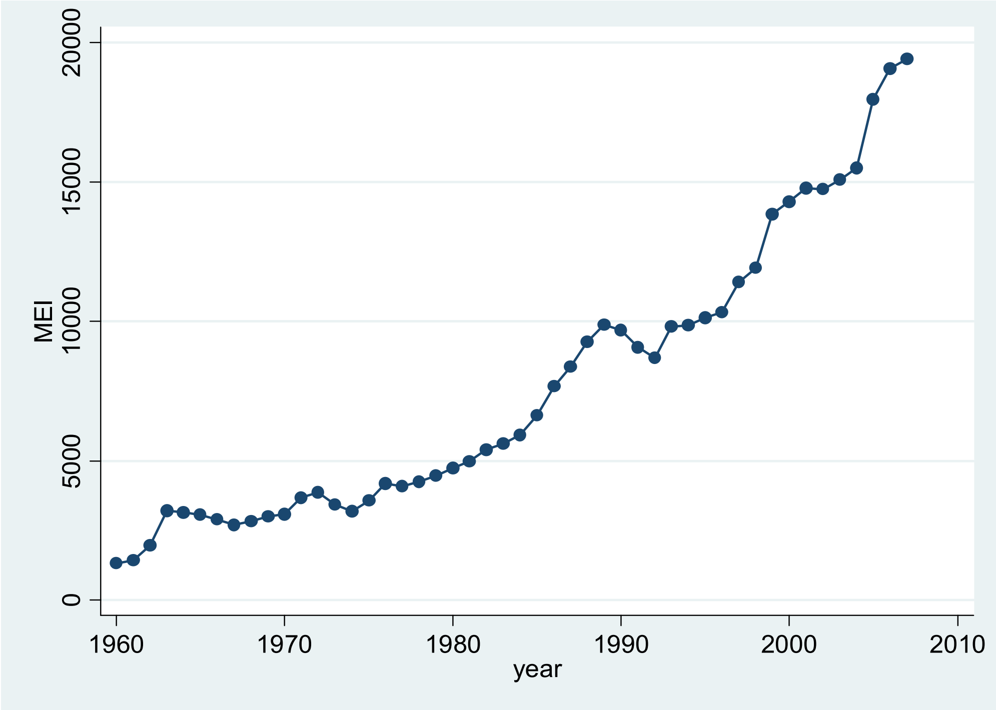
3. 4 India's Military Expenditure and Security Concerns

3.4.1 India's Military Expenditure and Its Trend

India is one of the largest and most powerful countries, with over one billion people and has one of the largest militaries in the world. In 2008, the military expenditure of India reached US$24,716 (SIPRI 2009: in constant 2005 prices), ranking as 10th in the world. In term of PPP dollar, it has the fourth largest military expenditure and is only after USA, China and Russia (SIPRI 2009, p183). As one of the world's emerging economic powers, India demonstrated a sustained increase in military expenditure and contributed to the growth in world military spending in the recent years.

As can be seen from Figure 3.2, India's real military expenditure (MEI) has been increasing for the period 1960-2007. It illustrates that India's military expenditure is keeping increasing over years. The real MEI increased from US$1321.8 millions in 1960 to US$ 19407.9 million in 2007 and the amount of military expenditure increased more than 13 times from 1960 to 2007. Furthermore, the speed of increase was not stable and there existed some periods with big increases in the level of real military expenditure.

Figure 3.2 India's Military expenditure, MEI (Constant 2000 Millions US$), 1960-2007



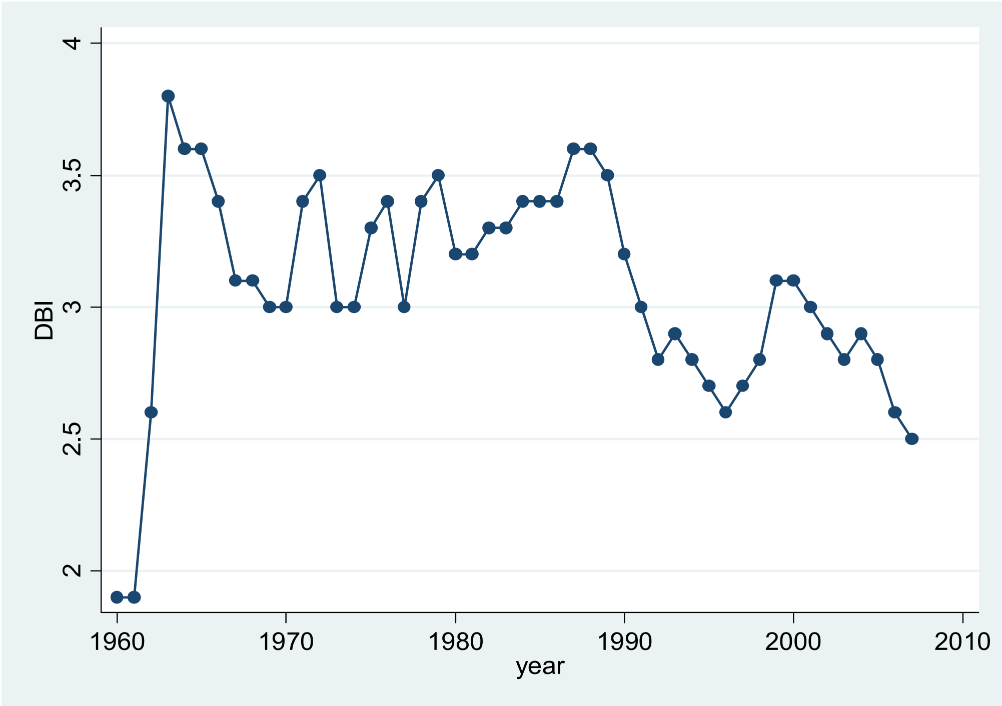
Data sources: SIPRI yearbooks

As shown in Figure 3.2, the top three biggest jumps in military expenditures are as follows.

1. The real MEI increased from US$1426.4 million in 1961 to US$1960.4 million in 1962 where the rate of increase is 37.4 per cent.
2. The real MEI increased from US$ 3076.9 million in 1970 to US$3668.7 million in 1971 where the rate of increase is 19.2 per cent.
3. Then the real MEI increased from US$11918.6 million in 1998 to US$13840.2 million in 1999 where the rate of increase is 16.1 per cent.

The three jumps in the level of military expenditures are corresponding to India's s external wars with China in 1962 and with Pakistan in 1971 and 1999.

Figure 3.3 Defence Burdens of India (DBI), 1960-2007

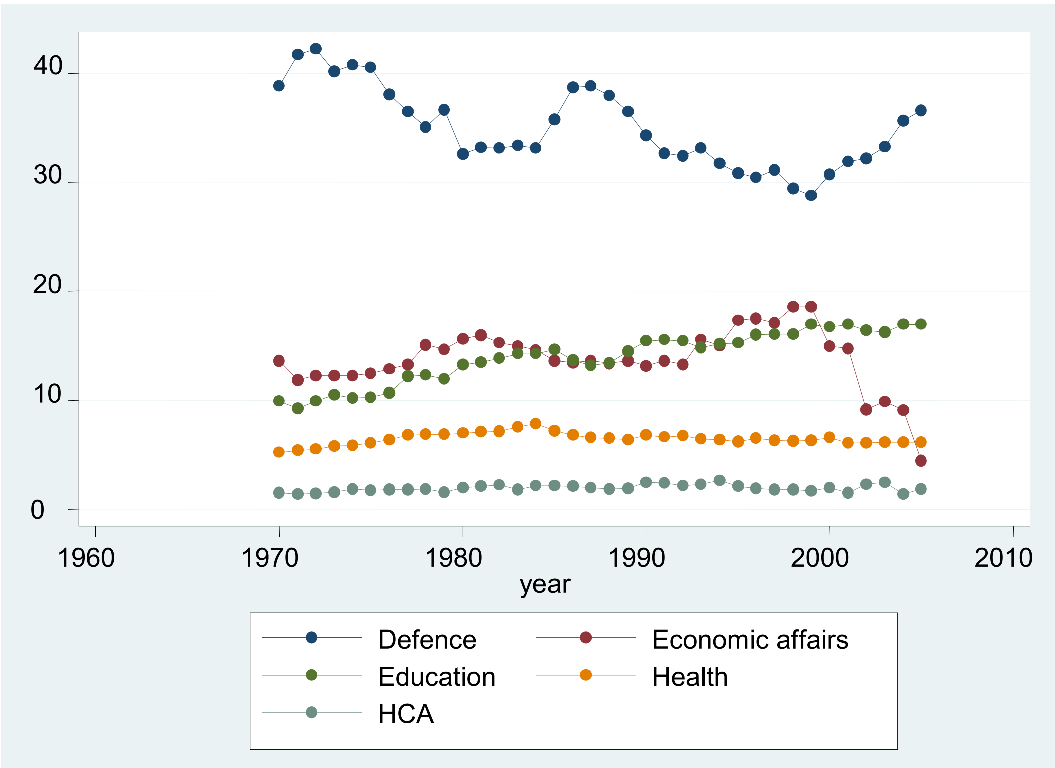


Data sources: SIPRI Yearbooks

The trend of India's defence burden (DBI: military expenditure as a proportion of GDP) is shown in Figure 3.3. The range of DBI is from 1.9 per cent to 3.9 per cent. The lowest point was at the start of 1960s and before the Indo-China war in 1962. The highest point was in 1963 which was just after the Indo-China war. Thus, in the wake of the war with China in 1962, the defence burden of India rose from 1.9 percent of the gross domestic product in 1961 to 2.6 per cent in 1962 and then to 3.8 in 1963. In the period 1963-1971, there was a decline in the burden; but the decline ended in 1971 due to the war with Pakistan in the year. The defence burden rebounded from 3 per cent in 1970 to 3.4 percent in 1971. Except slightly declining after the war, defence burden kept growing steadily to the start of 1990s. During the period 1991-97, the level of defence burden in India was under 3 per cent. Then the burden rose again in 1998 with the nuclear test and went back to above 3 per cent in 1999 due to the Kargil conflict. In the 21st century, Indian military expenditure has generally fluctuated around 2.8 percent of GDP.

The share of military expenditure to the total central government expenditure (CGE) is also an important indicator to understand the pattern of India's military spending. Figure 3.4 and Table 3.2 give time-series data for India's central government expenditure shares by function which include the expenditure on defence, economic affairs, health, education and housing and community amenities (HCA). For India, the biggest share of CGE went to defence sector. During the period 1970-2005, the defence share was almost always over 30 per cent of CGE. The average share of 1971-75 was even as high as 41.08 per cent. In 1990s, the defence share slightly declined but since 2000, it has increased again.

Figure 3.4 India's Central Government Expenditure Share by Function, 1970-2005



Data sources: United Nations Statistics Division

Table 3.2 India's Central Government Expenditure Share by Function, 1970-2005

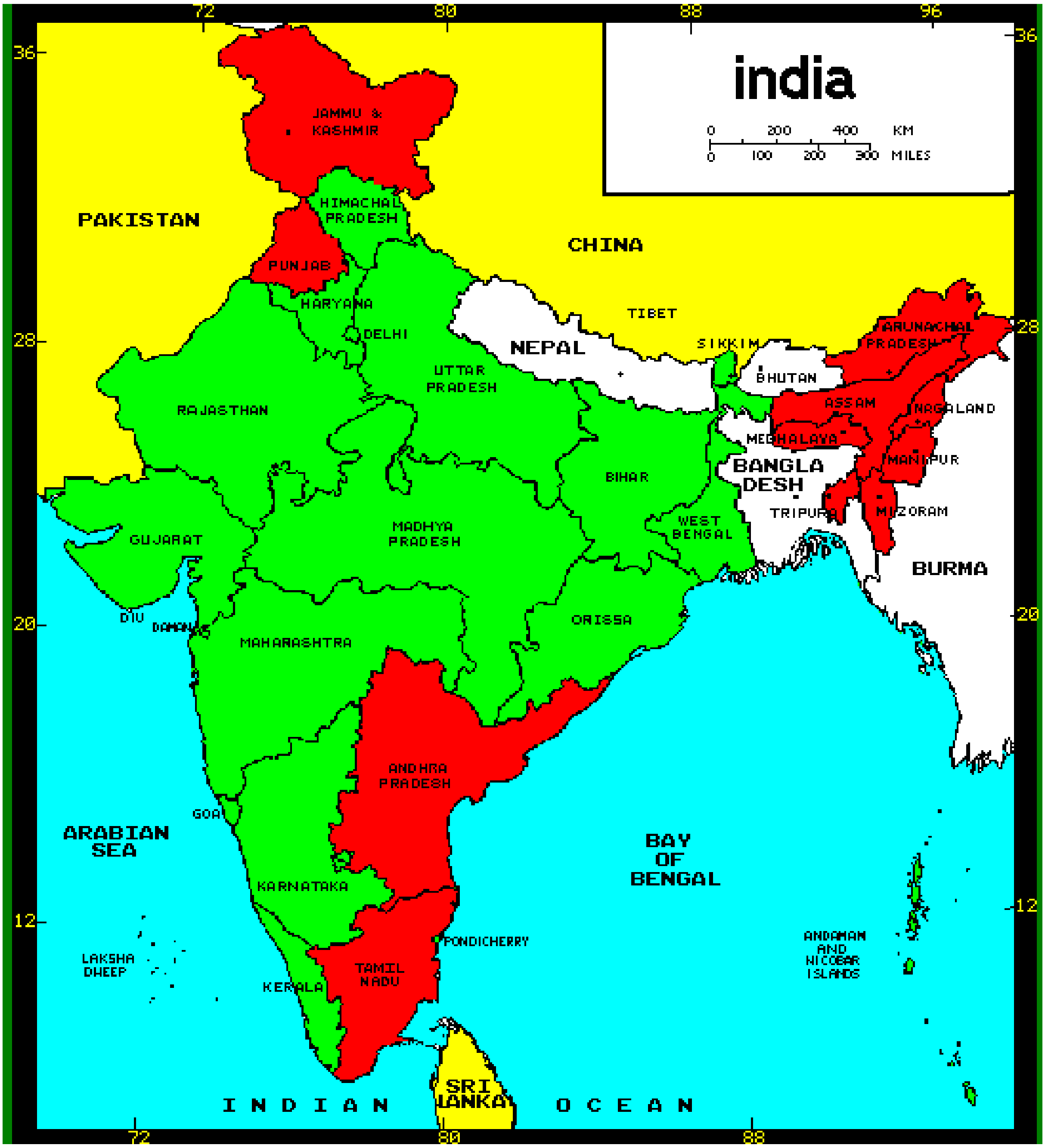
(Five-year Average % of total CGE)

Year	*Defence*	*Economic affairs*	*Education*	*Health*	*Housing and community amenities*
1971-1975	41.08	12.22	10.05	5.76	1.63
1976-1980	35.76	14.31	12.10	6.79	1.84
1981-1985	33.72	14.90	14.14	7.39	2.10
1986-1990	37.26	13.46	14.06	6.63	2.08
1991-1995	32.16	14.98	15.29	6.48	2.33
1996-2000	30.11	17.32	16.39	6.41	1.85
2001-2005	33.90	9.45	16.72	6.14	1.91

Data sources: United Nations Statistics Division

Comparing with the big defence share in CGE and its increasing trend in recent years, other forms of central government expenditure showed different status. Education share increased from about 10 per cent in the 1970s to over 16 per cent in recent years. However, health and housing and community amenities shares remained at a low level and even declined recently. The share of economic affairs had an increasing trend till 2000 and after that, it also declined. Thus, the large defence share in CGE indicates the priority of India's government. Although India focuses on social-economic developments, it remains committed to peace and security which are seen to be fundamental for continued economic development and prosperity of Indian people. The high growth of GDP in India might boost the speed of increases in military expenditure, but limited expenditure on economic affairs, education, health and other related social and economic activities might be detrimental to economic growth.

Figure 3.5 the Map of India's Security Threats, 2009



Source: India Security Threat Environment

http://www.fas.org/irp/world/india/threat/, Accessed 08/2009

Note: internal security threats mainly exist in the red coloured areas and external security threats mainly exist in the yellow coloured areas.

3.4.2 India's Security Concerns

Even though India keeps the developing country status and is one of the poorest countries in the world based on GDP per capita PPP, it still devotes a substantial portion of its resources for defence. India's strategic location and its violent history of external and internal conflicts have a crucial impact on its believing that an assured level of regional stability is necessary for socio-economic development. Hence, security concerns of India which could be divided into external and internal security problems are crucial determining factors of its military expenditures. Figure 3.5 presents the map of security threats faced by India in 2009.

3.4.2.1 Internal Security Threats

Internally, India faces violent secessionist movements and communal rioting problems which have become perennial since independence. The existence of fissures and divisions in caste, ethnicity, culture, language, religion and economic disparity are challenges for India's internal security and influence its pattern of military expenditure. In general, the internal security threats mainly exist in the red coloured areas shown in Figure 3.5 and can be grouped as follows.

- **The North-East**

There are seven states in the North-East of India including Assam, Meghalaya, Tripura, Arunachal Pradesh, Mizoram, Manipur, and Nagaland. They are linked to the rest of India only by a narrow strip of land known as the Siliguri Corridor and many of those states are notably ethnically and linguistically different from the rest of the country. Since independence, complex patterns of violence existed and continued in the region. Many different insurgent groups operate in different states and for different objectives. Some call for secession from the India Union, some others seek separate states and others demand greater autonomy within the existing state.

For example, the United Liberation Front of Assam (ULFA)[8] seeks to establish a sovereign state of Assam and the Bodo Security Force[9] aims to create an autonomous region Bodoland. Those insurgencies have taken a heavy toll in Assam and caused the installation of a "Unified Command" counter insurgency system which combines civilian, military and paramilitary forces in the state. Other main insurgent groups in the region include two factions of the National Socialist Council of Nagaland (NSCN)[10] in Nagaland,

Meitei extremists[11] in Manipur, the all Tripura Tiger Force (ATTF) and the National Liberation Front of Tripura (NLFT)[12] in Tripura, Bru National Liberation Front (BNLF)[13]

---

[8] The United Liberation Front of Assam was formed in April 1979 to establish a sovereign state of Assam through an armed struggle. In recent times the organization has lost out its middle rung leaders after most of them surrendered to the Indian forces.

[9] The National Democratic Front of Bodoland was formed in 1989 as the Bodo Security Force, aims to set up an autonomous region Bodoland.

[10] The National Socialist Council of Nagaland was formed in 1980 to establish a Greater Nagaland, encompassing parts of Manipur, Nagaland, the north Cachar hills (Assam). The NSCN split in 1988 to form two groups namely NSCN (IM) & NSCN (K). As of now, both the groups are in ceasefire with the Indian government. However, they continue to be actively involved in illegal activities including extortion, kidnapping, inter-factional clashes, bootlegging and recruitment.

[11] Meitei extremists in Manipur, similarly, are organised in over half a dozen groups, the prominent ones being United National Liberation Front (UNLF), People’s Liberation Army (PLA) and People’s Revolutionary Party of Kangleipak (PREPAK), each with their own patrons demanding a separate and independent homeland.

[12] The insurgent groups in Tripura were emerged in the end of the 1970s, as ethnic tensions between the Bengali immigrants and the tribal native population. The All Tripura Tiger Force was formed in 1990 with the sole aim of the expulsion of all Bengali speaking immigrants and the National Liberation Front of Tripura was formed in March 1989.

[13] The Bru National Liberation Front was formed in 1997 to protect the rights and dignity of the Reangs. The BNLF have surrendered with 757 of their comrades to the Mizoram Government on October 21, 2006.

in Mizoram and Achik National Volunteer Council (ANVC), and Hynniewtrep National Liberation Council (HNLC)[14] in Meghalaya. Furthermore, there also exist conflicts among different states and among different tribal or non-tribal people within a state in the region. For instance, there are existing territorial disputes between Manipur and Nagaland.

The India's North-East has witnessed sustained separatist insurgencies, mass agitations and ethnic riots. Regional development has been limited and the economic disparity has worsened. On the one hand, economic disparity and endemic poverty are among the most important factors that cause violence in those states. On the other hand, the violent political environments hamper economic development. The existence of that vicious circle might make regional security and development more complicated and difficult which influence the pattern of government's military expenditure.

- **Naxalite Insurgencies**

There are many Maoist groups in India, especially in the region of West Bengal and Andhra Pradesh. Since the end of 1960s, Maoist groups have already advocated poor peasantry revolt against the caste system and oppression by the landlord class. In the late of 2004, the Communist Party of India (Maoist) becomes the largest Maoist rebel group in India by merging the Peoples' War Group (PWG) and the Maoists Communist Centre (MCC). Their fighting has spread to most of rural India across ten states and are especially concentrated in the areas of Chhattisgarh, Orissa, Andhra Pradesh, Maharashtra, Jharkhand, Bihar, Uttar Pradesh, and West Bengal. Members of the Communist Party of India and

---

[14] The Achik National Volunteer Council was formed in 1995 with the intentions of forming an Achik Land in the Garo Hills and The Hynniewtrep National Liberation Council aims to free the state from Garo domination and was formed in 1992.

other smaller Maoist groups are called informally "Naxalites" after the Indian town of Naxalbari and insurgencies conducted by them are called the Naxalite-Maoist insurgency.

The violence and insurgencies of Naxalites pose a major challenge to India's internal security. In 1980, the Naxalite-Maoist insurgency began guerrilla-style attacks on police and the police responded with executions of suspected Naxalites in "encounter" killings. The clashes between Naxalite-Maoist and police led to hundred of killings and serious human rights abuses by both sides. According to Armed Conflict Report 2009 by Ploughshares[15], more than 6,000 people have been killed directly by the conflicts in the last twenty years. The number of deaths for the period 1996-2007 are presented in Table 3.3.

The roots of those conflicts are primarily economic such as wealth inequality and limited development. Furthermore, due to the areas which are most affected by the Naxalite violence having 85% of India's coal reserves, conflicts over resources are growing and almost half of India's total energy supply is under serious political risks. Those insecurity statuses might cause changes in India's military expenditures. The growing influence of Naxalism insurgencies on India's politics, security and economy promotes the government of India to treat them as the most serious threat to India's national security. In February 2009, India central government announced a long-haul strategy that would involve simultaneous, co-ordinated counter-operations in all Left-wing extremism-hit states to plug all possible escape routes of Naxalites.

[15] "Armed Conflicts Report - India-Andhra Pradesh". Ploughshares http://www.ploughshares.ca/libraries/ACRText/ACR-IndiaAP.html. Accessed in 08/2009.

Table 3.3 Deaths related to Naxalite-Maoist Insurgency, 1997-2007

Year	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Deaths	350+	300+	350+	50+	100	140	500	500+	892	749	650

Data sources: Armed Conflict Report 2009

- **Trans-Border Security Threats: Jammu and Kashmir**

The last group of internal security threats is the insurgencies in Jammu and Kashmir (J&K), the north-westernmost region of India where India shares the border with Pakistan and China. The J&K problem has been with India since independence in 1947. According to the Independence Act, states in this region could choose to join India or Pakistan by holding a plebiscite. However, the plebiscite was never held and India would like to regard Kashmir as an integral part of India. While Pakistan insists that Kashmir is a disputed territory and the final status should be settled by the willingness of Kashmiri. Both countries reject Kashmir's independence but some groups in the region seek total independence from both India and Pakistan.

The rival territorial disputes led to three wars between India and Pakistan but the problems are unresolved. Pakistan started a proxy war in 1989 when it thought that wars with India were not able to achieve its object in Kashmir. Since 1989, the conflict in J&K has been one of the most important issues of India's internal security environments. There are many insurgent and terror groups in J&K that seek either independence or Joining Pakistan (pro-Pakistan). Among those groups, Lashkar-e-Taiba[16] (LeT - Army of the Pure), Hezb-ul-

[16] LeT is one of the largest and most active militant organizations in South Asia with Headquartered near Lahore, Pakistan. Its members have carried out major attacks against India and its objective is to set up an Islamic state in South Asia and to "liberate" Muslims residing in Indian-administered Kashmir. LeT has established training camps across Pakistan and Pakistan-occupied Kashmir. While it operates mainly in

Mujahedeen[17], the All Parties Hurriyat Conference[18] (APHC) and Jaish-e-Mohammed (JeM)[19] are more prominent. Furthermore, those groups have al-Qaeda connections. For instance, the LeT is claimed to have operated a military camp in post-Sept 11 Afghanistan.

The relationship between these groups and the Taliban-al Qaeda would threaten the stability of not only this region but also the sub-continent of India and Pakistan, even the whole world through fuelling the export of terrorism. According to the Armed Conflict Report 2009, J&K insurgencies have caused estimated deaths up to 77,000 since 1989. The casualties and broad influences of J&K insurgencies pose one of the most serious threats to India's security.

In 2004, India and Pakistan launched a peace process and their relationship has been improved. Both countries agreed upon reducing the number of troops present in this region. The number of insurgency-related deaths in J&K has declined sharply in that year. The Pakistani government started to take actions against the militants' training camps in Pakistan-administered Kashmir area. In 2008, Pakistan President Zardari declared that Kashmir's "freedom fighters" were terrorists. However, there are still many active insurgent and terror groups in J&K and the 2008 Mumbai Attacks caused at least 173

Kashmir where one estimate places its numbers at over 750, it has also carried out attacks in other parts of India.

[17] One of the largest militant groups at around 1500 members and is based in Pakistan- occupied Kashmir, Hezb-ul-Mujahedeen has conducted regular attacks across Kashmir.

[18] APHC is a political front formed as an alliance of 26 political, social and religious organizations in Kashmir. It was formed achieving the right of self-determination according to the UN resolution. In 2003, it split into pro-Pakistan and pro-independence factions.

[19] JeM was formed in 2000 and is based in Pakistan. It aims to separate Kashmir from India and has carried out a series of attacks primarily in Indian-administered Kashmir.

deaths and 308 wounded. The Jammu and Kashmir disputes will still exist, at least in the near future and the road to peace will still be torturous and uncertain.

The internal security problems of India still lead to some challenges to its national security environment and are still an area of core concern. The development of asymmetric warfare capabilities by various insurgent and terror groups has an impact on the need of India's army to dealing with those asymmetric threats, as well as the pattern and priority of India's defence spending.

3.4.2.2 External Security Threats

Externally, India faces major security challenges from its two main neighbours: the unstable Islamic state of Pakistan and a resurgent China which are shown by yellow colour in Figure 3.5. Firstly, the conflict history of India and Pakistan since partition in 1947 was outlined in Chapter 2 and it showed that there is a long-run relationship between India and Pakistan's real military expenditure which provides evidence to support the existence of confrontation and the India-Pakistan arms race. Thus, Pakistan poses a serious threat to Indian external security.

Secondly, it is the turn to look at the relationship between India and China. After India's independence in 1947 and the setup of the People's Republic of China in 1949, an eight-year agreement on Tibet in the form of the Five Principles of Peaceful Coexistence[20] in

[20] The Five Principles of Peaceful Coexistence are a series of agreements between the People's Republic of China and India. In 1954, the two nations drew up the Five Principles of Peaceful Coexistence:

1. Mutual respect for each other's territorial integrity and sovereignty.
2. Mutual non-aggression.
3. Mutual non-interference in each other's internal affairs.
4. Equality and mutual benefit.
5. Peaceful co-existence.

1954 and the relationship between India and China was described as "brothers" until 1959. In 1959, the government of China claimed that the Aksai Chin regions over which India's maps showed sovereignty and asked for "rectification" of the entire border but the Indian government rejected the idea of settlement. In the same year, the religious leader of Tibetan people, the Dalai Lama fled from Tibet to India after the Tibetan rebellion against Chinese rule failed and sought sanctuary in Himachal Pradesh. Thousands of refugees from Tibet moved into North-western India. The Chinese government accused India of the expansionists operating in Tibet. Hence, the Sino-Indian relationship suffered a serious setback. In October1962, a border war took place between India and China in the disputed areas of both eastern and western sectors as shown in Figure 3.6. On 20th November, Chinese troops secured the disputed area and unilaterally declared a ceasefire. The short border war thus ended. Since then, the conflict of interest in Tibet and the border disputes have been the core concern of those two neighbour countries. After the defeat in the Sino-Indian war of 1962, India revamped its entire military system and set up the Department of Defence. India realized the need to strengthen its defence power and to create its own defence industrial base via indigenous sources and self-sufficiency.

Even though the border disputes between India and China continued, India's relations with China have experienced a slow but steady improvement since the 1980s. Nowadays, after more than 45 years of the Sino-Indian war, the mutual economic engagements and continued efforts to resolve the border disputes have ensured peace along the India-China border. However, India still concerns about the implication of China's military modernization and the improvement of infrastructure in the Tibet and still treats China as its main external threat in the long term.

Based on national security concerns and international political considerations, the primary goal of Indian defence policy is to acquire self-reliance to sustain its position as an important political actor in Asia. Combined with the urgency to military modernization, India needs to acquire smart weapons and modern defence systems from external sources by military imports. Furthermore, India security concerns also include the proliferation of Weapons of Mass Destruction (WMD), energy security and the security of India Ocean region which all have important effects on India's national security and its economy. These factors are all likely to drive up India's military expenditure and influence the security environment not only in India but also in the entire Asia and the whole world.

Figure 3.6 the Sino-Indian Border War

Source: The University of Texas at Austin, PCL Map Collection. Accessed at 08/2009, http://www.lib.utexas.edu/maps/middle_east_and_asia/china_india_border_88.jpg.

3.5 Model Specification and Data

3.5.1 Model Specification for the Determinants of India's Military Expenditure

Over the years, the study of the demand for military expenditure in LDCs has been carried out using a variety of different approaches as reviewed in sections 3.2 and 3.3. It has attempted to identify the military, economic and other factors that influence the evolution of military expenditure. Many studies have focused upon the military, economic and political determinants of military expenditure. The formal models have developed from the neoclassical approach by Smith (1980 and1989). In a general functional form, the demand for a country's military expenditure can be modelled in a single regression equation, as shown in the Equation (3.5), $E = M(p_m/p_c\,, Y, N, M_1, \ldots, M_n, ZW, ZS)$.

Due to the lack of data, price deflators are usually dropped. Hence, the demand function is specified to describe India's characteristics, to indicate the country's security concerns and to suit the data availability. This leads to the demand equation as follows:

$$\text{MEI} = \text{M}\ (GDPC, POP, CGE, TB, POL, THREAT, WAR) \qquad (3.15)$$

Where MEI denotes India's real military expenditure, *GDPC* indicates *GDP* per capita of India, *POP* is total Indian population, CGE represents the share of central government expenditure in *GDP*, *TS* denotes the share of trade balance in GDP, *POL* indicates political variables, *THREAT* could be represented by the defence burden of Pakistan as a rival of India , security web of India and a internal threat variable, and *WAR* indicates war dummy variables for the India's external wars with Pakistan and China.

In the literature reviewed above, GDP per capita plays an important role in determining of the level of military burden in many developing countries (Tambudzai 2007). In the case of

India, when GDP per capita rises, India has more resources available for defence and a greater need for protection. This should be captured by the positive coefficient of GDP per capita variable. The population variable is introduced to capture any possible size effect of military spending and possible public good effect. The sign of the population variable is ambiguous. CGE is expected to enter the equation with a positive sign which could provide more resources available for defence. The share of the trade balance in GDP reflects the openness of the economy and its sign is ambiguous. The political variable represents the relationship between political status and military expenditure in India and the expected sign is negative.

The defence burden of Pakistan is included in the demand equation to reflect the confrontation and arms race between India and Pakistan. The average defence burden of countries inside India's security web is also added into the demand equation. Due to the lack of data on military burden of Bhutan and Burma, the security web of India in this study includes Bangladesh, Nepal and Sri Lanka. These defence burden variables capture the external threats faced by India and should have a positive effect on India's military expenditure. The war dummy for India's external wars with Pakistan in 1965, 1971 and 1999 and with China in 1962 is included to capture the threats as well. The expected sign of the war dummy variable is also positive.

The last consideration is the internal security threats facing by India. As discussed in earlier section, activities of different insurgent and terror groups would have an important influence on the pattern of India's military expenditure. For example, after the Mumbai Attack in 2008, India increased its defence budget by 25 percent in 2009-10 (to $29.39

billion) in July 2009 and \$562 million will be spent exclusively for boosting border security and modernising its police force. Uday Bhaskar, the director of National Maritime Foundation said that "this specific allocation for border management and modernising the police force appears to be a direct fallout of the Mumbai attacks". Hence, the internal and cross-border security problems also influence the amount and the pattern of India's military expenditure. The signs of these effects are expected to be positive. However, it is very hard to get an appropriate proxy for those internal security problems and the reliable data are hard to access. In this study, the data on the number of riots in the whole India is used to capture the effect of internal security threats on India's military expenditure.

Given the above discussion, the demand for India's military expenditure is determined by economic, political and security related factors and can be modelled in the logarithmic form (denoted by *ln*) as follows:

Model 1:
$$lnmei_t = \alpha_0 + \beta_1 lngdpc_t + \beta_2 lnpop_t + \beta_3 tb_t + \beta_4 lndemoc_t + \beta_5 lndbp_t + \beta_6 war + \varepsilon_t \quad (3.16)$$

Model 2:
$$lnmei_t = \alpha_0 + \beta_1 lngdpc_t + \beta_2 lnpop_t + \beta_3 lncge_t + \beta_4 tb_t + \beta_5 lndemoc_t + \beta_6 lndbp_t + \beta_7 war + \beta_8 lnsw + \varepsilon_t \quad (3.17)$$

Model 3:
$$lnmei_t = \alpha_0 + \beta_1 lngdpc_t + \beta_2 lnpop_t + \beta_3 lncge_t + \beta_4 tb_t + \beta_5 lndemoc_t + \beta_6 lndbp_t + \beta_7 lnsw + \beta_8 lnriots + \beta_9 war + \varepsilon_t \quad (3.18)$$

Where Model 1 is the basic framework which includes income, population, trade balance, democracy, defence burden of Pakistan, and war dummy variables. Then the model is extended by adding the share of central government expenditure in GDP and security web variables in Model 2. In Model 3, the riots variable is included to capture the effect of internal threats on India's military spending.

3.5.2 Data Sources and Descriptions

In this study, the demand for India's military expenditure is estimated for the period 1960-2006. The data on India's military expenditure and the data on defence burden of Pakistan, Bangladesh, Nepal and Sri Lanka are obtained from various issues of SIPRI yearbooks and SIPRI online database which were accessed in August, 2009. Data on GDP per capita, population, central government expenditure and trade balance are taken from World Development Indicators online database and were also accessed in August, 2009. Democracy index data are obtained from Polity IV: Regime Authority Characteristics and Transitions Datasets. War dummy variable takes value of one for 1965, 1971, and 1999 when India had wars with Pakistan and for 1962 when the Sino-India war took place; and equals zero elsewhere. Data on the number of riots in India are taken from Conflict in India Datasets - Crime in India: Riots, Murders, and Dacoity 1954-2006.

The variables used in our estimation are as follows:

mei – India's real military expenditure in constant 2000 million US$;

gdpc – India's GDP per capita in constant 2000 US$;

pop – Total population of India in millions;

cge – the % share of central government expenditure of India in its GDP;

tb – India's % share of trade balance in GDP;

democ – democracy index, which ranges from -10 (autocracy) to 10 (democracy);

dbp – the defence burden (the share of defence spending in GDP) of Pakistan as a rival of India;

sw – the security web of India (i.e. the average defence burden of Bangladesh, Nepal and Sri Lanka);

riots – the number of riots in India in one year as a internal threat proxy;

war – War dummy for the India's external wars with Pakistan and China, which equals 1 for years 1962, 1965, 1971 and 1999 and equals 0 for other years during the period 1960-2006.

3.6. Estimation Methods

A number of alternative methods have been applied to estimate the demand for military expenditure. For example, some studies have used simultaneous-equation approaches to estimate the demand for military expenditure systematically. These system estimations could be used for the allies' military spending where the military spending of allied countries are jointly determined. Some studies have applied a single-equation approach to estimate the demand for military spending in a country and have employed different cointegration techniques. However, these approaches have shortcomings and are not suitable for this study. It has been widely criticized that simultaneous-equation approaches have to divide the endogenous and exogenous variables which are generally not clear in many empirical models. In the demand models for India's military expenditure, there are at least seven variables. Cointegration estimation based on VAR framework would be problematic due to the degree of freedom considerations.

Pesaran and Shin (1999) develop the autoregressive distributed lag approach (ARDL) to cointegration which is more suitable for this study than the above alternative approaches. The main reasons for using the ARDL to cointegration procedure are as follows. Firstly, many time-series variables in this study are non-stationary and contain unit root. Traditional OLS regressions would become spurious while the ARDL to cointegration procedure can be applied regardless of the stationary properties of the variables in the model. Secondly, contrary to the VAR frameworks, the number of variables in the regression model can be large. Thirdly, this procedure allows for inferences on long-run estimates and also presents short-run dynamics.

For simplicity, consider the following ARDL (p, q) model (unrestricted ECM model) which only includes one independent variable:

$$\Delta y_t = \alpha_0 + \beta y_{t-1} + \theta x_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \psi_j \Delta x_{t-j} + u_t \qquad (3.19)$$

According to Pesaran and Shin (1999), the ARDL procedure requires the following three steps and the procedure and steps could be applied to multivariate models as well.

1. Chose the lag order (p and q) of the ARDL model by using model selection criteria such as the Akaike Information Criterion and the Schwarz Bayesian Criteria.
2. Run a regression of Equation (3.19) and test the existence of any long-run relationship between the variables by using an F-test (i.e. the coefficients of $y_{t-1}$and x_{t-1} do not equal zero jointly).
3. Then, the long-run relationship and the short-run dynamics of the variables could be estimated with the ECM representation of the ARDL model.

3.7 Empirical Analysis

3.7.1 The Estimation Equation

Based on the discussion in above sections, the ECM representation of the ARDL models for the demand models are given by:

Model 1: $$\Delta lnmei_t = a_0 + b_1 lnmei_{t-1} + b_2 lngdpc_{t-1} + b_3 lnpop_{t-1} + b_4 tb_{t-1} + b_5 lndbp_{t-1} + b_6 war + \sum_{j=1}^{p-1} c_{1j} \Delta lnmei_{t-j} + \sum_{j=1}^{q_1-1} c_{2j} \Delta lngdpc_{t-j} + \sum_{j=1}^{q_2-1} c_{3j} \Delta lnpop_{t-j} + \sum_{j=1}^{q_3-1} c_{4j} \Delta tb_{t-j} + \sum_{j=1}^{q_4-1} c_{5j} \Delta lndbp_{t-j} + \sum_{j=1}^{q_5-1} c_{6j} \Delta war_{t-j} + \varepsilon_t \quad (3.20)$$

After adding central government expenditure and the security web variable, the demand model is:

Model 2: $$\Delta lnmei_t = a_0 + b_1 lnmei_{t-1} + b_2 lngdpc_{t-1} + b_3 lnpop_{t-1} + b_4 lncge_{t-1} + b_5 tb_{t-1} + b_6 lndbp_{t-1} + b_7 lnsw + b_8 war + \sum_{j=1}^{p-1} c_{1j} \Delta lnmei_{t-j} + \sum_{j=1}^{q_1-1} c_{2j} \Delta lngdpc_{t-j} + \sum_{j=1}^{q_2-1} c_{3j} \Delta lnpop_{t-j} + \sum_{j=1}^{q_3-1} c_{4j} \Delta lncge_{t-j} + \sum_{j=1}^{q_4-1} c_{5j} \Delta tb_{t-j} + \sum_{j=1}^{q_5-1} c_{6j} \Delta lndbp_{t-j} + \sum_{j=1}^{q_6-1} c_{7j} \Delta lnsw_{t-j} + \sum_{j=1}^{q_7-1} c_{8j} \Delta war_{t-j} + \varepsilon_t \quad (3.21)$$

Then the variable of the number of riots is added into the demand model for:

Model 3: $$\Delta lnmei_t = a_0 + b_1 lnmei_{t-1} + b_2 lngdpc_{t-1} + b_3 lnpop_{t-1} + b_4 lncge_{t-1} + b_5 tb_{t-1} + b_6 lndbp_{t-1} + b_7 lnriots + b_8 war + \sum_{j=1}^{p-1} c_{1j} \Delta lnmei_{t-j} + \sum_{j=1}^{q_1-1} c_{2j} \Delta lngdpc_{t-j} + \sum_{j=1}^{q_2-1} c_{3j} \Delta lnpop_{t-j} + \sum_{j=1}^{q_3-1} c_{4j} \Delta lncge_{t-j} + \sum_{j=1}^{q_4-1} c_{5j} \Delta tb_{t-j} + \sum_{j=1}^{q_5-1} c_{6j} \Delta lndbp_{t-j} + \sum_{j=1}^{q_6-1} c_{7j} \Delta lnriots_{t-j} + \sum_{j=1}^{q_7-1} c_{8j} \Delta war_{t-j} + \varepsilon_t \quad (3.22)$$

The parameters b_i where i =1, 2…, n are the corresponding long-run multipliers, while the c_{ij} where i =1, 2…, n are the short-run dynamic coefficients of the ARDL models. The number of n equals 7, 8 and 8 in Model 1, 2 and 3, respectively. In the ARDL models outlined, the first step is to choose the lag length for the variables based on information criteria - the Schwarz Bayesian Criteria (SBC). Then the second step is to estimate Equations (3.20 - 3.22) by ordinary least squares (OLS) in order to test for the existence of a long-run relationship among the variables. For example, in Model 2, the null hypothesis of no long-run relationship (no cointegration) as defined by H_0: $b_1=b_2=b_3=b_4=b_5=b_6=b_7= b_8$

=0 is tested against the alternative by conducting the F-test. In the third step, if the existence of long-run relationship is proved, both the long-run relationship and the short-run dynamics can be estimated.

3.7.2 Empirical Results

3.7.2.1 The Order of ARDL Model and the F-tests for Cointegration

The empirical estimations are carried out by using *Microfit 4.0* developed by M.H. Pesaran and B. Pesaran. Firstly, the lag lengths of the variables in our three models are selected by SBC. Because all series in the sample are annual and the sample size is small for the period 1960-2006, the maximum order of lag in the ARDL models is chosen to be 2. The results show that our regression Model 1, 2 and 3 would be in form of ARDL(2,0,0,0,0,2,1), ARDL(1,1,1,1,0,2,0,2,2) and ARDL(2,0,0,2,0,0,0,0,0). Based on these selected ARDL models, the F-tests for cointegration are operated. The calculated F-statistics are then compared with the critical values. Given the small sample size, the critical values are extracted from Narayan (2005).

According to Bahmani-Oskooee and Nasir (2004), these critical values include an upper and a lower band covering all possible classifications of the variable into I(1), I(0) or even fractionally integrated. The null hypothesis of no cointegration is rejected if the calculated F-statistic is bigger than the upper bound. If the calculated F-statistic is smaller than the lower bound, then the null hypothesis cannot be rejected. Finally, if it falls in between the lower and the upper bound, then the result is inconclusive. The results of F-tests for the three ARDL models are presented in Table 3.4.

Table 3.4 the F-test for Cointegration

		5% Critical Value Bounds		*10% Critical Value Bounds*	
	F-statistics	I(0)	I(1)	I(0)	I(1)
Model 1	5.874	2.643	4.004	2.238	3.461
Model 2	5.427	2.875	4.445	2.384	3.728
Model 3	3.527	2.643	4.004	2.238	3.461

Notes: Critical values are obtained from Narayan (2005)

The F-statistics are above the upper bound at the 5% level of significance for Models 1 and 2 and at the 10% level of significance for Model 3. This implies that the null hypothesis of no cointegration in Equations (3.20-3.22) cannot be accepted. Hence, the results of F-tests indicate that there is a long-run relationship amongst the variables in all three models.

3.7.2.2 Long-Run Estimating Results

Having found a long-run relationship amongst the variables, the long run elasticities can be estimated. The long-run coefficients of the variables for Models 1and 2 are estimated and the results are provided in Table 3.5, Part 1 and the results for Model 3 are shown in Table 3.5, Part 2. In the long-run estimation, the dependent variable is *lnmei*. As presented in the results of Model 1, all long run coefficients have the expected sign; expect the one for the trade balance. As a proxy of openness, the trade balance variable would lead to a higher military expenditure because an open country would be easier to access finance for arms purchases. However, the status is different in India where the estimated coefficient of trade balance has a negative sign. The possible reason for the negative trade effect on military expenditure in India is that India is a net arms importer.

Table 3.5 the Long-Run Coefficients Estimating Results, Part 1

Model 1			*Model 2*		
45 observations used for estimation from 1962 to 2006			30 observations used for estimation from 1977 to 2006		
Regressor	*Coefficient*	*T-Ratio[Prob]*	*Regressor*	*Coefficient*	*T-Ratio[Prob]*
lngdpc	1.230	4.292 [.000]***	lngdpc	1.754	11.365 [.000]***
lnpop	0.968	2.942 [.006]***	lnpop	0.460	1.046 [.318]
tb	-0.034	-1.799[.081]*	lncge	0.792	7.572 [.000]***
lndemoc	-0.812	-2.320[.027]**	tb	-0.037	-4.287 [.001]***
lndbp	0.452	2.934 [.006]***	lndemoc	-1.416	-4.938 [.000]***
war	0.385	3.158 [.003]***	lndbp	0.386	4.261 [.001]***
c	-3.742	-3.147[.003]***	lnsw	0.101	1.747 [.109]
			war	0.091	1.403 [.188]
			c	-5.278	-2.334 [.040]**

Part 2

Model 3		
45 observations used for estimation from 1962 to 2006		
Regressor	*Coefficient*	*T-Ratio[Prob]*
lngdpc	0.862	3.754 [.001]***
lnpop	0.916	2.544 [.016]**
lncge	1.314	7.579 [.000]***
tb	-0.016	-2.005 [.054]*
lndemoc	-0.150	-1.038 [.307]
lndbp	0.268	4.334 [.000]***
lnriots	-0.178	-2.944 [.006]***
war	-0.032	-1.094 [.282]
c	-5.088	-5.304 [.000]***

*Note: Significance levels: *** at 1%, ** at 5% and * at 10%*

The estimated coefficients of income coefficients are positive and significant and thus support the initial expectation. The estimated coefficients of population is positive which may show that large population enables India has a large army and the large army in turn need more expenditures. The estimated coefficient of the democracy index of India also has the expected negative sign and is significant. The democratic status in India constrains the level of its military expenditure. The defence burden of Pakistan has a positive and significant effect on India's military expenditure which relects that there is a rivalry relationship or arms race between India and Pakistan in the long run. Thus, one of the important long-run determinants of India's military expenditure has been the enduring arms race between India and Pakistan. Finally, the external wars with Pakistan (in 1971 and 1999) and with China (in 1962) have a positive and significant effect on India's military expenditure.

After adding CGE and security web variables into the regression equation, we get similar results as shown in Table 3.5, Model 2. The sign and value of the estimated coefficients are similar to those of Model 1. The effect of the central government expenditure on defence spending is positive and significant in India which confirms the defence priority of India's government. Looking at the security web variables, the average defence burden of the security web countries influences India's military expenditure insignificantly. Due to the limited sample size (the data on security web is available from 1975) in Model 2, the results might be unreliable. Finally, we turn to investigate the effect of internal threats on India's demand for military spending in Table 3.5, Model 3. But the results are not satisfying. The estimated coefficient of riots variable has a negative and significant sign which is opposite to the initial expectation. Hence, using the number of riots as a proxy of internal security threats of India might be problematic.

3.7.2.3 The Short-Run Error Correction Estimating Results

The short run estimates in form of the error correction model (ECM) representation are given in Table 3.6. In Table 3.6, the dependent variable is *dlnmei* where *d* denotes the first difference of the variable.

The results of Model 1 suggest that India's military expenditure is positively influenced by the previous year's spending. The change of GDP per capita has a positive and significant effect which indicates that increases in the income lead to increases in military expenditure in India. The effect of population growth on military expenditure growth is insignificant. The change of trade balance is negative and significant and the coefficient of democracy is also significant and negative. The change of Pakistan's defence burden has a significant and positive effect on the change of India's military expenditure. But the lag of change of Pakistan's defence burden has a negative and significant effect on the change of India's military expenditure. The war dummy has a significant and positive effect. The coefficient of error correction term (ECM) is equal to -0.586 which imply that the deviation from the long-term change rate in military expenditure in India is corrected by more than half within one year. This finding shows that the speed of adjustment is high, indicating that economy returns to its equilibrium level quickly, once shocked.

Table 3.6 the Short-Run Error Correction Elasticity Estimating Results

Part 1

Model 1			***Model 2***		
45 observations used for estimation from 1962 to 2006			30 observations used for estimation from 1977 to 2006		
Regressor	*Coefficient*	*T-Ratio[Prob]*	*Regressor*	*Coefficient*	*T-Ratio[Prob]*
dlnme(1)	0.472	4.306 [.000]***	dlngdpc(1)	0.936	2.499 [.023]**
dlngdpc	0.721	3.886 [.000]***	dlnpop	67.255	2.253 [.038]**
dlnpop	0.568	2.514 [.538]	dlncge	-0.077	-0.027[.788]
dtb	-0.020	-1.935[.038]**	dtb	-0.057	-4.761[.000]***
dlndemoc	-0.476	-2.651 [.020]**	dlndemoc	-0.239	-0.749[.464]
dlndbp	0.332	2.603 [.007]***	dlndemoc(1)	0.525	1.783 [.092]*
dlndbp(1)	-0.388	-3.402 [.002]***			
dwar	0.082	2.269 [.030]**	dlndbp	0.606	4.046 [.001]***
dc	-2.194	-2.453[.019]**	dlnsw	-0.200	-2.732[.014]**
ecm(1)	-0.586	-6.518[.000]***	dlnsw(1)	-0.032	-4.52 [.000]***
			dwar	-0.056	-1.441[.168]
			dwar(1)	-0.112	-2.893[.010]**
			dc	-8.302	-1.784[.092]*
			ecm(1)	-1.573	-5.572[.000]***

Part 2

Model 3		
45 observations used for estimation from 1962 to 2006		
Regressor	*Coefficient*	*T-Ratio[Prob]*
dlnme(1)	0.611	5.389 [.000]***
dlngdpc	0.837	3.149 [.003]***
dlnpop	0.889	2.524 [.017]**
dlncge	1.058	5.927 [.000]***
dlncge(1)	-0.761	-2.835[.008]***
dtb	-0.015	-1.909[.065]**
dlndemoc	-0.146	-1.050[.301]
dlndbp	0.260	3.309 [.002]***
dlnriots	-0.172	-2.921[.006]***
dwar	-0.031	-1.072 [.292]
dc	-4.939	-4.349 [.000]***
ecm(1)	-0.971	-6.912 [.000]***

*Note: Significance levels: *** at 1%, ** at 5% and * at 10%*

As discussed above, data for the security web are only available from 1975-2006 and the limited sample size might lead to unreliable results. So the values and signs of some estimated coefficients have big changes and not under our expectations. Thus, more observations are needed for a more reliable and efficient estimation. Then we turn to look at the results of Model 3 and we find out that the results are similar with those of Model 1. Furthermore, the change in number of riots has a negative and significant effect on the change of India's military expenditure which is also different with our expectation. Hence, that proxy for internal security threats is proved to be problematic again in the short-run analysis

3.8 Conclusion

This chapter provides an empirical analysis of the demand for India's military expenditure from 1960 to 2006, employing the ARDL approach to cointegration. Based on the explicit review of theoretical and empirical literature on the demand for military expenditure, the neoclassical model is selected to analyze the determinants of India's military expenditure. India's economic, political and security environments are investigated which provide information for model specification. Then the regression equations of the demand for India's military expenditure and the empirical estimations are presented for India. The determinant factors of India's military expenditure include income, population, central government expenditure, trade balance, defence burden of Pakistan, average defence burden of countries in India's security web, domestic riots and external war. The economic, political and security variables are all taken into considerations.

The empirical results suggest that India's military expenditure is mainly determined by its income, democratic status, the perceived threat from Pakistan and external wars both in the long-run and in the short-run. Higher income level does have a significant and positive effect on India's military expenditure. In recent years, the rapid economic growth provided ore resources and opportunities for increases in India's military expenditure. The democratic status in India does constrain its military expenditure and has a negative impact on military expenditure. Central government expenditure has a positive and significant effect on military expenditure. As discussed above, security and military expenditure still have high priorities among India's central government expenditure.

The external wars of India with Pakistan and China have a significant and positive effect on India's military expenditure which implies the external threats faced by India from its neighbours – Pakistan and China play an important role in determining India's military expenditure. Finally, Pakistan's defence burden has a positive and significant effect on India's military expenditure which is consistent with the results of Chapter 2. Thus, both provide evidences to support the existence of the long-running arms race between India and Pakistan.

Thus, this chapter also implied the existence the 'security dilemma' in terms of India's relationship with Pakistan. The core factors that motivate the demand for defence as a public good were examined both in the long-run and in the short-run. What is clear is that both the arms race factor and related economic and political factors are important to determine India's defence spending. However, high military expenditure would have adverse impacts which is analyzes as 'developmental failure'. The effect of defence on development in India is still unclear and will be examined in the next chapter. Then the twin claims of security and development will be reconciled to understand India's defence expenditure issues.

Chapter 4 Military Expenditure and Economic Growth in Developing Countries

4.1 Introduction

"*The single and most massive obstacle to development is the worldwide expenditure on national defence activity*."[21]

Military expenditure in developing countries is important and a major aspect of government expenditure which often far exceeds health and education spending. As suggested in the above quotation, many economists believe that military expenditure crowds out more productive expenditure and civilian investment and thus has a negative impact on economic growth. We also believe that for India, the 'security dilemma', India-Pakistan arms race and related economic and political factors lead to its high military expenditure. Then the high military expenditure would cause 'developmental failure' and have a negative effect on economic growth.

However, Benoit (1978) found that military expenditure actually accelerates economic growth in less developed countries (LDCs). Since then, many studies have been carried out to assess the impact of military expenditure on economic performances by using different samples, different time periods and different theoretical and empirical methods. However, the results are always controversial and the defence-growth nexus is still important for explicit analyzing.

With the end of the Cold War, global military expenditure has been decreasing and it is expected that this reduction in military expenditure (or military burden) will lead to peace

[21] Quote which was cited in Deger and Sen (1983), from a statement issued by a UN Committee for Developing Planning in the 1970s

dividends for developing countries. However, many developing countries still spend a large amount of scarce resources on defence. For example, 15.6 per cent of central government expenditure and 2.01 per cent of GDP are spent on defence in lower and middle income countries. While the corresponding figures for the EU area are only 4.5 per cent and 1.7 per cent (WDI, 2006). A lacking of investment and expenditures in education, health and other social-economic activities, many LDCs' economic growth will be affected by high defence spending. For these reasons, the impact of defence spending on economic growth in developing countries need to be explored and analyzed carefully.

This chapter firstly surveys the theoretical models and empirical studies involved in the debate of the defence-growth relationships. The following literature can fall into seven groups: Benoit's work, demand side models, supply side models, Deger type models which incorporate demand and supply side factors, the Barro models, the Solow models and the Granger causality analysis. The related theoretical issues, results of empirical studies and characteristics of different models are provided respectively. General conclusions on theoretical and empirical methods are provided. Thus not only the traditional studies but also recent analyses which apply more popular growth theories are reviewed and assessed which provide the direction and structure of this chapter's empirical analysis for the defence-growth nexus in developing countries.

As noted by Ram (1995), individual-country and cross-section studies should be treated as complementary and not as competing alternative. A single-country case analysis is based on more detailed specification and provides valuable information. However, many problems are involved with the single-country data, such as the limited sample size, nonstationarity of time-series variables and limited generalizability to other contexts. On the other hand, cross-sectional or panel data analysis can be applied for countries which are grouped by cohorts based on similar economic, political and other considerations (Sandler and Hartley, 1995). But heterogeneity among countries should be considered to provide more efficient results.

Thus, according to the complementarities between individual and cross-sectional estimates, empirical studies of this chapter will provide evidences of both type of estimations. The assessment of the impact of defence spending on economic growth in India represents the single-country case study. For the period 1970-2003, the growth effects of India's military expenditure are explored and estimated by using the Deger type model. Then cross-sectional and panel data estimations are employed to investigate the impact of defence burden on economic growth in 36 developing countries during 1975-2004. These estimations are based on the Augmented Solow growth model which defence variables are integrated into. Different panel data techniques are used to estimate the defence-growth relationship, which are believed to provide robust empirical results.

The structure of this chapter is as follows. Section 4.2 provides the review of literature on military expenditure and economic growth in LDCs, including both theoretical models and corresponding empirical studies; Section 4.3 gives a single country study of the relationship between military expenditure and economic growth in India; Section 4.4 examines the long-run and short-run impact of defence spending on economic growth based on cross-sectional and panel analyses for 36 developing countries during 1975-2004.

Sub-sample panels data for the Cold War periods and Post Cold War periods are also estimated. Section 4.5 presents the conclusion.

4.2 Military Expenditure and Economic Growth: Literature Review on Theoretical Models and Empirical Studies

The aim of this section is to review the existing literature on the topic of military expenditure and economic growth in developing countries. Since Emile Benoit's (1978) pioneering work which find that military expenditure has an unexpected positive effect on economic growth for 44 LDCs, various models have been applied to study the defence-growth nexus in developing countries. The literature on theoretical models and according empirical studies can be broadly grouped into: the Benoit-type regressions, supply-side (Feder-type) models, demand-side models, demand and supply side (Deger-type) models, the Barro models and the Solow models. The reviewed empirical results are found to be inconclusive as shown in Table 4.7. Furthermore, some empirical studies apply the Granger causality tests and try to find the direction of statistical causality relationships between military expenditure and economic growth.

The Details of literature review on the defence-growth relationships are provided in A7 of the Appendix. These explicit literature reviews not only synthesize and evaluate the researches undertaken in the areas, but also identify information and methodologies that could be relevant to our studies in the following sections. For example, the Deger-type models consider both demand and supply side influences and can provide more sophisticated and robust results, especially for Individual country studies. While cross-sectional and panel data analysis can be examined by the Solow model augmented by military variables which integrates implications stemming from defence economics literature into the neoclassical growth model. Thus, the following sections will present our empirical analysis of the defence-growth relationship in developing countries.

Table 4. 7 the Summary of the Results of the Empirical Literature Review

Models	***Number of Literature***	***Positive***	***Negative***	***Insignificant***	***Non-linear***
Benoit-type	3	2		1	
Demand models	3		3		
Feder-type	8	4		3	1
Deger-type	9	2	7		
Barrow models	3				3
Solow models	4		4		
Total	30	8	14	4	4

Notes: Positive, Negative and *Insignificant* denote that the impact of defence on growth is positive, negative and insignificant, respectively. *Non-linear* denotes that the defence-growth relationship is examined in non-linear regression frameworks.

4.3 A Single-Country Study: Military Expenditure and Economic Growth in India

4.3.1 Introduction

In this section, the relationship between military expenditure and economic growth in India is investigated by using the Deger type (demand and supply side) model. As discussed in the previous review of models for analysing the defence-growth relationships, the Deger type model consider both demand and supply side influences and can provide more sophisticated and robust results. An individual country study of India can be characterized by its special economic, political and other related factors. This will resolve the problem of specifications and overcome the heterogeneity in cross-sectional studies. The estimation period for India is from 1970 to 2003 (the upper boundary of the sample period is limited by data availability on real effective exchange rate).

The structure of this section is as follows. Section 4.3.2 provides model specifications and defines the data. Section 4.3.3 presents empirical results and analysis. Section 4.3.4 gives the conclusion.

4.3.2 Model Specifications and Data

Military expenditure influences economic growth through many channels and thus many variables need to be included into the model. Some variables might be endogenous. For instance, there exist direct and indirect effects from defence to growth. Therefore, the multi-equation model based on Deger (1986b) is employed. It consists of four equations on growth, the saving ratio, the balance of trade and military burden. The exogenous variables are chosen considering India's economy, defence and security. Specially, the defence equation is based on the analysis of the demand for military expenditure in India in Chapter 3 (Equation (3.16)). The simultaneous equation model (SEM) consisting of 4 equations is constructed as follows.

Growth equation:

$$g = a_0 + a_1 s + a_2 m + a_3 tb + a_4 l \tag{4.38}$$

Saving equation:

$$s = b_0 + b_1 m + b_2 g + b_3 tb + b_4 inf + b_4 ng \tag{4.39}$$

Balance of trade equation:

$$tb = c_0 + c_1 m + c_2 g + c_3 reer + c_4 dummy \tag{4.40}$$

Defence equation:

$$m = d_0 + d_1 gdpc + d_2 pop + d_3 democ + d_4 tb + d_5 dbp + d_6 war \quad (4.41)$$

where:

g is growth measured as the log of real GDP minus the log of real GDP in the previous year,

s is the share of gross national saving to GDP,

tb is balance of trade measured by the share of external balance on goods and services to GDP,

m is India's military expenditure measured by the share of military expenditure to GDP,

l is the rate of population growth as a proxy for labour growth,

inf is the inflation rate,

ng is the share of non-defence government expenditure to GDP,

reer is real effective exchange rate,

dummy is a dummy variable for second oil shock in 1980.

gdpc is India's GDP per capita in constant 2000 US$;

pop is the total population of India valued in millions;

democ is the democracy index, which ranges from -10 (autocracy) to 10 (democracy);

dbp is the defence burden of Pakistan as a rival of India;

war – War dummy for the India's external wars with Pakistan and China, which equals 1 for years 1962, 1965, 1971 and 1999 and equals 0 for other years during the period 1960-2006.

The sources of data except m, ng and $reer$ are from World Development Indicators (World Bank Online Database). m is from SIPRI yearbooks and online database for military expenditure. Data on ng is derived from Government Final Consumption Expenditure by Function (UN data). Data on $reer$ is obtained from Reserve Bank of India. The details of the data in the defence equation are provided in chapter 3.

In the growth equation (Equation (4.38)), saving and labour are expected to have positive effects on growth which based on basic growth theories. Military burden tends to capture the spin-off effect of defence on growth through modernization and resource mobilization. The sign of a_2 is expected to be positive. The balance of trade ratio is used to pick up the effect of India's net exports on economic growth. In the saving equation (Equation (4.39)), military burden is assumed to have a negative (crowding-out) effect on the saving ratio. Following life cycle theories of consumption, the saving ratio depends on the economic growth rate and a higher saving ratio is expected with higher growth. The exports and imports will affect saving through income-multiplier and trade taxes and thus the trade balance is expected to affect the saving ratio positively. Inflation would cause forced saving and thus has a positive effect on savings. Finally, the expectation of non-defence government expenditure such as government expenditure on health and education is ambiguous.

In the balance of trade equation (Equation (4.40)), military burden will affect the balance of trade. Increases in military expenditure may increase the aggregate demand and combined with relatively inelastic domestic supply, imports will be increased and/or exports will be reduced. Thus the coefficient of military burden is expected to be negative.

Deger (1986b) suggests that if a country follows export-promoting strategies, the growth of GDP will have positive effects on the trade balance, or if a country follows import substitution policy, the growth of GDP will have negative effects on the trade balance. The real effective exchange rate has been added into the equation to examine the effect of a change in the international purchasing power of the domestic currency. It is expected to have a positive effect on the balance of trade. A dummy variable is used to capture the second-oil shock in 1980 and is expected to have negative sign.

In the defence equation (Equation (4.41)), the independent variables included in the equation are based on the specification and estimation in chapter 2, where we analyzed the demand for military expenditure in India.

4.3.3 Empirical Results

Taking into account simultaneity and high covariance between variables, simultaneous equation methods are employed to estimate the equations as a system by 3SLS[22]. The empirical results of 3SLS as well as OLS and 2SLS are obtained by using the Stata 10 and presented in Table 4.8. All variables except *tb* are employed by the logarithm forms of series (*ln*).

Comparing the estimating results from 3SLS, 2SLS and OLS, the estimated coefficients of many variables are insignificant when 2SLS and OLS methods are used while those coefficients become significant under the 3SLS estimation. For example, in the results of the growth equation, the estimated coefficients of *lns* and *lndbi* become significant by

[22] For a detailed discussion, see Baltagi (2002, p281)

applying 3SLS method while they are insignificant when using OLS and 2SLS methods. Thus, as a system estimation technique, 3SLS method provides superior results in our case. The following analysis is based on the results from 3SLS.

In many single-country studies, all variables are first differenced due to the existence of non-stationarity. Thus, the SEM in the form of first difference is also estimated. After first differencing, the estimating results present the dynamic structure of the system and provide weak estimates (See Appendix Table A4). Thus, we will focus on the analysis of the estimating results from original system equations. Additional tests are carried out to show the existence of long-run relationships in the four equations. The results of the Engle-Granger cointegration tests (see Appendix Table A5) for the four equations show that all residuals are stationary. So the four equations do present long-run equilibrium relationships. The tests based on original SEM can provide valuable results to analyse the defence-growth nexus in India.

In the growth equation, the savings ratio and balance of trade have positive and significant effects on growth. The growth effect of population is insignificant. Military burden does have a spin-off effect in India and there exist a direct positive impact from defence to economic growth.

Table 4. 8 Estimation Results for the Original SEM (1970-2003)

		Estimation method					
	Explaining variables	*3SLS*		*2SLS*		*OLS*	
Growth equation	*lns*	0.16	(0.07)**	0.08	(0.09)	0.09	(0.07)
	lndbi	0.22	(0.11)**	0.23	(0.14)	0.13	(0.10)
	tb	0.02	(0.01)***	0.02	(0.01)*	0.01	(0.01)
	lnl	0.04	(0.09)	-0.07	(0.13)	-0.01	(0.10)
	constant	-0.69	(0.24)***	-0.41	(0.31)	-0.36	(0.25)
Saving equation	*lndbi*	-0.50	(0.20)**	-0.37	(0.23)	-0.19	(0.17)
	g	0.95	(0.58)	0.35	(0.68)	0.35	(0.44)
	tb	0.01	(0.02)	0.02	(0.02)	0.02	(0.02)
	lninf	0.01	(0.02)	0.00	(0.03)	0.00	(0.03)
	lnng	0.68	(0.12)***	0.76	(0.14)***	0.79	(0.11)***
	constant	2.38	(0.35)***	2.15	(0.41)***	1.90	(0.32)***
Balance of trade equation	*lndbi*	-10.69	(2.41)***	-7.99	(3.00)***	-3.06	(1.97)
	g	31.29	(5.79)***	20.69	(7.38)***	7.00	(4.49)
	lnreer	3.13	(0.82)***	2.61	(1.04)**	1.09	(0.76)
	dummy	-2.00	(0.74)***	-2.91	(1.01)***	-2.41	(0.84)***
	constant	-4.23	(2.91)	-4.48	(3.37)	-2.70	(2.74)
Defence equation	*lngdpc*	1.61	(0.42)***	1.13	(0.59)*	0.62	(0.52)
	lnpop	-2.24	(0.54)***	-1.63	(0.76)**	-0.95	(0.66)
	lndemoc	-1.52	(0.29)***	-1.11	(0.37)***	-0.84	(0.34)**
	tb	-0.09	(0.02)***	-0.06	(0.02)***	-0.03	(0.02)*
	lndbp	0.30	(0.11)***	0.29	(0.16)*	0.21	(0.15)
	war	0.07	(0.04)	0.07	(0.06)	0.09	(0.06)
	constant	9.53	(1.65)***	7.36	(2.19)***	5.36	(1.92)***

Notes:
Significance levels: *** at 1%, ** at 5% and * at 10%.

In the saving equation, defence burden is correlated negatively with savings and it indicates that military expenditure might reallocate saving from productive investment. The crowing-out effect affects economic growth indirectly. The finding is consistent with Deger (1986b). The impacts of growth, balance of trade and inflation on savings are insignificant. The non-defence government expenditure has a significant and positive effect on the saving ratio.

In the balance of trade equation, defence burden has a negative and significant effect on trade balance in India as our expectation. Growth is positively correlated with the balance of trade and denotes the dominated export-promoting strategies in India. The estimated coefficient of the real effective exchange rate is positive and significant which is as expected. The oil shock dummy picks up the negative and significant effect on growth. Finally, in the defence equation, we get similar results with estimations in Chapter 3. Income variable is positively correlated with Indian defence spending. Defence burden of Pakistan and external wars both have a significant and positive effect on India's military spending. Due to the limitation of the sample size, data reliability and estimating methods, the results of some estimated coefficients are not consistent with the results from Chapter 3. However, the main aims of our empirical analysis are not affected.

The multiplier of defence burden on economic growth can be calculated by:

$$\frac{dg}{dm} = \frac{a_2 + a_1(b_1 + b_3c_1) + a_3c_1}{1 - (a_1b_2 + a_1b_3c_2 + a_3c_2)} \tag{4.42}$$

The multiplier equals -0.32 in our analysis. Thus, the overall effect of military expenditure on economic growth is estimated to be negative in India. The indirect effect from defence to growth via savings and balance of trade out-weight the direct growth effect of defence.

4.3.4 Conclusion

Using Deger type model, the impact of military expenditure on economic growth is estimated. Based on the original SEM rather than the first differenced, the 3SLS estimator provides system estimating results. We find that the direct effect of military expenditure on growth is positive and significant which represents the spin-off from defence to growth in India. However, when we fully consider the interdependence between defence, savings and balance of trade, it shows that growth can be reduced through indirect effects. Defence can depress the saving ratio and the balance of trade. Taking both direct and indirect effects together, empirical estimations for India indicate that an increase in the defence burden reduces the growth rate in the long run. The negative indirect effects dominate the direct growth-stimulating effect in India. In general, one per cent increase in defence will cause approximately 0.32 per cent decrease in the growth rate.

4.4 Cross-sectional and Panel Data Analysis of the Defence-Growth Nexus in Developing Countries, 1975-2004

4.4.1 Introduction

The net effect of military expenditure on economic growth was already estimated to be negative in India. Due to the complementary between individual-country and cross-section studies, we will explore the defence-growth nexus in developing countries by using cross-sectional and panel data in this section.

The effect of military expenditure on economic growth in developing countries has been investigated by many empirical literatures. However, there is little consensus of the effect from defence on growth and the diversity seems to come from the use of different models. As suggested by Knight, Loayza, and Villanueva (1996) and Dunne, Smith and Willenbockel (2005), this study use a model which integrates implications stemming from defence economics literature into the neoclassical growth model (i.e. the augmented Solow growth model with defence variables).

Using cross-sectional and panel data from 36 developing countries in Africa, Latin America and South Asia over the period of 1975 to 2004, the impact of defence burden on the growth rate is estimated. Different techniques are employed to provide robust empirical results. Standard cross-sectional regressions are operated to present the long-run relationship estimation from 1975 to 2004. Then the static and dynamic panel regressions are estimated to capture the short-run dynamic between defence and growth. The negative effects from defence to growth are expected in both long-run and short-run regressions. The structure of this section is as follows. In section 4.4.2, empirical methods are provided. The standard cross-sectional regressions are presented firstly. Then estimating methodologies of panel data are provided including the fixed-effect model (FEM), the Feasible Generalized Least Squares (FGLS) estimator, the first-differenced Generalized Method of Moments (GMM) estimator and the system GMM estimator. Section 4.4.3 gives data descriptions and sources. Section 4.4.4 and section 4.4.5 demonstrate the cross-sectional and panel empirical estimating results, respectively. Section 4.4.6 concludes.

4.4.2 Standard Cross-sectional Regressions

By using a cross-section regression framework, MRW estimate the long-run economic growth for the period 1960-1985. Similarly, the long-run analysis in this study is based on a regression in the following form:

$$gr_i = \eta + (\alpha - 1)lny_{0i} + \beta_1 lnk_i + \beta_2 lnh_i + \beta_3 \, ln(n_i + g + \delta) + \beta_4 lnm_i + \epsilon_i \qquad (4.43)$$

where i=1, …, 36 denotes a country index, gr_i is the difference of GDP per capita between 1975 and 2004, and lny_{0i} represents the initial level of GDP per capita of country i. The standard cross-section growth regression suffers from some problems. The main problems are as follows. First, the standard cross-section estimation does not use all available information by reducing the panel data to a time-average data. Second, it suffers from omitted variable bias and measurement errors. The cross-section estimation cannot allow for individual country effects. Third, the endogeneity of one or more regressors are likely to make the cross-section estimation inconsistent. Thus, panel data analysis will be focused in the following empirical studies.

4.4.3 Panel Data Methodologies

The short-run estimations are based on 36 countries (cross-section) spanning six five-year periods and are analyzed by using different panel estimating techniques to judge the robustness of results. It needs to be noted that the panel of this empirical analysis has a small number of time-series period, T (T=6) and a large number of countries, N (N=36) which will affect the estimations. Following the growth empirical literature such as Bond, Hoeffler and Temple (2001) and Yakovlev (2007), the panel data methods applied in this study include the FEM, the FGLS estimator, the first-differenced GMM estimator and the system GMM estimator.

4.4.3.1 The Static Panel: the Fixed-Effect Model and FGLS Estimator

The FEM restricts the slope coefficients to be constant over both countries and periods and allows for an intercept coefficient which differs by countries or by periods. The growth equation of FEM to be estimated has the following form:

$$\begin{aligned} g_{it} = \eta_i + \gamma_t + (\alpha - 1)\, ln\, y_{i,t-1} + \beta_1 lnk_{it} + \beta_2 lnh_{it} \\ + \beta_3\, ln(n_{it} + g + \delta) + \beta_4 lnm_{it} + \epsilon_{it} \end{aligned} \tag{4.44}$$

for i=1, …, N and t=2,…, T

Here the two-way FEM is applied which allow for both the unobserved country-specific effect (η_i) and the period-specific intercepts(γ_t). η_i capture differences in the initial level of efficiency and γ_t reflect productivity changes which are common to all countries. Furthermore, η_i and γ_t may also reflect country and period specific components of measurement errors. So the estimation model specifies *i-1* country dummies, *t-1* time dummies, and applies the Least Squares with Dummy Variables (LSDV) estimator.

However, the lagged dependent variable on the right-hand-side of the growth equation is correlated with the error term. As shown by Nickell (1981), the LSDV estimator will provide biased and inconsistent estimates, particularly in the context of "small T, large N". If there is autocorrelation and a country-specific heteroskedasticity, the problems of the static panel data model will be more severe and the normality and homogeneity of error assumption will be violated. The use of a White's heteroskedasticity consistent covariance estimator with ordinary least squares (OLS) in fixed effects models can produce standard errors which are robust to unequal variance along the predicted line (Wooldridge, 2002). Hence the FGLS estimator is applied to control for the heteroskedasticity and first-order autocorrelation in the error term.

4.4.3.2 Dynamic Panel Approaches: the First-Difference GMM and the System GMM

The first-difference GMM, proposed by Arellano and Bond (1991) is introduced into the growth literature by Caselli, Esquivel and Lefort (1996, hereinafter CEL). The dynamic growth regression equation is firstly be taken the first-differences to remove unobserved country-specific effects and then in this first-differenced equation, levels of the series lagged two periods or more of the right-hand-side variables are used as instruments in the regression. By rewriting the above growth equation equivalently, the dynamic growth regression equation is:

$$\begin{aligned} lny_{it} &= \eta_i + \gamma_t + \alpha \, ln \, y_{i,t-1} + \beta_1 lnk_{it} + \beta_2 lnh_{it} \\ &+\beta_3 \, ln(n_{it} + g + \delta) + \beta_4 lnm_{it} + \epsilon_{it} \end{aligned} \tag{4.45}$$

for i=1, …, N and t=2,…, T

Taking the first differences, the first-differenced equation is:

$$\begin{aligned} lny_{it} - ln \, y_{i,t-1} &= \gamma_t - \gamma_{t-1} + \alpha\Delta \, ln \, y_{i,t-1} + \beta_1 \Delta lnk_{it} + \\ &\beta_2 \Delta lnh_{it} + \beta_3 ln \, (n_{\ it} + g + \delta) + \beta_4 \Delta lnm_{it} + \Delta\epsilon_{it} \end{aligned} \tag{4.46}$$

for i=1, …, N and t=3,…, T

Specially, the following assumptions are made. First, the transient errors are serially uncorrelated (i.e. $E[\epsilon_{it}\epsilon_{is}] = 0$ for i=1, …, N and $t \neq s$). Second, the initial conditions satisfy $E[lny_{i1}\epsilon_{is}] = 0$ for $t \geq 2$. Thus, lny_{it-2} and earlier values are correlated with $\Delta \ln y_{i,t-1}$, but not with $\Delta\epsilon_{it}$. The values of lny_{it} lagged two periods or more are valid instruments in the first differenced growth equation.

As in recent empirical growth models, regressors, X_{it} (i.e. the row vector of variables lnk_{it}, lnh_{it}, $\ln(n_{it} + n + \delta)$, and lnm_{it}) are all treated as endogenous variables. This means there exist correlations between the current value of regressors and current shocks to lny_{it}, as well as feedback from past shocks to lny_{it}. $E[X_{it}\,\epsilon_{is}] \neq 0$ for $s \leq t$ and $E[X_{it}\,\epsilon_{is}] = 0$ for $s > t$ are then derived. The moment conditions hold for the first-differences equations (Arellano and Bond, 1991) are as follows:

$$E(\Delta\epsilon_{it}y_{it-r}) = 0; E(\Delta\epsilon_{it}X_{it-r}) = 0 \qquad (4.47)$$

where *r*=2*, …, t-1* and *t*=3*, …, T*. So the values of the endogenous regressors lagged two periods or more are valid instruments as well. In the presence of heteroskedasticity, autocorrelation and endogeneity, Yaffee (2003) recommends that first-differences GMM estimation with robust (the White and Newy-West) panel standard errors is a robust estimator.

However, as shown by Blundell and Bond (1998, 2000) and Bond, Hoeffler and Temple (2001), when the time-series are persistent or close to random walk processes, the lagged values of the variables are only weakly correlated with the endogenous variables and are weak instruments. The first-differences GMM estimation also suffers from a loss of valuable observations. Under these conditions, the first-differences GMM estimation is likely to perform poorly and has poor finite sample properties (bias and imprecision). Instead, the system GMM estimator suggested by Arellano and Bover (1995) and Blundell and Bond (1998) is more plausible.

The system GMM estimator combines two sets of equations: the standard set of equations in first-differences and an additional set of levels equations. The first set of equations is the same as discussed for the first-differences GMM estimation. The other set of levels equations is:

$$lny_{it} = \eta_i + \gamma_t + \alpha\, ln\, y_{i,t-1} + \beta_1 lnk_{it} + \beta_2 lnh_{it} + \beta_3\, ln(n_{it} + g + \delta) + \beta_4 lnm_{it} + \nu_{it} \tag{4.48}$$

Blundell and Bond (1998) provide the additional assumption that:

$$E(\eta_i \Delta y_{i2}) = 0;\ E(\eta_i \Delta X_{it}) = 0 \tag{4.49}$$

The sufficient conditions for these additional assumptions are for the series X_{it} and y_{it} to have stationary/time-invariant means. These allow the use of the lagged first-differences of dependent and independent variables as instruments for the level equations. Blundell and Bond (1998) show that the system GMM estimator results in consistent and efficient parameter estimates, and has better asymptotic and finite sample properties than the straightforward first-differences GMM estimator.

As an empirical matter, specification tests proposed by Arellano and Bover (1995) are applied to test the validity of the instruments in our GMM estimation. First, the Arellano-Bond test for the serial correlation is adapted to test whether there is a second order serial correlation in the first-differenced residuals. The null hypothesis is that the residuals are serially uncorrelated. If the null hypothesis cannot be rejected, it provides the evidence that there is no second order serial correlation and the GMM estimator is consistent. Second, the Sargan test for over identifying restrictions is used to determine whether there is any correlation between instruments and residuals. The null hypothesis is that the instruments and the residuals are not correlated (i.e. the validity of instruments). Failure to reject this null hypothesis means that the instruments are valid.

4.4.4 Descriptions of Data and Data Sources

Data on 36 developing countries are derived from several different sources for the period 1975-2004. Data on GDP per capita, investment and population are obtained from the Penn World Table 6.2. Barro and Lee (2000) data set provides a proxy for human capital. Data on military burden are taken from various SIPRI yearbooks and SIPRI online database. Table 4.9 display names, description and summary statistics of the variables,

Table 4. 9 Variable Descriptions

Variable	***Description***	***Source***
lny	Log of real GDP per capita (Laspeyres)	PWT 6.2
lnlagy	Lagged of *lny*	
gr	the difference of *lny* between 2004 and 1975	
g	the difference of *lny* for the six five-year periods	
lnk	Five-year average investment as a share of GDP	PWT 6.2
lnngd	Five-year average population growth rate n plus 0.05	PWT 6.2
lnh	Average number of years of schooling of both sexes	
	25 years of age or older	Barro-Lee, 2000
m	Five-year average military expenditure as a share of GDP	SIPRI

For the empirical analysis, choosing appropriate data for the variables is one of the most important aspects. Each variable has different form of proxies. The data are basically chosen based on specification and availability. MRW use per worker GDP and the growth of the workforce. Due to lack of per worker data, per capita data and population growth rate are used in this analysis by following Islam (1995) and CEL (1996). Data on investment to GDP ratio are collected to proxy the saving rate. Technological progress pulsing the depreciation rate, $g+\delta$ is assumed to be constant across countries and equals 0.05 (see MRW, 1992). However the alternative measure 0.07 is also tried for a robustness check.

MRW use school enrolment rates as the proxy of human capital investment. The proxy of the average years of schooling is used instead in this study due to data availability. The data on average years of schooling of both sexes 25 years of age or older are obtained from Barro and Lee (2000) data set. The schooling data at the beginning year of each 5 year period are used. Following by Knight *et al.* (1996) and Dunne, Smith and Willenbockel (2005), military expenditure share data are used to measure the effect of military expenditure on growth.

The estimation samples of 36 countries include 16 South American countries, 15 Africa and 5 South Asia countries. Data are available for these 36 countries for all periods and the panel is balanced. In this section, the estimation methods described above are applied to the augmented Solow model with the military variable. The purpose is twofold. First, the growth effect of military expenditure will be examined for the cross-section data and the balanced panel data of 36 developing countries. Second, whether the importance of the econometric issues is borne out by the data will be investigated.

4.4.5 Cross-Section Analysis: The Long-Run Estimating Results

The long-run estimation results are reported in Table 4.10. The Augmented Solow growth equation is estimated by the OLS estimator with the White heteroskedasticity consistent standard errors and covariance. The estimated coefficient on the initial level of real GDP per capita is significantly negative. Thus there is an evidence of convergence that poor countries grow faster than rich countries. The estimated coefficients on *lnngd* and *lnh* are both significant with expected sign. *lnngd* has a negative effect on growth and *lnh* has a positive effect on growth. The estimated coefficient on *lnk* is insignificant. The growth effect of military expenditure is insignificant. Thus, the estimation results are not strong enough to make the conclusion of the negative effect from defence to economic growth in the long run.

Table 4. 10The Standard Cross-Section Regression

Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
Contant	1.0789***	0.3538	3.0490	0.0048
lnY75	-0.2884**	0.1193	-2.4163	0.0220
lnk	0.0168	0.0549	0.3061	0.7616
lnngd	-0.2004*	0.1097	-1.8281	0.0775
lnh	0.1428**	0.0635	2.2501	0.0319
lnm	-0.0738	0.0462	-1.5952	0.1211
R-squared	0.3441	Prob(F-statistic)	0.0212	

Notes:
1）*ln75* is the log of real GDP per capita in the initial year, 1975.
2）Significance levels: *** at 1%, ** at 5% and * at 10%.

4.4.6 The Dynamic Panel Results

The short-run estimation results are reported in Table 4.11. The econometrics package used is Stata 10. The first three columns of Table 4.10 report the results using the OLS levels, FEM and FGLS estimators, respectively. The fourth column presents the results using the first-differences GMM estimator and the last column reports from using the system GMM estimators. Since in small samples, standard errors tend to be underestimated by the two-step estimator, our reported results from GMM estimators are the one-step estimates.

Period dummies are found to be jointly significant in every regression. In order to conserve space, the coefficients on the period dummies are not presented.

As mentioned by Bond, Hoeffler and Temple (2001), omitting variables (i.e. unobserved country-specific effects) will give an estimate of the coefficient on *lnlagy* which is biased upward. The FEM will cause an estimate of this coefficient to be seriously downward biased. Thus， the estimated coefficient on *lnlagy* from OLS and FEM can be regarded as an approximate upper bound and lower bound, respectively. A consistent estimate of the coefficient can be expected to lie in these two bounds. This simple indication is useful to detect the first-differences GMM results. If the first-differences GMM estimate lies close to or below the FEM estimator, it is also biased downward due to weak instruments. As discussed above, the two-way fixed effect FGLS estimator and the system GMM estimator are expected to perform better empirically.

Beginning with OLS results, the estimated coefficients on all variables are statistically significant and with the expected sign. *lnngd* and *lnh* are only significant at the 10% level. The estimated coefficient on *lnm* is negatively and significantly related to economic growth. Then when a FEM estimator is used, the results show that military burden appears to be insignificant. Only the estimated coefficients on lagged GDP per capita and investment are significant. Column 3 presents the results using the two-way fixed effects FGLS estimator. It allows the estimation in the presence of panel specific AR (1) autocorrelation and heteroskedasticity across panels. All estimated coefficients are significant and with the expected signs. The estimated coefficient on *lnlagy* falls between the upper and lower bounds and military burden has a significant and negative effect on growth.

Table 4.11 The Effect of Military Expenditure in the Augmented Solow Growth Model

	OLS	***FEM***	***FGLS***	***DIF-GMM***	***SYS-GMM***
lnlagy	-0.0078**	-0.0505***	-0.0109***	-0.3483***	-0.0444***
	(-0.0033)	(0.0100)	(0.0026)	(0.1286)	(0.0190)
lnk	0.0056**	0.0138***	0.0060***	0.0732**	0.0757***
	(0.0018)	(0.0030)	(0.0015)	(0.0347)	(0.0220)
lnngd	-0.0036*	-0.0029	-0.0058***	-0.0189	-0.0332**
	(0.0021)	(0.0032)	(0.0018)	(0.0362)	(0.0259)
lnh	0.0029*	0.0010	0.0048***	-0.0486	0.0071
	(0.0017)	(0.0039)	(0.0014)	(0.0497)	(0.0167)
lnm	-0.0032***	-0.0020	-0.0037***	-0.0107	-0.0195*
	(0.0011)	(0.0020)	(0.0009)	(0.0181)	(0.0101)
constant	0.0181*	0.1476***	0.0245***	-	-
	(0.0104)	(0.0360)	(0.0080)	-	-
Arellano-Bond test	-	-	-	0.1634	
Sargan test	-	-	-	0.5644	0.8312

Notes：

1）Dependent variable is *growth.* Standard errors are shown in parentheses.

2）'DIF-GMM' is the first-differences GMM estimate and 'SYS-GMM' is the system GMM estimate. Instrument used for DIF-GMM are lagged two and further periods of lny_{it} lnk_{it}, lnh_{it}, $\ln(n_{it}+n+\delta)$, and lnm_{it}. Instruments used for first differenced equations in SYS-GMM are lagged two and further periods of lnk_{it}, lnh_{it}, $\ln(n_{it}+n+\delta)$, and lnm_{it}; for levels equations in SYS-GMM are Δlny_{it-2} Δlnk_{it-1}, Δlnh_{it-1}, $\Delta\ln(n_{it-1}+n+\delta)$, and Δlnm_{it-1}.

3）The figures reported for the Sargan test and Arellano-Bond test are the p-values for the null hypothesis.

4）Significance levels: *** at 1%, ** at 5% and * at 10%.

Using the first-differences GMM estimator, the estimated coefficient on *lnlagy* (-0.3483) lies below the corresponding FEM estimate. The first-differences GMM estimator is thus seriously biased downward. Only the estimated coefficients on initial income and investment are significant and the estimate of the estimated coefficient on human capital measure has an unexpected negative sign. So the first-differences GMM estimator is likely to be poorly behaved.

The last column of Table 4.11 presents the system GMM estimate. Here the estimate of the coefficient on *lnlagy* lies above the corresponding FEM estimate and below the corresponding OLS estimate. Physical investment has a significant and positive effect on growth. The variable of schooling years as the measure of human capital is not a significant determinants of economic growth. Both the growth rate of population and military burden had a significant and negative effect on growth.

Using the OLS levels, the FEM (LSDV), the FGLS, the first-differences and system GMM estimators, the effect of military burden on economic growth in Augmented Solow model is investigated. The estimated results are summarized as follows. First, military burden has a negative and significant effect on economic growth in the robust estimations (i.e. FGLS and the System GMM). It implies that after controlling for investment, population growth and human capital measurement, military burden exerts a direct negative impact on growth in 36 developing countries.

Second, the estimate coefficients on the initial level of income are significant and negatively related to economic growth by all estimators used above. This suggests the existence of “conditional convergence” and is consistent with the standard results of empirical growth literature. The convergence rate is only approximate 1% a year by the FGLS and the System GMM estimators which is similar with the finding of MRW. However, as Nerlove (2000) has mentioned, the measuring of convergence rate depends on the different choice of estimator. An uncertainty is acknowledged in this measurement result. Third, the comparison of different estimators and the estimate results both show the importance of the choice of robust estimators. The two-way fixed effects FGLS estimator and the System GMM estimator are robust estimators in this study and produce reasonable and compatible empirical results

Furthermore, the sample is divided into two groups: Cold War periods (1975-1989) and post-Cold War Periods (1990-2004) and both include 3 five-year periods. According to SIPRI Yearbook 2009, after the Cold War, most developed countries tend to decrease their military expenditure and there is a decreasing trend in the world military expenditure from 1988 to 1998. However, the world military expenditure has been increasing recently since 1999. Thus, we want to check the influence of these changes on the defence-growth relationship in our 36 sample developing countries. Because each panel only have 3 intervals, methods with first differencing would become unsuitable for small sample. So the two sub-groups are estimated by FGLS with two-way fixed effect. The estimating results are provided in Table 4.12.

The estimated coefficients of *lnm* are -0.0054 and -0.0018 for Cold War periods and post-Cold War periods, respectively. Thus, the absolute value of the estimated coefficient of *lnm* increases and the negative effect of military burden on economic growth becomes smaller. This provides the evidence to support the existence of a peace dividend after the Cold War. Comparing the estimated coefficients of *lnlagy* in the two sub-periods, we find that the conditional convergence speed becomes slower in the post-Cold war periods. However, the estimated coefficient of the investment ratio is insignificant in the post-Cold war periods. Furthermore, compared with the Cold War regression, all estimated coefficients of the Post-Cold War regression become smaller. The possible reason for this change is that other factors would influence economic growth rates which are not included in our regression equations. For example, international trade development, changes in international political environments and globalization might all play important roles in economic growth process in recent years.

Table 4.12 The Cold War Periods vs. the Post Cold War Periods

	Cold War		***Post-Cold War***	
Variable	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*
C	0.0498***	0.0108	0.0293***	0.0087
lnlagy	-0.0184***	0.0036	-0.0084***	0.0027
lnk	0.0080***	0.0019	0.0012	0.0018
lnngd	-0.0044**	0.0018	-0.0090***	0.0022
lnh	0.0067***	0.0016	0.0036*	0.0019
lnm	-0.0054***	0.0013	-0.0018*	0.0010

Notes:

Significance levels: *** at 1%, ** at 5% and * at 10%.

4.4.7 Cross-sectional and panel analysis conclusion

The impact of defence on economic growth is examined for 36 developing countries during 1975-2004. The long-run estimating results show that military burden has a negative effect on economic growth, albeit insignificant. Due to problems with the OLS estimator in the long-run estimation, the empirical results based on panel estimations provide more robust evidence to support the negative effect from defence to growth. The reasonable and compatible results are provided by the FGLS and the System GMM estimators based on 6 five-year periods panel data. The results indicate that defence has a significant and negative effect on economic growth in 36 sample developing countries. Furthermore, comparing with the Cold War period, the negative effect becomes smaller in the post-Cold War period. Thus, these panel estimating results provide strong evidences to support the existence of a peace dividend which indicates that a decrease in military expenditure would stimulate economic growth in developing countries.

4.5 Conclusion

"Guns kill in more ways than one."[23]

The defence-growth nexus has been an issue of keen concern in defence economics and there is a large amount of literature investigating the growth effect of military expenditure in developing countries. This chapter reviews a large body of the defence-growth literature which use different theoretical models, different empirical techniques and different samples. The reviewed literature is inconclusive as to the effect of defence on economic growth. Among various models and estimating methods, the Deger-type model in the

[23] Quote from Whynes (1979, p152)

framework of SEM is applied to examine the impact of defence on economic growth in India for the period 1970-2005. The 3SLS system estimating results indicate that defence has an overall significant and negative effect on economic growth in India. Using the Deger-type model and system estimating technique for single-country study do provide valuable results for the empirical analysis of the growth effect of defence.

The cross-sectional and panel data studies for 36 developing countries are also carried out. A variable of military burden is integrated into the augmented Solow growth model. Although the long-run results by the standard cross-sectional regression provide a negative but insignificant effect of military burden on economic growth, the short-run panel regressions present reasonable and robust results by applying more recent econometric techniques such as the FGLS and the System GMM estimators. The empirical panel results indicate that defence has a significant and negative effect on economic growth in 36 sample developing countries.

Thus, the empirical estimations support the negative effect of defence on growth and are consensus of Whynes (1979)'s opinion that guns really kill in more ways than one in developing countries. Compared with the existing studies on defence-growth nexus, the empirical studies in this chapter are based on specific circumstances of a single country or a group of developing countries with specific regression models and advanced econometric methodologies which make contributions to the defence economics literature.

Chapter 5 Conclusions

5.1 Summary and Conclusions

This chapter summarises the empirical results of the earlier chapters and provides the general conclusions of this thesis. The core issues of this study have been to investigate the causes and effects of military expenditure in India. We concentrate on three aspects of this subject. These three aspects link well with the core stylised facts of the Indian defence effort and her developmental problems: the 'security dilemma' in terms of its relationship with its neighbour, Pakistan; the core factors that motivate the demand for defence as a public good; the economic impact of militarization and the effect of defence on development. Our analyses therefore focus on three inter-linked topics, although for tractability we deal with them separately. First, the arms race between India and Pakistan is analyzed by using a Richardson action-reaction model and cointegration techniques. Second, the demand for India's military expenditure is explored by applying the neoclassical demand model and the autoregressive distributed lag (ARDL) approach to cointegration. Third, the effect of India's military expenditure on its economic growth is examined by employing the Deger type model and 3SLS method. Furthermore, the relationship between military expenditure and economic growth is studied in a broader context, namely, in a cross-sectional and panel data study of 36 developing countries.

In Chapter 2, the review of literature on theoretical arms race models is presented. There are many different types of arms race models. The classical Richardson action-reaction model and some representative models of its variants, which are reviewed in this section, are also discussed. The key elements of those variants include emulation, rivalry, submissiveness, bureaucracy, public opinion and social welfare maximization. Then the Intriligator and Brito strategic deterrence-attack model is introduced. This chapter also reviews literature on empirical studies of the arms race between India and Pakistan. Different theoretical and empirical models were applied to explore the India-Pakistan arms race while those empirical results were controversial.

The aim of Chapter 2 is to investigate the existence of an arms race between India and Pakistan. Based on the analysis of the conflict history between India and Pakistan since their independence in 1947 and the dynamics of India and Pakistan's military expenditure, it has been found that there is an interaction between India and Pakistan's arms acquisition process. In many ways their military expenditures have been driven by the arms race with each other which could be characterized by an action-reaction model. Hence, the classical Richardson arms race model is employed for the empirical study. Then the econometric methodologies are provided and assessed. Data on India and Pakistan's real military expenditure between 1960 and 2007 are used to explore the long-run relationship between India and Pakistan's arms acquisition process. The existence of unit root and structural breaks in the series are estimated by using different methods. Finally, both traditional cointegration tests and more recent techniques taking into account a structural break are applied to investigate the possible long-run relationship between India and Pakistan's real military expenditure. The empirical results of different cointegration tests all indicate the existence of a cointegrating relation between the two counties' real military expenditure, even after taking into account a structural break. Since the existence of a cointegrating relation implies a stable long run relationship, we believe that the hypothesized post independence arms race does indeed exist. Although domestic factors are important, as we show later, the existence of a military rival creates an environment of continuing long-run military spending dynamics. Thus Chapter 2 concludes that there are quite strong evidences to support the existence of an enduring arms race between India and Pakistan.

In Chapter 3, the demand for India's military expenditure is examined. This chapter reviews the theoretical models of the demand for military expenditure which focus on the framework of the neoclassical demand model. The empirical literature on the determinants of military expenditure in developing countries is also reviewed. The determining factors are grouped by military activities, economic and geo-strategic factors, the political environment and other related factors. After investigating the security concerns of India, the determining factors of India's military expenditure are specified which include economic variables, political variables and security considerations (internal and external). Specially, the military spending of Pakistan is included in the regression equations to capture the effect of arms race on India's military expenditure. The focus in this chapter is on the domestic economy and polity of India; however, given the conclusions of the previous chapter the linkages with Pakistan cannot be ignored. The autoregressive distributed lag approach to cointegration is employed to investigate the demand for India's real military expenditure for the period 1960-2006. The empirical results indicate that the demand for India's military expenditure is mainly determined by its income, political status, the perceived threat from Pakistan and the external wars with Pakistan and China. Even though India's military expenditure is influenced by many factors, Pakistan's military spending still plays an important role in India's arms acquisition process which is consistent with the finding of Chapter 2.

Chapter 4 provides empirical studies of the effect of military expenditure on economic growth not only in India but also in 36 developing countries. The theoretical and empirical literature on the defence-growth relationship is reviewed. Seven groups of different models are discussed which include Benoit's work, demand side models, supply side models, Deger type models which incorporate demand and supply side factors, Barro models, Solow models and Granger causality analysis. Among those models, the Deger type model is preferred for the single country studies while the Solow growth model is employed for cross-sectional studies.

Thus firstly, Chapter 4 examines the net effect of military expenditure on economic growth in India for the period 1970-2003 in the framework of Deger type model. By applying 3SLS approach, four equations are estimated systemically which include growth equation, saving equation, trade balance equation and defence equation. The defence equation for India is based on the analysis of the demand for India's military expenditure in chapter 3. The empirical results indicate that there is a direct effect of military expenditure on growth which is positive and significant and represents the spin-off from defence on growth in India. However, India's military expenditure also has indirect and negative effects on economic growth which through the interdependence between defence, savings and balance of trade. Defence might depress saving ratio and balance of trade in India and hence after taking both direct and indirect effects together, the net effect of India's military spending on economic growth is significant and negative where the negative indirect effects dominate the direct growth-stimulating effect in India.

Secondly, Chapter 4 studies the influence of military expenditure on economic growth in developing countries. The augmented Solow growth model which incorporates a military variable is used in the cross-sectional and panel data estimations for 36 developing countries in Africa, Latin America and South Asia over the period of 1975 to 2004. Standard cross-sectional regressions are carried out and the results show that the growth effect of military expenditure is insignificant. Then based on 6 five-year periods panel data, different panel data estimating methods are operated including OLS levels, FEM, FGLS, the first-differences and System GMM estimators The reasonable and compatible results are provided by FGLS and System GMM estimators which indicate that defence has a negative and significant effect on economic growth in the sample countries. Furthermore, the negative effect becomes smaller after the Cold War period. Chapter 4 concludes that both the single country study of India and the cross-sectional estimations for 36 developing countries provide strong evidences to support the existence of peace dividend which indicate that a decrease in military expenditure would stimulate economic growth in developing countries.

The main findings and contributions of this thesis could be summarised as follows:

1. ***There is an enduring arms race between India and Pakistan.***

There is a long run relationship between their real military expenditures, even after taking into account a structural break. More advanced econometric methods for unit root, structural breaks and cointegration tests are employed. Specially, a regime shift (structural break) is found endogenously in 1997. Compared with the period before 1997, the real military expenditure of India increases by a larger per cent after 1997, with respect to the increase in the real military expenditure of Pakistan. Thus, the preparation of nuclear tests in 1998 by both India and Pakistan might cause a regime shift in the long run relationship between their real military expenditures.

2. ***The demand for India's military expenditure is determined by economic, political and security factors.***

By employing the ARDL approach to cointegration, the demand for India's military expenditure is estimated and the results indicate that its military expenditure is mainly determined by income, political status, the perceived threat from Pakistan and the external wars both in the long-run and in the short-run. Specially, Pakistan's defence burden has a positive and significant effect on India's military expenditure which provides an evidence to support the existence of arms race between India and Pakistan.

3. ***Military expenditure has a significant and negative effect on economic growth in India and in 36 developing countries.***

By applying the Deger type model and 3SLS approach, the effects of India's military expenditure on its economic growth are estimated and the empirical results show that the net effect of defence on growth is significant and negative in India during 1970-2003. For 36 developing countries between 1975 and 2004, both cross-sectional and panel results indicate that the increases in military spending would reduce economic growth. Specially, the uses of robust estimators (FGLS and System GMM) and augment Solow model with human capital variable and military variable are noteworthy and have added to literature on the defence-growth relationship.

5.2 Further Research

This thesis has strengths but is far from perfect where some limitations exist. Here, we review some of the limitations and propose possible solutions which could be possible directions for further research.

There are some limitations in Chapter 2. Firstly, the arms race between India and Pakistan is empirically analyzed by using real military expenditure data. However, the accuracy and reliability of military expenditure data are always problematic due to many reasons such as different definitions, different measurements and different data sources. Furthermore, the India-Pakistan arms race might be estimated by using not only military expenditure data but also arms stock and military personnel data. That will depend on better data availability. Secondly, as we discussed, there might be more than two players in an arms race. In the case of India, China could be another important factor that influences India's arms acquisition process. Thus, there is a possible multi-player arms race among India, China and Pakistan where India responds to China and Pakistan and Pakistan responds to India. In the case of Pakistan, Afghanistan may play a similar role where Pakistan's military preparedness against one neighbour may constitute a threat to the other neighbour. Thirdly, in our empirical analysis of India-Pakistan arms race for the period 1960-2007, one structural break is used to allow for a regime shift in 1997. Two structural breaks could be estimated in the cointegration framework relying on a longer period and improved methodologies.

The main limitation of Chapter 3 is data availability. Internal security challenges do influence India's military expenditure but data and the suitable proxy for internal security are very hard to access. Data on annual insurgencies number, casualties and activities of terrorists in India need to be collected in further studies. Also, India treats China as its major external threats. The data on Chinese military expenditure are also problematic.

In Chapter 4, there are still some limitations due to data availability and reliability. One of the main problems in growth models is the use of human capital variables. In terms of India's growth equation, there is no proper data available for India's human capital. In our panel data analysis, data on average number of years of schooling are used as a proxy of human capital. However, similar with other available data such as the education expenditure and enrolment ratio, data on schooling years are not output but input of human capital. Thus, those data are not expected to provide good indicators for a country's human capital. Better human capital data offers scope for further work.

This thesis has added to knowledge of defence economics by its comprehensive analyses of the causes and effects of India's military expenditure. It also provides a panel data estimations of the defence-growth relationship in 36 developing countries. The empirical studies are based on specific circumstances of a single country or a group of developing countries with specific regression models and econometric methodologies. The empirical results of this thesis are noteworthy and make contributions to the defence economics literature.

References

Aizenman, J. and Glick, R. (2003). Military Expenditure, Threats and Growth. *NBER Working Paper , 9618*， Massachusetts.

Aizenman, J. and Glick, R. (2006). Military Expenditure, Threats and Growth. *The Journal of International Trade & Economic Development: An International and Comparative Review*, *15* (2), 129 – 155.

Alesina, A. , Spolaore, E. and Wacziarg, R. (2008). Trade, Growth and Size of Countries. in (ed), P. Agnion, S.N.Durlauf, *Handbook of Economic Growth*, North Holland, Amstrerdam (2008)

Anderton, C. (1992). A New Look at the Relationship Among Arms Races, Disannament, and the Probability of War. In M. C. Forcey, *Disarmament, Economic Conversion, and Management of Peace.* New York: Praeger.

Arellano, M. and Bover, O. (1995). Another Look at the Instrumental Variable Estimation of Error-Components Models. *Journal of Econometrics*, *68*, 29-52.

Arellano,M. and Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and An Application to Employment Equations. *Review of Economic Studies*, *58*, 277-297.

Bahmani-Oskooee, M. and Nasir, A. (2004). ARDL Approach to Test the Productivity Bias Hypothesis. *Review of Development Economics*, *8* (3), 483-488.

Ball, N. (1983). Defence and Development: A Critique of Benoit Study. *Economic Development and Cultural Change*, *31* (3), 507-524.

Ball, N. (1988). *Security and Economy in the Third World.* London: Adamantine Press Limited.

Barrett, R. and S. Sen. (2009). War and Peace: Rational Defence and the Case of South Asia. *the Public Choice Society Annual Meeting.* Las Vegas.

Barro, R J. and X. Sala- i-Martin. (1995). *Economic Growth.* The MIT Press.

Barro, R. J. and Lee, J. W. (2000). International Data on Educational Attainment: Updates and Implications. *CID Working Paper No. 42*.

Batchelor, P. Dunne, P. and Lam, G. (2002). The Demand for Military Spending in South Africa. *Journal of Peace Research*, *39* (3), 339-354.

Batchelor, P., Dunne, P. and Saal, D. (2000). Military Spending and Economic Growth in South Africa. *Defence and Peace Economics*, *11* (6), 553–571.

Benoit, E. (1978). Growth and defence in LDCs. *Economic Development and Cultural Change , 26*, 271-280.

Biswas, B. and Ram R. (1986). Military Spending and Economic Growth in Less Developed Countries: An Augmented Model and Further Evidence. *Economic Development and Cultural Change*, *34* (2), 361-372.

Blundell, R. and Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics*, *87* (1), 115-143.

Blundell, R. and S. Bond. (2000). GMM Estimation with Persistent Panel Data: An Application to Production Functions. *Econometric Reviews*, *19* (3), 321-340.

Bond, S., Hoeffler, A. and Temple, J. (2001). *GMM Estimation of Empirical Growth Models,No 2001-W21.* Economics Group, Nuffield College, University of Oxford.

Bremer. (1986). *The GLOBUS Model.* Boulder: Westview.

Brito, D.L. and M.D. Intriligator . (1995). Arms Race and Proliferation. In K. a. Hartley, *Handbook of Defence Economics* (pp. 109-164). Amsterdam: Elsevier Science.

Caselli, F., G. Esquivel and Lefort, F. (1996). Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth*, *1*, 363-389.

Charemza, W.W. and Deadman, D.F. (1992). *New Directions in Econometric Practice.* Aldershot: Edward Elgar.

Choucri, N. and R. C. North. (1975). *Nations in Conflict.* San Francisco: W. H. Freeman.

Chowdhury, A. (1991). Defence Spending and Economic Growth. *Journal of Conflict Resolution , 35* (1), 80-97.

Christiano, L. (1992). Searching for a Break in GNP. *Journal of Business and Economic Statistics , 10*, 237-249.

Clemente, J., Montanes, A., and Reyes, M. (1998). Testing for a Unit Root in Variables with a Double Change in the Mean. *Economics Letters*, *59*, 175-182.

Collier, P. and Hoeffler, A. (2002). *Military Expenditure: Threats, Aid and Arms Races.* World Bank Policy Research Working Paper 2927, Washington.

Collier, P., Hoeffler, A., Elliot, L., Hegre, H., Reynal-Querol, M. and Sambanis, N. (2003). *Breaking the Conflict Trap: Civil War and Development Policy.* Washington, DC and New York : Oxford University Press and the World Bank .

Cusack, T. R. and M. D. Ward. (1981). Military spending in the United States, Soviet Union, and the People's Republic of China. *Journal of Conflict Resolution*, *25*, 429-469.

Dakurah A. H., Davies, S. P. and Sampath, R. K. (2001). Defense Spending and Economic Growth in Developing Countries: A Causality Analysis. *Journal of Policy Modelling*, *23*, 651–658.

Deger, S. and Sen S. (1983). Military Expenditure, Spin-off and Economic Development. *Journal of Development Economics*, *13*, 67-83.

Deger, S. and Sen, S. (1995). Military ExpenditLires and Third World Countries. In K. Hartley, & T. Sandler (Eds.), *Handbook of Defense Economics* (Vol. 1, pp. 275–307). Amsterdam: Elsevier.

Deger, S. and Sen, S. (1990). Military Security and the Economy: Defence Expenditure in India and Pakistan. In K. H. Sandler, *The Economics of Defence Spending.* London and New York: Routledge.

Deger, S. and Smith, R. (1983). Military Expenditure and Growth in Less Developed Countries. *Journal of Conflict Resolution*, *27* (2), 335-353.

Deger, S. (1986a). Economic Development and Defence Expenditure. *Economic Development and Cultural Change*, *35* (1), 179-196.

Deger, S. (1986b). *Militanẏ Expenditure and Third World Countries: The Economic Effect.* London: Routledge and Kegan Paul,.

Dickey, D. and W. A. Fuller. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association, 74*, 427-431.

Division, U. N. (2008). Government Final Consumption Expenditure by Function at Current Prices. *UN Data.* Accessed in 08/2009. http://data.un.org/Data.aspx?q=government+&d=SNA&f=group_code%3a301.

Dommen, E. and Maizels, A. (1988). The Military Burden in Developing Countries. *The Journal of Modern African Studies*, *26* (3), 377-401.

Dunne, J. P., Smith, R. P. and Willenbockel, D. (2005). Models of Military Expenditure and Growth: A Critical Review. *Defence and Peace Economics*, *16* (6), 449-461.

Dunne, J.P. and Mohammed N.A.L. (1995). Military Spending in Sub-Saharan Africa. *Journal of Peace Research*, *32* (3), 331-343.

Dunne, J.P., Nikolaidou, E. and Roux, A. (2000). Defence Spending and Economic Growth in South Africa: A Supply and Demand Model. *Defence and Peace Economics*, *11* (4), 573 — 585.

Dunne, P. and Perlo Freeman, S. (2003a). The Demand for Military Spending in Developing Countries. *International Review of Applied Economics*, *17* (1), 23-48.

Dunne, P. and Perlo Freeman, S. (2003b). The Demand for Military Spending in Developing Countries: A Dynamic Panel Analysis. *Defence and Peace Economics*, *14* (6), 461-474.

Dunne, P. and R. Smith. (2007). The Econometrics of Arms Races. In Hartley, K. and Sandler, T., *Handbook of Defence Economics* (Vol. 2, pp. 913-940). Amsterdam: Elsevier.

Dunne, P., Eftychia, N. and Smith, R. (1999). Arms Race Models and Econometric Applications. *The Arms Trade, Security and Conflict.* Middlesex University Business School.

Dunne, P., Perlo Freeman, S. and Smith, R. (2008). The Demand for Military Expenditure in Developing Countries: Hostility versus Capability. *Defence and Peace Economics, 19* (4), 293 - 302.

Engle, R.F. and C.W.J. Granger. (1987). Co-integration and error correction: Representation, estimation and testing. *Econometrica, 55*, 251-76.

Engle, R.F. and Yoo, B.S. Cointegrated Economic Time Series: an O (Alesina, A. Enrico Spolaore and RomainWacziarg)verview with New Results. In R. a. Engle, *Long Run Economic Relationships.* Oxford: Oxford University Press.

Faini, R., Annez. P. and Taylor, T. (1984). Defence Spending. Economic Structure and Growth Evidence among Countries and Overtime. *Economic Development and Cultural Change*, *32* (3), 487-498.

Feder, G. (1983). On Exports and Economic Growth. *Journal of Economic Development*, *12*, 59-73.

Frederiksen, P. C and Looney, R. E. (1983). Defence Expenditures and Economic Growth in Developing Countries. *Armed Forces and Society*, *9* (4), 633-645.

Galvin, H. (2003). The Impact of Defence Spending on the Economic Growth of Developing Countries: A Cross-Section Study. *Defence and Peace Economics, 14* (1), 51–59.

Government final consumption expenditure by function at current prices. (n.d.). Retrieved 08/2009, from UN data.
http://data.un.org/Data.aspx?d=SNA&f=group_code%3a301%3bitem_code%3a11

Gregory, A. W and Hansen, B. E. (1996). Tests for Cointegration in Models with Regime and Trend Shifts. *Oxford Bulletin of Economics and Statistics*, *58*, 555-560.

Gregory, A. W. and B. E. Hansen. 1996. (1996). Residual-Based Tests of Cointegration in Models with Regime Shifts. *Journal of Econometrics, 70*, 99-126.

Hartley, K. and Sandler, T. (1995). *Handbook of Defence Economics, Vol. 1.* North Holland: Amsterdam.

Hartley, T. and B. Russett. (1992). Public Opinion and the Common Defense: Who Governs Military Spending in the United States? *American Political Science Review*, *86* (4), 905-915.

Hewitt, D. (1996). Military Expenditures 1972-1990: The Resons Behind The Post-1985 Fall In World Military Spending. *Public Budgeting and Financial Management*, *7* (4), 520-558.

Hollist, W. L. (1977). Alternative Explanations of Competitive Arms Processes: Tests on Four Pairs of Nations. *American Journal of Political Science*, *21* (2), 313-340.

Huang, C. and Mintz, A. (1991). "Defence Expenditure and Economic Growth: The Externahty Effect. *Defence Economics*, *3* (2), 35-40.

India Security Threat Environment. (1998). *Retrieved at 08/2009.*
http://www.fas.org/irp/world/india/threat/index.html.

Intriligator, M. D. and D. L. Brito. (1986). Arms Races and Instability. *Journal of. Strategic Studies*, *9*, 113-131.

Intriligator, M. D. and D. L. Brito. (1984). Can Anns Races Lead to the Outbreak of War? *Journal of Conflict Resolution*, *28* (1), 63-84.

Intriligator, M. D. and D. L. Brito. (1976). Formal Models of Arms Races. *Journal of Peace Science*, *2* (1), 77-88.

Intriligator, M. D. (1975). Strategic Considerations in the Richardson Model of Arms Race. *Journal of Political Economy*, *83* (2), 339-353.

Isard, W. and C.H. Anderton. (1988). A Survey of Anns Race Models. In W. Isard, *Arms Races, Arms Control and Conflict Analysis* (pp. 17-85). Cambridge: Cambridge University Press.

Islam, N. (1995). Growth Empirics: A Panel Data Approach. *Quarterly Journal of Economics*, *110* (4), 1127-1170.

Johansen, S and K. Juselius. (1990). Some Structural Hypotheses in a Multivariate Cointegration Analysis of the Purchasing Power Parity and the Uncovered Interest Parity for UK. *Discussion Papers 89-11.* University of Copenhagen. Department of Economics.

Johansen, S. (1992). Determination of Co-integration Rank in the Presence of a Linear Trend. *Oxford Bulletin of Economics and Statistics*, *54*, 383–397.

Johansen, S. (1995). *Likelihood-based Inference in Cointegrated Vector Autoregressive Model.* Oxford: Oxford University Press.

Karagianni and Pempetzoglu. (2009). Defense Spending And Economic Growth In Turkey: A Linear And Non-Linear Granger Causality Approach. *Defence and Peace Economics*, *20* (2), 139–148.

Klein, T. (2004). Military Expenditure and Economic Growth: Peru 1970-1996. *Defence and Peace Economics*, *15* (3), 275 - 288.

Knight, M., Loayza, N. and Villanueva, D. (1996). The Peace Dividend: Military Spending Cuts and Economic Growth. *IMF Staff Papers*, 1-44.

Kollias, C., Naxakis, C. and Zarangas, L. (2004). Defence Spending and Growth in Cyprus: A Causal Analysis. *Defence and Peace Economics*, *15* (3), 299 — 307.

Kusi, N. K. (1994). Economic Growth and Defence Spending in Developing Countries. *Joumal of Conflict Resolution*, *38* (1), 152-159.

Kwiatkowski D., Phillips P.C.B., Schmidt P., and Y.Shin. (1992). Testing the Null of Stationarity against the Alternative of a Unit Root. *Journal of Econometrics*, *54*, 159-178.

Lai, C.N., Huang, B.N. and Yang, C.W. (2005). Defense Spending and Economic Growth Across the Taiwan Straits: A Threshold Regression Model. *Defence and Peace Economics ,* *16* (1), 45–57.

Lee, C. C. and Chen, S. T. (2007). Do Defence Expenditures Spur GDP? A Panel Analysis From OECD And Non-OECD Countries. *Defence and Peace Economics*, *18* (3), 265–280.

Lee, J. and Strazicich, M.C. (2004). Minimum LM Unit Root Test with One Structural Break. *Working Paper, Department of Economics*, Appalachian State University, North Carolina.

Lee, J. and Strazicich, M.C. (2003). Minimum LM Unit Root Test with Two Structural Breaks. *Review of Economics and Statistics*, *63*, 1082-1089.

Liossatos, P. (1980). Modeling the nuclear arms race: a search for stability. *Journal of Peace Science*, *4*, 169-185.

Looney, R. (1989). Internal and External Factors in Effecting Third World Military Expenditures. *Journal of Peace Research*, *26* (1), 33-46.

Lucier, C. E. (1979). Changes in the Values of Arms Race Parameters. *Journal of Conflict Resolution*, *23* (1), 17-39.

Lumsdaine, R. L and. Papell, D. H. (1997). Multiple Trend Breaks and the Unit Root Hypothesis. *Review of Economics and Statistics*, *79* (2), 212-218.

Luterbacher, U. (1976). Arms Race Models: Where Do We Stand? *European Journal of Political Research*, *3*, 199–217.

Maddala, G.S. and Kim, I.M. (1998). *Unit Root, Cointegration and Structural Change.* Cambridge: Cambridge University Press.

Maizels, A. and Nissanke, M. (1986). The Determinants of Military Expenditure in Developing, Countries. *World Development*, *14* (9), 1125-1140.

Majeski, S. (1983). Mathematical Models of the U. S. Miltary Expenditure Decision-Making Processes. *American Journal ofPolitical Science*, *27*, 485-514.

Mankiw, N. G., Romer, D. and Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, *107*, 407–437.

McGuire, M. C. (1965). *Secrecy and the Arms Race.* Cambridge: MA: Harvard University Press.

Mintz, A. and Stevenson, R. T. (1995). Defense Expenditures, Economic Growth, and the 'Peace Dividend': A Longitudinal Analysis of 103 Countries. *Journal of Conflict Resolution*, *39*, 283–305.

Murdoch, J. C., Pi, C.R. and Sandler, T. (1997). The Impact of Defense and Non-defense Public Spending on Growth in Asia and Latin America. *Defence and Peace Economics*, *8* (2), 205–224.

Murdoch, J.C. and Sandler, T. (2002b). Civil Wars And Economic Growth: A Regional Comparison. *Defence and Peace Economics*, *13* (6), 451–464.

Murdoch, J.C. and Sandler, T. (2002a). Economic Growth, Civil Wars, and Spatial Spillovers. *Journal of Conflict Resolution*, *46* (1), 91-110.

Nerlove, M. (2000). Growth Rate Convergence, Fact or Artifact? An Essay on Panel Data Econometrics. In E. Ronchetti (Ed.), *Panel Data Econometrics: Future Directions: Papers in Honour of Professor Pietro Balestra.* Amsterdam: North-Holland.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica , 94* (5), 1002-1037.

Öcal, N. (2003). Are the Military Expenditures of India and Pakistan External Determinants for Each Other: An Empirical Investigation. *Defence and Peace Economics*, *14*, 141 - 149.

Oren, I. (1994). The Indo-Pakistani Arms Competition: A Deductive and Statistical Analysis. *Journal of Conflict Resolution*, *38* (2), 185-214.

Ostrom, C.W. and Marra, R.F. (1986). US Defense Spending and the Soviet Estimate. *American Political Science Review, 80*, 819-842.

Perron, P. and Vogelsang, T. J. (1992). Nonstationarity and Level Shifts with an Application to Purchasing Power Parity. *Journal of Business and Economic Statistics*, *10*, 301–320.

Perron, P. (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Econometrica, 57*, 1361-1401.

Pesaran, M. H. and Shin, Y. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. In S. H. Strom, *Centennial Volume of Ragnar Frisch.* Cambridge: Cambridge University Press.

Ram, R. (1995). Defense expenditure and economic growth. In K. Hartley, & T. Sandler (Eds.), *Handbook of Defense Economics* (pp. 251–273). Amsterdam: Elsevier.

Ramos, E. M. (2004). CountrySurvey XIX: Mexico. *Defence and Peace Economics*, *15* (1), 83–99.

Rattinger, H. (1975). Armaments, Detente, and Bureaucracy. *Journal of Conflict Resolution*, *19* (4), 571-595.

Reitschuler, G. and Loening, J.L. (2005). Modeling the Defense-Growth Nexus in Guatemala. *World Development*, *33* (3), 513–526.

Richardson, L. F. (1960). *Arms and Insecurity: A Mathematical Study of Causes and Origins of War.* Pittsburgh: Boxwood Press.

Rosh, R. (1988). Third World Militarization: Security Webs and the States They Ensure. *Journal of Conflict Resolution*, *32* (4), 671-698.

Said, S. E. and D. A. Dickey. (1984). Testing for Unit Roots in Autoregressive-Moving Average Models of Unknown Order. *Biometrika , 71*, 599-607.

Sezgin, S. (2001). An Empirical Analysis of Turkey's Defence-Growth Relationships with A Multi-Equation Model (1956-1994). *Defence and Peace Economics*, *12* (1), 69 — 86.

Sezgin, S. (1997). Country survey X: Defence spending in Turkey. *Defence and Peace Economics*, *8* (4), 381–409.

Siljak, D. D. (1977). On the Stability of the Arms Race. In J. V. Zimmes, *Mathematical Systems in International relations reserch.* New York: Praeger Publishers.

SIPRI. (various years). *SIPRI Yearbook, World Armaments and Disarmaments.* Oxford: Oxford University Press.

Smith, R. (1980). Military Expenditure and Investment in OECD Countries 1954-1973. *Journal of Comparative Economics*, *4* (1), 19-32.

Smith, R. (1989). Models of Military Expenditure. *Journal of Applied Econometrics*, *4* (4), 345-359.

Smith, R. (1995). The Demand for Military Spending. In Hartley, K. and Sandler, T., *Handbook of Defense Economics.* Amsterdam: Elsevier Science.

Smith, R.P., Dunne, P. and Nikolaidou, E. (2000). The Econometrics of Arms Races. *Defence and Peace Economics*, *11*, 31-43.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, *70*, 65-94.

Stock, J.H., and M. W. Watson. (1993). A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems. *Econometrica, 61*, 783-820.

Stroup, M.D. and Heckelman, J.C. (2001). Size Of The Military Sector And Economic Growth: A Panel Data Analysis Of Africa And Latin America. *Journal of Applied Economics*, *IV* (2), 329-360.

Sun,Q. and Yu,Q. (1999). Determinants of China's Military Expenditures: 1965-93. *Journal of Peace Research*, *36*, 23-33.

Tambudzai, Z. (2005). Determinants of Zimbabwe's Military Expenditure, 1980-2003. *The Biennial Conference of the Economic Society of South Africa (ESSA).* Durbanm, South Africa.

Tambudzai, Z. (2007). Military Burden Determinants in Southern Africa, 1996-2005: A Cross-section and Panel Data Analysis. *Economic Development in Africa Conference.* Oxford: St Catherine's College.

Wallace, M.D. and J.M. Wilson. (1978). Non-linear Arms Race Models. *Journal of Peace Research*, *15*, 175-192.

Ward, M. D., Davis, D., Penubarti, M., Rajmaira, S. and Cochran, M. (1991). Military Spending in India: Country Survey I. *Defence Economics*, *3* (1), 41-63.

Weede, E. (1986). Rent Seeking, Military Participation and Economic Performance in LDCs. *Journal of Conflict Resolution*, *30*, 291-314.

Whynes, D. (1979). *The Economics ofThird World Military Expenditures.* Austin: University of Texas Press.

Wolfson, M. (1968). A Mathematical Model of the Cold War. *Peace Research Society*, *9*, 107-123.

Wolfson, M. (1990). Perestroika and the quest for peace. *Defense Economics*, *1* (3), 221-232.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross-section and Panel Data.* MIT Press, Cambridge, MA.

World Development Indicators. (n.d.). Retrieved 2009, from World Bank Database: http://esdsw2.mc.manchester.ac.uk/WDS_WB/TableViewer/dimView.aspx?ReportId=57

Yaffee, R. (2003). *Connect: Information technology*.
Retrieved from www.nyu.edu/its/socsci/Docs/pda.pdf.

Yakovlev, P. (2007). Arms Trade, Military Spending, and Economic Growth. *Defence and peace Economics*, *18* (4), 317–338.

Yildirim, J. and Sezgin, S. (2005). Democracy and Military Expenditure: A Cross-Country Evidence. *Transition Studies Review*, *12* (1), 93-100.

Yildirim, J., Sezgin, S. and Ocal, N. (2005). Military Expenditure and Economic Growth in Middle Eastern Countries: A Dynamic Panel Data Analysis. *Defence and Peace Economics, , 16* (4), 283–295.

Yu, M. (2002). The Impact of US-China Relations on Taiwan's MIlitary Spending: An Analytical Model of Error Correction Mechanism. *APSA's Annual Meeting.* Boston.

Zivot, E. and Andrews, K. (1992). Further Evidence On The Great Crash, The Oil Price Shock, and The Unit Root Hypothesis. *Journal of Business and Economic Statistics. , 10* (10), 251–270.

Appendix

Table A1 Real military expenditure of India and Pakistan (at constant 2000 price US$), 1960-2007

Year	***MEI***	***MEP***	***Year***	***MEI***	***MEP***
1960	1321.799	381.9202	1984	5924.147	2021.198
1961	1426.415	378.0614	1985	6627.872	2189.434
1962	1960.404	362.2588	1986	7672.583	2395.653
1963	3208.831	391.6982	1987	8369.799	2532.142
1964	3132.25	441.388	1988	9264.527	2485.322
1965	3061.708	712.6479	1989	9875.283	2500.679
1966	2883.094	831.1688	1990	9694.537	2652.806
1967	2693.723	676.9279	1991	9068.909	2815.423
1968	2815.647	695.9878	1992	8692.082	3011.685
1969	2983.993	756.6471	1993	9806.598	3005.727
1970	3076.893	825.6237	1994	9851.336	2912.659
1971	3668.71	988.3939	1995	10122.75	2963.012
1972	3868.027	1095.882	1996	10317.7	2972.152
1973	3416.427	961.0761	1997	11410.88	2840.754
1974	3181.502	958.6795	1998	11918.63	2836.277
1975	3576.109	964.0188	1999	13840.15	2859.627
1976	4191.85	966.8556	2000	14285.71	2870.457
1977	4077.015	965.7902	2001	14786.69	3071.972
1978	4239.154	1030.303	2002	14740.18	3289.02
1979	4453.845	1134.763	2003	15071.15	3518.876
1980	4729.271	1285.38	2004	15497.36	3670.599
1981	4960.858	1395.466	2005	17978.45	3815.276
1982	5390.918	1682.265	2006	19070.01	3857.854
1983	5611.84	1880.543	2007	19407.92	3835.264

Source: SIPRI Yearbook (various years)

Table A2 Defence Burden of India and Pakistan, 1960-2007

Year	***DBI***	***DBP***	***Year***	***DBI***	***DBP***
1960	1.9	2.8	1984	3.4	6.6
1961	1.9	2.6	1985	3.4	6.5
1962	2.6	2.4	1986	3.4	7.1
1963	3.8	2.4	1987	3.6	6.9
1964	3.6	2.6	1988	3.6	6.2
1965	3.6	4	1989	3.5	6
1966	3.4	4.5	1990	3.2	5.8
1967	3.1	3.5	1991	3	5.8
1968	3.1	3.4	1992	2.8	6.1
1969	3	3.5	1993	2.9	5.7
1970	3	3.8	1994	2.8	5.3
1971	3.4	4.5	1995	2.7	5.3
1972	3.5	7.2	1996	2.6	5.1
1973	3	6.2	1997	2.7	4.9
1974	3	6.1	1998	2.8	4.8
1975	3.3	6	1999	3.1	3.8
1976	3.4	5.7	2000	3.1	3.7
1977	3	5.4	2001	3	3.8
1978	3.4	5.5	2002	2.9	3.9
1979	3.5	5.6	2003	2.8	3.7
1980	3.2	5.7	2004	2.9	3.6
1981	3.2	5.9	2005	2.8	3.5
1982	3.3	6.6	2006	2.6	3.3
1983	3.3	6.9	2007	2.5	3.1

Source: SIPRI Yearbook (various years)

Table A3 Military Personnel of India and Pakistan, 1985-2005 (Thousands)

Year	***Military Personnel***
1985	1260.0
1989	1260.0
1990	1260.0
1991	1270.0
1992	1270.0
1993	1270.0
1994	1270.0
1995	2149.5
1996	2223.0
1997	2223.0
1998	2265.0
1999	2263.0
2000	2372.0
2001	2352.7
2002	2387.7
2003	2414.7
2004	2617.0
2005	3047.0

Source: World Bank Development Indicator, 2009.

Table A4. Estimation Results for the First Differenced SEM (1970-2003)

		Estimation method					
	Explaining variables	*3SLS*		*2SLS*		*OLS*	
Growth equation	*dlns*	-0.15	0.19	-0.11	0.22	-0.03	0.07
	dlndbi	-0.20	0.13	-0.11	0.15	0.01	0.10
	dlntb	0.00	0.01	0.00	0.01	0.00	0.01
	dlnl	-0.33	0.32	-0.32	0.36	-0.31	0.31
	constant	0.04	0.01***	0.04	0.01***	0.04	0.01***
Saving equation	*dlndbi*	0.23	0.68	1.14	0.47	0.76	0.36**
	g	-0.80	0.88	-0.22	1.01	-0.37	0.58
	dtb	-0.03	0.04	-0.03	0.04	-0.01	0.03
	dlninf	-0.02	0.03	-0.04	0.04	-0.03	0.03
	dlnng	-0.26	0.68	-0.36	0.79	-0.61	0.51
	constant	-0.05	0.04	0.02	0.05	0.04	0.03
Balance of trade equation	*dlndbi*	-1.96	2.78	-1.29	3.05	1.09	1.90
	g	-1.99	6.47	-2.30	7.09	-1.81	3.88
	dlnreer	-5.97	2.39**	-6.10	2.63**	-5.40	2.35**
	ddummy	-0.09	0.46	0.15	0.52	0.11	0.50
	constant	-0.18	0.54	-0.22	0.61	-0.18	0.52
Defence equation	*dlngdpci*	-0.45	0.37	-0.20	0.45	-0.20	0.45
	dlnpop	-1.42	4.22	-1.64	5.04	-1.44	4.98
	dlndemoc	-0.41	0.31	-0.47	0.37	-0.45	0.36
	dtb	0.01	0.02	0.02	0.03	0.02	0.02
	dlndbp	0.15	0.10	0.17	0.12	0.17	0.12
	dwar	0.07	0.03**	0.08	0.03**	0.08	0.03**
	constant	0.04	0.09	0.04	0.11	0.03	0.10

Notes: Significance levels: *** at 1%, ** at 5% and * at 10%.

Table A5 Unit Root Tests

The Null Hypothesis: Residual has a unit root		
	t-statistics	***Prob.***
Residual 1	-5.928	0.000***
Residual 2	-4.878	0.000***
Residual 3	-3.293	0.023**
Residual 4	-2.965	0.050**

Notes:

1) MacKinnon (1996) one-sided p-values.

2) Significance levels: *** at 1%, ** at 5% and * at 10%.

3) Residual 1, 2, 3, 4 are from growth equation, saving equation, trade balance equation and defence equation, respectively.

A6**:** List of Variables Descriptions in Empirical Estimations

Chapter 2

LNMEI	the logarithm of the real military expenditure of India
LNMEP	the logarithm of the real military expenditure of Pakistan

Chapter 3

mei	India's real military expenditure in constant 2000 million US$
gdpc	India's GDP per capita in constant 2000 US$
pop	Total population of India valued in millions
cge	the share of central government expenditure of India in its GDP
tb	India's share of trade balance in GDP
democ	democracy index
dbp	the defence burden of Pakistan as a rival of India
sw	the security web of India
riots	the number of riots in India in one year as a internal threat proxy
war	War dummy for the India's external wars with Pakistan and China

Chapter 4

For the study of India:

g	the growth measured as the log of real GDP minus the log of real GDP in the previous year
s	the share of gross national saving to GDP
tb	the balance of trade measured by the share of external balance on goods and services to GDP
m	India's military expenditure measured by the share of military expenditure to GDP

l	the rate of population growth as a proxy for labour growth
inf	the inflation rate
ng	the share of non-defence government expenditure to GDP,
reer	real effective exchange rate
dummy	a dummy variable for second oil shock in 1980
gdpc	India's GDP per capita in constant 2000 US$
pop	the total population of India valued in millions
democ	the democracy index
dbp	the defence burden of Pakistan as a rival of India
war	War dummy for the India's external wars with Pakistan and China

For the study of cross-sectional and panel data of 36 developing countries:

lny	Log of real GDP per capita (Laspeyres)
lnlagy	Lagged of *lny*
gr	the difference of *lny* between 2004 and 1975
g	the difference of *lny* for the six five-year periods
lnk	Five-year average investment as a share of GDP
lnngd	Five-year average population growth rate n plus 0.05
lnh	Average number of years of schooling of both sexes 25 years of age or older
m	Five-year average military expenditure as a share of GDP

A7 Literature Review on the Defence-Growth Relationships for Chapter 4, Section 4.2

4.2.1 Benoit's (1978) work

Based on cross-section methods, Benoit (1978) estimated a sample of 44 LDCs for the period 1950-1965 and found that "countries with a heavy defence burden generally had the most rapid rate of growth and those with the lowest defence burdens tended to show the lowest growth rates." His estimations are based on the following regression equation:

$$AG' = \propto_0 + \beta_1 AB + \beta_2 AI + \beta_3 AR_2 + \varepsilon \qquad (4.1)$$

where AG' is the civilian growth rate, AB is the defence burden, AI is the investment ratio and AR_2 is bilateral aid. All variables are averaged over the period 1950-1965; ε is the error term. Alternative regression equations with fewer independent variables were also estimated. The results indicate that defence burden is a significant determinant of growth. Benoit also tests the effects of growth on defence and find that growth seems to only have a weak influence on defence burdens. Thus, he believes that the causation between economic growth and defence burden appears to go from defence to growth rather than vice versa.

By analyzing the opportunity costs and benefits of defence on growth, Benoit denotes that the defence sector may make contributions to civilian sectors and the opportunity cost of defence expenditure may be quite low. The reason of possible low opportunity cost is that the alternative uses of resources which are not spent on defence might go into consumption and social investment rather than productive investments. Thus, a heavier defence burden can increase the total uses of resource and the benefits of defence can offset the adverse growth effects.

However, as the starting point of studying defence-growth relationships, Benoit's work has some weaknesses which are criticised by subsequent research. Frederiksen and Looney (1983) extend Benoit's work by using the same sample, the same period and the same estimating method. They criticise Benoit's 44 LDCs sample as unsuitable and the estimation is based on a presumption that the defence burden can account for a reasonable share of the unallocable explanatory power. They claim that the sample countries should be divided into groups with similar characteristics. In their studies, sample countries are divided into two groups: poor countries (resource constrained) and relatively rich countries (relatively abundant financial resources). Their estimating results indicate that defence plays an important and positive role in enhancing growth for relatively rich countries but poor countries experience a negative growth effect.

Biswas and Ram (1986) re-estimate Benoit's regression equations for 58 LDCs for the periods1960-1970 and 1970-1977. The samples are also separated into low-income and middle-income LDCs. GDP growth is regressed as a function of the labour force growth rate, the ratio of investment in GDP and military burden. They find that the estimated coefficient on military burden is statistically insignificant for the low-income LDCs in both periods. The empirical results indicate that Benoit's result is a special case and cannot be reproduced.

Ball (1983) criticizes Benoit's work on his defined variables and the interpretations of the regression. There are serious problems in definition of foreign aid and the interpretation of relationships between foreign aid, military expenditure and economic growth. Another problem is the potentially favourable growth effects of defence burden. Rather than regression analysis, Benoit claims that the net effect of defence burden on economic growth is positive which is only based on his assessment of non-quantifiable benefits from defence to growth.

4.2.2 Demand-side Models

4.2.2.1 Theoretical Models

The demand-side models are based on the Keynesian theory which treats military expenditure as a component of the aggregate demand. The national accounting identity specifies the demand side and can be written as:

$$Y = Q - W = C + I + M + B \tag{4.2}$$

where *Y* is actual output, *Q* is potential output, *W* is the gap between the actual and potential output, *C* is the aggregate consumption, I is the investment (public and private), *M* is the real military expenditure, and *B* is the balance of trade. In terms of the share of potential output, the Equation (4.2) can be rearranged as:

$$i = 1 - w - c - m - b \tag{4.3}$$

Smith (1980) provides the share of consumption as follows:

$$c = \alpha_0 - \alpha_1 u - \alpha_2 g \tag{4.4}$$

where *u* is the unemployment rate and *g* is the growth rate of actual output. Increases in *u* and *g* can reduce the share of consumption of potential output. Then:

$$i = (1 - \alpha_0) + \alpha_1 u + \alpha_2 g - m - (w + b) \tag{4.5}$$

Assuming that (w+b), which reflects the balance between domestic demand and potential supply, is related to u, unemployment rate, one could get:

$$(w + b) = \beta u \tag{4.6}$$

Thus:

$$i = (1 - \alpha_0) - (\beta - \alpha_1)u + \alpha_2 g - m \tag{4.7}$$

The Equation (4.7) can examine the possibility of crowding-out. Military burden is apt to have a negative effect on investment and then this crowding-out effect will have a negative effect on growth.

4.2.2.2 Empirical Studies

Demand side models are used to investigate the possibility of a crowding-out effect (i.e. as one source of demand, military expenditure would compete for scarce resources with other sources). Faini, Annez and Taylor (1984) suggest that in poor countries, increases in military expenditure are associated with lower investment and saving shares in GDP and would likely limit the output growth. Based on the Keynesian demand identities, they provide a regression equation to empirically estimate the effect of military expenditure as follows:

$$Y' = g_0 + g_1 E' + g_2 P' + g_3 \Delta a + g_4 \Delta F + g_5 K' + g_6 \left(\frac{Y}{P}\right) + \varepsilon \tag{4.8}$$

where Y' is the growth rate of GDP, E' is the growth rate of exports, P' is the growth rate of population, Δa is the change in share of arms spending in GDP, ΔF is the change in capital inflows from abroad, K' is the growth rate of the country's capital stock, (Y/P) is GDP per capita, and ε is a error term.

Using a fixed effect model, Faini, Annez and Taylor (1984) estimate the effect of arms spending on growth for subgroups of 69 countries for the period 1950-1972. Their empirical results indicate that military expenditure has a clear negative impact on the growth rate for all developing country groups in the sample. The impact of defence burden on the investment share in GDP is also traced by their study and they find that an increase of 1% in the defence burden is associated with a reduction of 0.23% in the investment share in GDP. Thus military expenditure partly crowds-out investment and slows growth. Furthermore, the time-series estimation for India is carried out for the period covering period 1950- 1971. For India, defence spending had a negative impact on economic growth but the relationship between defence burden and investment share is positive which presents opposite results with cross-section estimations.

Deger (1986b) investigates investment equations with defence as an independent variable for 50 LDCs, 1965-1973. The investment ratio of GDP is a function of the growth rate, the defence burden and other variables such as exports, imports and the balance of payments (all as proportions of GDP). The cross-sectional results show that the estimated coefficients of defence burden in all alternative investment equations are statistically significant and negative. The absolute value of the coefficient of defence burden is below unity (about one-third). Thus, there is little doubt empirically that military expenditure partly crowds out investment in LDCs.

Knight *et al.* (1996) examines the relationship between defence and investment in 79 countries for the period 1971-1985. The ratio of investment in fixed capital is regressed as a function of the rate of investment in human capital, the restrictiveness of the trade system, the incidence of war proxy and the defence burden. Their panel data estimating results reveal that increases in military expenditure have a statistically significant and negative impact on investment and prove the existence of the crowding-out effect.

These empirical analyses of demand-side models have been criticized for the failure to consider supply side issues and are apt to be associated with a negative impact on economic growth because defence spending crowds-out investment. Sandler and Hartley (1995) suggest that both the supply-side and demand-side influences should be constructed in a model to provide a more accurate analysis of the defence-growth relationship.

Table 4.1 Review on Benoit and Demand Side Literature

Author(s)	***Sample***	***Remarks***	***Main Conclusion***
Panel A: Benoit Studies			
1 Benoit (1978)	44 LDCs, 1950-1965	Correlations and cross-sectional estimation (OLS)	Positive and significant effect of defence spending on growth.
2. Frederiksen and Looney (1983)	44 LDCs, 1950-1965	Subgroups cross-sectional estimation	Defence plays an important and positive role in enhancing growth for relatively rich countries but poor countries experience a negative growth effect.
3. Biswas and Ram (1986)	58 LDCs, 1960-1970, and 1970-1977	Subgroups cross-sectional estimation	Insignificant effect of defence spending on growth for the low-income LDCs.
Panel B: Demand Side studies			
4. Faini, Annez and Taylor (1984)	69 countries (mainly LDCs), 1952-1970	Subgroups cross-sectional time series estimation	Negative effect of military burden on investment and economic growth in LDCs.
5. Deger (1986b)	50 LDCs, 1965-1973	Cross-sectional estimation	Negative effect of military burden on investment.
6. Knight *et al.* (1996)	79 countries, 1971-1985	Panel estimation (fixed effect)	Negative effect of military burden on investment.

4.2.3 Supply-side models

4.2.3.1 Theoretical models

The supply-side models are based on Feder's (1983) model of the effects of exports on economic growth. Biswas and Ram (1986) employs Feder's methodology for analysing the defence-growth relationship in a two-sector (military and civilian) framework and since then many other studies have employed several versions of the Feder-Ram model. The models consider the externality effect of military sector and the factor productivity variation between the two sectors.

The basic two-sector model assumes that the economy consists of two distinct sectors: defence output, M and civilian output, C. Labour (L) and capital (K) are the two inputs and homogeneous for the two sectors. Defence output has an "externality" effect on the civilian output. Production functions for the two sectors are in form of:

$$M = M(L_M, K_M), \qquad C = C(L_c, K_c, M) \tag{4.9}$$

The factor endowment constraints can be written as:

$$L = L_M + L_C, K = K_M + K_C \tag{4.10}$$

and the sum of M and C is total output (Y):

$$Y = M + C \tag{4.11}$$

It further allows the marginal productivities across M and C sectors to differ by:

$$\frac{M_K}{C_K} = \frac{M_L}{C_L} = 1 + \delta \tag{4.12}$$

where the subscripts refer to the partial derivatives of M and C with respect to the subscripted input.

In this model, military output affects the aggregate output through two channels. First, $C_M\,(\partial C/\partial M)$ is the one channel which represents the externality effect of military output on the civilian output. Second, the second channel is δ which implies the relative factor productivity difference between the two sectors. If δ>0, the productivity in the defence sector is higher, and thus when inputs are shifted to the more productive defence sector, aggregate output will increase.

Taking time derivatives of Equations (4.9) and (4.11) and using the information from Equations (4.10) and (4.12), an equation for growth of aggregate output can be derived:

$$\dot{Y} = \alpha\frac{I}{Y} + \beta\dot{L} + (\frac{\delta}{1+\delta} + C_M)\dot{M}\frac{M}{Y} \quad (4.13)$$

$$\beta = C_L\frac{L}{Y}\,, \alpha = C_K \quad (4.14)$$

where a dot over the variable indicates its rate of growth (e.g. $\dot{Y} = [(dY/dt)/\,Y\,]$) and I indicates aggregate investment.

Assuming the externality parameter is $C_M(M/C)$ and is denoted by θ in the following form:

$$C = M^{\theta}H(K_c, L_C) \quad (4.15)$$

Then Equation (4.13) can be reformulated as:

$$\dot{Y} = \alpha\frac{I}{Y} + \beta\dot{L} + \left(\frac{\delta}{1+\delta} - \theta\right)\dot{M}\frac{M}{Y} + \theta\dot{M} \quad (4.16)$$

which permits the separate identification of the externality and the factor productivity difference effect.

The basic two-sector model can be augmented by including more sectors such as exports and government sectors. But Ram (1995) indicates that such multi-sectoral modelling seems problematic and hazardous to be applied to get separate information about the external effects and factor productivity differences relative to any sector.

Although the Feder-Ram models are grounded in the neoclassical theory of growth (Mintz and Stevenson (1995)), there exist some potential theoretical problems. First, the above analysis ignores the effect of demand side elements. Second, it has basic interpretation problems. As argued by Dunne, Smith, and Willenbockel (2005), the production functions (4.16) are specified for a given invariant level of intra-sectoral organizational or X-efficiency. The Feder-Ram model is by construction incapable of accounting for intra-sectoral organizational inefficiencies.

4.2.3.2 Empirical Studies

Biswas and Ram (1986) firstly employ the Feder-type two-sector model to analyse the impact of military expenditure on economic growth. They suggest that the Feder model is grounded in the neoclassical production-function framework and can lead to a conventional linear regression equation as follows:

$$\dot{Y} = \beta_1 \frac{I}{Y} + \beta_2 \dot{L} + +\beta_3 \dot{M} \frac{M}{Y} + \mu \quad (4.17)$$

$$\dot{Y} = \beta_1 \frac{I}{Y} + \beta_2 \dot{L} + +\beta_3 \dot{M} \frac{M}{Y} + \beta_4 \dot{M} + \mu \qquad (4.18)$$

where $\dot{Y}$ is the annual rate of growth of total output (GDP), I/Y is the investment-output ratio, $\dot{L}$and $\dot{M}$ are the annual growth rates of the labor force and military expenditure, respectively, and μ is the error term. Equation (4.17) only can estimate the overall effect (the externality effect and the relative sectoral factor productivity differential) but Equation (4.18) can estimate these two effects separately.

Biswas and Ram (1986) use the average value of variables over period 1960-1970 and 1970-1977 for the full sample 58 countries and for two sub-samples (17 Low-income LDCs and 41 Middle-income LDCs). The estimating results of Biswas and Ram (1986) indicate that in both groups and for both periods, most of the estimated coefficients of $M^{\cdot}(M/Y)$ and $\dot{M}$ are insignificant. Thus, military expenditure has no significant effect on growth and the relative sectoral factor productivity differential is statistically insignificant.

Mintz and Stevenson (1995) employ a three-sector Feder model to investigate the effect of military expenditure on economic growth. There are civilian (C), non-military public (N) and military (M) sector in the model. The estimation equation is based on Huang and Mintz (1991)'s study which disaggregate the government output into non-military and military sector. The regression equations can be written as:

$$\dot{Y} = \alpha \frac{I}{Y} + \beta \dot{L} + (\delta'_n + C_N) \left[\dot{N} \left(\frac{N}{Y} \right) \right] + (\delta'_m + C_M) \left[\dot{M} \left(\frac{M}{Y} \right) \right] + \mu \qquad (4.19)$$

$$\dot{Y} = \alpha \frac{I}{Y} + \beta \dot{L} + \delta'_n \left[\dot{N} \left(\frac{N}{Y} \right) \right] + \pi_n \left[\dot{N} \left(\frac{C}{Y} \right) \right] + \delta'_m \left[\dot{M} \left(\frac{M}{Y} \right) \right] + \pi_m \left[\dot{M} \left(\frac{C}{Y} \right) \right] + \mu \tag{4.20}$$

where $\dot{Y}$ is the annual rate of growth of total output (Y) , I/Y is the investment-output ratio, $\dot{L}$, $\dot{N}$ and $\dot{M}$ are the annual growth rates of the labour force, non-military public expenditure and military expenditure, respectively, and μ is the error term. C_N and C_M represent the marginal externality effect of the non-military public sector and military sector on the non-government sector, respectively. In Equation (4.19), $\delta'_i + C_i$, $i = n, m,$ can be interpreted as the total effect of sector i on growth. In Equation (4.20), $\delta'_i, i = n, m$, capture the direct effect of sector i on economic growth, while $\pi_i, i = n, m$, denote the externality effect which is the effect of sector i on economic growth through its effect on other sectors.

Mintz and Stevenson (1995) estimate Equations (4.19) and (4.20) for each of the 103 countries for different periods between 1950 and 1985. Their finding indicates that the non-military public spending has a significant and positive impact on economic growth whereas the impact of military spending on growth is insignificant for most countries. Furthermore, by comparing the estimated coefficients, they find that the externality effect for both the non-military public and military spending is small in relation to the total effect. Following the similar three-sector Feder model, Murdoch, Pi and Sandler (1997) present time-series and cross-sectional estimates for two cohorts which consist of 8 Asian and 16 Latin American countries. They suggest that the estimations should be applied to a well-defined cohort of nations which have similar economic, political and regional characteristics. For econometric method, the appropriate method can be the one which pooled time-series, cross-sectional estimations. Their time-series results are inconclusive as expected but by using the two-way fixed effect model for the panel data, the results indicate that military spending and other forms of public spending are all growth-promoting in Asia and Latin America which are consistent with Benoit's finding. However, for Latin America countries, other forms of public spending are more productive than military spending.

Yildirim, Sezgin and Ocal (2005) use the recent static and dynamic panel estimation techniques to examine the effects of military expenditure on economic growth for the Middle Eastern countries and Turkey during the period 1989-1999. Base on traditional two-sector Feder model, their empirical analysis indicate that military expenditure enhances economic growth in the Middle Eastern countries and Turkey as a whole and the defence sector is more productive than the civilian sector. According the income level, they divide the sample countries into three groups: low, middle and high income countries and their comparative analysis reveal consistent results with the full sample.

Different with the above cross-national literature, some studies focus on the defence-growth relationship in individual developing countries. Ward *et al.* (1991) apply a three-sector Feder model to investigate the effect of military expenditure in India for the period 1950-1987. The regression equation is in form of:

$$\begin{aligned}\dot{Y} = &\propto_0 + \propto I + \beta \frac{Y}{L}\dot{L} + \left(\frac{\delta_m}{1+\delta_m} - \theta_m\right)\dot{M} + \theta_m \frac{\dot{M}}{S} Y \\ &+ \left(\frac{\delta_n}{1+\delta_n} - \theta_n\right)\dot{N} + \theta_n \frac{\dot{N}}{S} Y + \varepsilon\end{aligned} \qquad (4.21)$$

where Y is the total output, M is the military sector, N is the non-military state sector and S is the state sector. Growth is a function of investment (I), the change in labour [$(Y/L)\,\dot{L}$], the size effect of military expenditure ($\dot{M}$), the externality effect of military expenditure $[(\dot{M}/S)Y]$, the size effect of non-military expenditure ($\dot{N}$) and the externality effect of non-military expenditure $[(\dot{N}/S)Y]$. As usual, ε is the error term. The authors use historical, empirical and other heuristic information to make speculations about the signs of the coefficients and most have been borne out by their empirical analysis. They find that the size effect of military sector is positive but the non-military state sector has a negative size effect. The overall impact of state spending on growth seems to be slightly negative. The civilian sector has a greater marginal productivity than state sectors in India. Furthermore, there are no spill-over benefits from the military sector.

Employing the two-sector Feder mode, Sezgin (1997) estimate the effect of defence spending on economic growth in Turkey over the period 1950-1993. His empirical results indicate that the total effect and the size effect of defence spending on growth are significant and positive, but the externalities from defence sector are negative. The civilian sector is more productive that the defence sector in Turkey. The study makes two other contributions. Firstly, it adds a human capital variable into the Feder model by using the share of educational expenditure in the government budget. However, due to the likely inadequate proxy for human capital, the results are not improved and the estimated coefficient for human capital is statistically insignificant. Secondly, it analyses the defence-growth relationship over the 44 years period 1950-1993 in Turkey and find that the effect of defence spending is not constant. The size impact of defence spending on economic growth began positive but become negative quickly, whereas the externality effect of defence spending began negative and then turns insignificant.

Batchelor, Dunne and Saal (2000) undertake empirical analysis of the impact of military expenditure on economic growth and on the manufacturing sector in South Africa for the period 1964-1995. The two-sector Feder type model is applied in their study. Instead of using the conventional regression equation as above, the instantaneous rate of change of the variables are replaced by their discrete equivalents. The regression equation can be written as:

$$\Delta Y_t/Y_{t-1} = \propto_0 + \propto_1 \Delta L_t/L_{t-1} + \propto_2 \Delta K_t/K_{t-1} + \propto_3 \Delta M_t/M_{t-1}(M_t/Y_{t-1}) + \propto_4 \Delta M_t/M_{t-1} + \mu \qquad (4.22)$$

where *Y* is total output, *L* is labour, *K* is capital and *M* is military spending. For the estimation of the effect of military spending on manufacturing sector, *Y* is now the manufacturing component of GDP (value added), *L* is manufacturing employment, *K* is the manufacturing capital stock *and M* is domestic military procurement expenditure. An additional estimation procedure, the Autoregressive Distributed Lag method is used to allow the data to capture the short run dynamics. The empirical analyses based on both estimations indicate that there is no significant effect of military expenditure on the aggregate output growth, but military expenditure has a significant and negative effect on the manufacturing output growth in South Africa.

Reitschuler and Loening (2004) investigate the defence-growth nexus for Guatemala by using longitudinal data 1951-2001 and the two-sector Feder model. They employ recently developed econometric methods to take into account the possible non-linearity relationship between defence and growth. The regression framework is given by:

$$\frac{\frac{dY(t)}{dt}}{Y(t)} = \propto \frac{I(t)}{Y(t)} + \beta \frac{\frac{dL(t)}{dt}}{L(t)} \frac{L(t)}{Y(t)} + \omega^i \frac{\frac{dD(t)}{dt}}{D(t)} \frac{D(t)}{Y(t)} + \theta^i \frac{\frac{dD(t)}{dt}}{D(t)} \qquad (4.23)$$

where:

$$i = \begin{cases} 1\ if\ D(t) \leq \gamma \\ 2\ if\ D(t) > \gamma \end{cases} \tag{4.24}$$

where *Y* is total output, *D* denotes defence sector, *I* is investment and *L* is labour force. γ is the threshold parameter which is estimated by finding the value of *D(t)* that minimizes the sum of squared residuals in the non-linear regression of Equations (5.13) and (5.14). They provide new evidences on the defence-growth nexus for Guatemala that military spending only has a positive effect on growth under a comparatively low threshold. Their estimations indicate that the threshold is around 0.33% of GDP. Beyond that level, the effect of military spending on economic growth becomes negative (albeit non-significant). The defence sector is less productive than the civilian sector in Guatemala.

The review of most of the supply side (Feder type) literature in Table 4.2 has found no significant or a positive effect of military expenditure on economic growth in developing countries with different samples, different time periods and different estimating techniques. However, Dunne, Smith and Willenbockel (2005) suggest that there are a number of empirical technique problems with respect to testing the Feder type model. The empirical estimation of Equation (4.16) can be written in the form of:

$$\dot{Y} = \beta_1 \dot{L} + \beta_2 \frac{I}{Y} + \beta_3 \dot{M} \frac{M}{Y} + \beta_4 \dot{M} + \epsilon \tag{4.25}$$

First, the regression treats labour and capital asymmetrically, which with the growth rate as the variable and with share of investment as the variable, respectively. Second, if the share of military expenditure is constant, changes in the output will determine the changes or growth of military expenditure. Then when we have the growth rate of military expenditure on the right hand side, there is a severe simultaneity problem. Third, there may be high multicollinearity between the final two terms in Equation (4.25). It will cause imprecise estimates of the externality and/or the factor-productivity difference parameters. Finally, the model is static and without lagged dependent variables. It will cause a slow adjustment in time-series analysis and omitted important variable (i.e. initial income) problem in cross-section studies. So Dunne, Smith and Willenbockel (2005) conclude that "there seem to be strong theoretical and econometric reasons not to use the Feder-Ram model".

Table 4.2 Review on Supple Side (the Feder type) Literature

Author(s)	***Sample***	***Remarks***	***Main Conclusion***
Panel A: Cross-national Studies			
1. Biswas and Ram (1986)	58 LDCs, 1960-1970 and 1970-1977	Two sector: civilian and defence, Cross-sectional time series estimations.	No significant effect of defence spending on growth.
2. Mintz and Stevenson (1995)	103 countries, around 1950-1985	Three sector: civilian, defence and non-military public sector, Longitudinal estimates	No significant relationship between military expenditure and growth.
3. Murdoch, Pi and Sandler (1997)	8 Asia countries and 16 Latin America countries, Different periods between 1955-1988	Three sector: civilian, defence and non-military public sector, Time series estimates for each country and panel estimates (fixed effect models) for Asia and Latin America groups.	Defence spending and other forms of public spending are all growth promoting in Asia and Latin America. However, non-military public spending is a more effective way to growth in Latin America.
4. Yildirim, Sezgin and Ocal (2005)	Middle Eastern countries and Turkey, 1989-1999	Two sector: civilian and defence, Dynamic panel estimations (fixed effect model and GMM model).	Military expenditure enhances economic growth and defence sector is more productive than the civilian sector.
Panel B: National studies			
5. Ward et al. (1991)	India, 1950-1987	Three sector: civilian, defence and non-military public sector, Time series estimations	Military expenditure has a positive impact on growth but non-military state sector has a negative size effect.
6. Sezgin (1997)	Turkey, 1950-1993	Two sector: civilian and defence, Human capital is incorporated into the Feder model. Time series estimations.	There is a significant positive relation between military size and economic growth. The addition of human capital into the Feder model did not improve results.
7. Batchelor Dunne and Saal (2000)	South Africa, 1964-1995	Two sector: civilian and defence; manufacturing and defence, Time series estimations and ARDL procedures.	Military spending has no significant impact on aggregate growth, but there is a significant negative impact for the manufacturing sector.
8.Reitschuler and Loening (2004)	Guatemala, 1951-2001	Two sector: civilian and defence, Time series estimation involving threshold model.	For relatively low level, Military expenditure has significant and positive effect on economic growth. For higher level, the effect becomes negative, albeit insignificant.

4.2.4 The Demand and Supple-side Models

4.2.4.1 Theoretical Methods

Deger and Smith (1983), Deger and Sen (1983, 1995) and Deger (1986a, 1986b) develop a simultaneous equation model (SEM) and attempt to capture both the positive direct effects through the Keynesian demand stimulation and other spinoff effects, and the negative indirect effects through reductions in savings or investments. For instance, the Deger and Sen (1995) model consists of four equations, including a growth equation, a saving equation, a trade balance equation and a defence equation. The 4-equation SEM is as follows:

$$
\begin{aligned}
g &= a_0 + a_1 s + a_2 m + a_3 B + a_4 Z_1 \\
s &= b_0 + b_1 m + b_2 g + b_3 B + b_4 Z_2 \\
B &= c_0 + c_1 m + c_2 g + c_3 Z_3 \\
m &= d_0 + d_1 Z_4
\end{aligned}
\tag{4.26}
$$

where g is the growth rate of GDP, s is the saving ratio, m is military expenditure as a share of GDP, B is the trade balance share in GDP, Z_i are a set of exogenous variables which are chosen through data specification, and (a_1, b_i, c_i, d_i) is the set of parameters.

Deger (1986b) argues that the econometric model should allow for the following:

(i) A direct effect of military expenditure on growth through various spin-offs (modernisation and resource mobilisation);

(ii) An indirect effect through saving ratio;

(iii) The explicit modelling of open economy considerations;

(iv) The endogeneity of military expenditure.

So the SEM can examine the interaction of growth, saving, trade and military expenditure. The direct spin-off from military to civilian growth is apt to be positive. However, the effects of military burden on saving and trade balance are apt to be negative. When the direct and indirect effects are taken together to estimate a net impact of military burdens on growth, it provides:

$$\frac{dg}{dm} = \frac{a_2 + a_1(b_1 + b_3c_1) + a_3c_1}{1 - (a_1b_2 + a_1b_3c_2 + a_3c_2)} \tag{4.27}$$

The Deger type SEM studies are noteworthy because they combine both the supply and demand sides of the economy which enable the estimation of a net impact of military burdens on economic growth through a 3SLS procedure. However, these models have been criticised for relying on an *ad hoc* theoretical specification. The derivation of the estimating equation is not strongly based on theory and is not always clear. While the growth equation is derived from a theoretical framework, it does not include the effect of human capital on growth. Despite some of these weaknesses, the SEM studies overcome problems of exogeneity, simultaneity and causality that may bias the estimation of the defence-growth nexus when analyzed in a single equation.

4.2.4.2 Empirical studies

In the defence-growth literature, some studies (reviewed in Table 4.4) have analyzed both demand and supply side factors of economic growth. Deger and Sen (1983), Deger and Smith (1983) and Deger (1986a, 1986b) develop models comprising both demand and supply side factors to analyse the defence-growth nexus in LDCs. Using the same sample of 50 developing countries over period 1965-1973, they simultaneously estimate three or four equations representing growth, saving or investment, balance of trade and defence by three stage least squares (3SLS) methods. Deger and Sen (1983)'s estimations include three equations: growth, investment ratio and defence burden and reveal that defence spending has a positive direct impact on growth and a negative indirect effect through reducing investment. Thus the net effect of defence spending on economic growth is negative.

Deger and Smith (1983) and Deger (1986a) estimate three equations including growth, saving ratio and defence burden equation. Even they include different variables in the system, the consistent results present that defence spending has a direct positive effect on growth but this is out-weight by a negative indirect effect through reduced saving. The overall effect is negative. Deger (1986b) adds a balance of trade equation into the above system and estimates four equations simultaneously. The effect of defence spending on balance of trade is found to be negative. The study indicates that the size of the negative indirect effect from defence spending to economic growth is higher than the positive direct effect and thus leads to a net negative effect.

Galvin (2003) provides recent cross-sectional analyses of the defence-growth relationship for 64 developing countries in 1999. The demand and supply side model with three equations is estimated by using 2SLS and 3SLS. The empirical results suggest that defence spending has a net negative impact on economic growth. Furthermore, estimations and comparisons of low- and middle-income subgroups indicate that the negative impact is more severe for middle income economies than low income group.

Empirical results of cross-sectional analyses of Deger-type models reviewed above are summarized in Table 4.3. By estimating similar three or four equations simultaneously, the direct and indirect (via investment, saving or balance of trade) effect of defence spending on economic growth are investigated. All results suggest that the net effect from defence spending to growth is negative in LDCs.

Some studies focus on case studies of individual countries and try to improve the weakness of the Deger type models by the explicit selection of variables. Dunne, Nikolaidou and Roux (2000) use the four-equation Deger type model to investigate the interaction between military expenditure and economic growth in South Africa for the period 1961-1997. With relatively well specified and systems estimations, they provide evidences of an overall negative effect of military expenditure on economic growth in South Africa. Sezgin (2001) examines the defence-growth relationship in Turkey from 1956-1994. Using the four-equation Deger type model and simultaneous equation methodologies (2SLS and 3SLS), the empirical results reveal that Turkey's economy growth is stimulated by defence spending. There is no significant indirect effect from defence to growth via saving and the relationship between defence spending and balance of trade is insignificant. The author suggests that the non-negative effect of defence spending on balance of trade in Turkey might due to the military aid from the USA and NATO alliance.

Ramos (2004) provides a country survey of Mexico and outlines a demand-supply model to examine the impact of defence on economic growth during 1970-2000. Three equations of growth, saving and defence burden are estimated simultaneously by 3SLS. The empirical results show that military expenditure has a positive effect on economic growth in Mexico although it has a crowding-out effect on saving. Furthermore, he analyses the effect of US's military burden on Mexican military burden and indicates that Mexican policy of military expenditure might not respond to the changes in US's military burden and thus is not free-riding on US's military spending. Klein (2004) investigates the defence-growth relationship in Peru during 1970-1996. By using the three-equation Deger type model, the significant and substantial crowing-out effect of defence spending is found and the overall effect of defence spending on the economic is negative in Peru.

The individual case studies of defence-growth relationship in developing countries provide mixed results and indicate the weakness of cross-sectional studies. The Deger type models are always criticized for the *ad hoc* theoretical and empirical specifications. Individual country studies can contain well-organised variables and well-defined regression equations and thus provide more comprehensive analyses of the defence effect on economic growth. However, most macro-series are non-stationary and the whole model is set into first differences to obtain stationary series. Estimating of the differenced system is apt to give very poor results and make the interpretation unclear. Bearing in mind the weaknesses of model selection and estimation procedure, the Deger type models are still the best to date to give more accurate analysis for the defence-growth nexus.

In general, supply side (Feder type) models reveal that defence spending has no significant or (relative small) positive effect on growth. In contrast, demand side models are associated with a negative effect on growth. The Deger type (demand and supply side) models tend to show a net negative effect from defence spending to economic growth in most studies. However, Dunne, Smith and Willenbockel (2005) argue that the growth models widely employed in defence literature are not used in mainstream growth literature. One should introduce popular growth models into the analyses of the defence-growth relationship, for example, the Barro, the Solow and Augmented Solow growth models which are widely applied in general growth literature.

Table 4.3 Summary of Deger Type Cross-Sectional Analyses

Author(s)	*Sample*	*System*	R^2	*Effect of m on*	
1. Deger and Sen (1983)	50 LDCs, 1965-1973	$g = a_0 + a_1 i + a_2 m + a_3 GDP + a_4 n + a_5 a$		Growth	+
		$i = b_0 + b_1 g + b_2 \Delta GDP + b_3 m + b_4 a$		Investment	-
		$m = c_0 + c_1 GDP + c_2 D + c_3 N + c_4 D_1 + c_5 D_2$		Net	-
2. Deger and Smith(1983)	50 LDCs, 1965-1973	$g = a_0 + a_1 s + a_2 m + a_3 y + a_4 n + a_5 a + a_6 Ag$	0.22	Growth	+
		$s = b_0 + b_1 g + b_2 gy + b_3 m + b_4 a + b_5 \dot{p}$	0.86	Saving	-
		$m = c_0 + c_1 y + c_2 D + c_3 N + c_4 D_1 + c_5 D_2$	0.78	Net	-
3. Deger (1986a)	50 LDCs, 1965-1973	$g = a_0 + a_1 s + a_2 m + a_3 y + a_4 a$	0.30	Growth	+
		$s = b_0 + b_1 g + b_2 gy + b_3 m + b_4 a + b_5 \dot{p}$	0.86	Saving	-
		$m = c_0 + c_1 y + c_2 D + c_3 Gov + c_4 D_1 + c_5 D_2$	0.86	Net	-
4. Deger (1986b)	50 LDCs, 1965-1973	$g = a_0 + a_1 s + a_2 m + a_3 B + a_3 y + a_4 Ag$	0.32	Growth	+
		$s = b_0 + b_1 m + b_2 g + b_3 gy + b_4 B + b_5 \dot{p}$	0.78	Saving	-
		$B = c_0 + c_1 m + c_2 g + c_3 \dot{p} + c_4 D_1 + c_5 D_2$	0.67	Balance of Trade	-
		$m = dc_0 + d_1 y + d_2 D + d_3 GR + d_4 N + d_5 D_1 + d_6 D_2$	0.87	Net	-
5. Galvin (2003)	64 LDCs, 1999	$g = a_0 + a_1 s + a_2 B + a_3 n + a_4 m + a_5 y + a_6 \dot{p}$	0.23	Growth	+
		$s = b_0 + b_1 m + b_2 \dot{p} + b_3 g + b_4 B + b_5 gy$	0.45	Saving	-
		$m = c_0 + c_1 y + c_2 B + c_3 d_1 + c_4 d_2 + c_5 d_3 + c_6 N + c_7 m_{-1}$	0.73	Net	-

Notes:
g: average annual growth rate of GDP; *s*: national saving ratio; *m*: military burden; *y*: 1970 per capita income at official exchange rate; *a*: net foreign capital flows as a percentage of GDP; *n*: rate of population growth; *N*: total population; $\dot{p}$: inflation or rate of change of GDP deflator, per annum; *Gov*: government expenditure as a proportion of GDP; *GR*: rate of growth of government expenditure; *Ag*: average annual growth rate of agriculture product; *B*: balance of trade; *D*: difference between per capita income, at official exchange rate and purchasing power parity; D_1: dummy for capital surplus oil=exporting countries; D_2: dummy for war economies; *e*: growth rate of exports; d_1: dummy for countries threatened with military action in 1999; d_2: dummy for countries involved in military action in 1999; d_3: dummy for countries produce oil

Table 4.4 Review on the Deger type (Demand and Supply Models) Literature

Author(s)	*Sample*	*Remarks*	*Main Conclusion*
Panel A: Cross-national Studies			
1. Deger and Sen (1983)	50 LDCs, 1965-1973	Three equation model, Cross-sectional estimation (3SLS)	Positive direct effect of defence burden on growth but negative indirect effect through reducing saving. The net effect is negative.
2. Deger and Smith(1983)	50 LDCs, 1965-1973	Three equation model, Cross-sectional estimation (3SLS)	Positive direct effect of defence burden on growth but negative indirect effect through reducing investment. The net effect is negative.
3. Deger (1986a)	50 LDCs, 1965-1973	Three equation model, Cross-sectional estimation (3SLS)	Positive direct effect of defence burden on growth but negative indirect effect through reducing saving. The net effect is negative.
4. Deger (1986b)	50 LDCs, 1965-1973	Four equation model, Cross-sectional estimation (3SLS)	Positive direct effect of defence burden on growth but negative indirect effect via saving and balance of trade. The net effect is negative.
5. Galvin (2003)	64 LDCs, 1999	Three equation model, Cross-sectional estimation (2SLS and 3SLS)	Net negative impact from defence spending to economic growth. The negative impact is more severe for middle income economies than low income group.
Panel B: National studies			
6. Dunne, Nikolaidou and Roux (2000)	South Africa, 1961-1997	Four equation model, Time series estimation (3SLS)	Negative direct and indirect effect of military expenditure on economic growth.
7. Sezgin (2001)	Turkey, 1956-1994	Four equation model, Time series estimation (2SLS and 3SLS)	Positive direct effect of defence burden on growth. The negative indirect effect via saving and balance of trade is insignificant.
8. Ramos (2004)	Mexico, 1970-2000	Three equation model, Time series estimation (3SLS)	Positive direct effect of defence burden on growth. Negative indirect effect via saving. The net effect is positive.
9. Klein (2004)	Peru, 1970-1996	Three equation model, Time series estimation (2SLS and 3SLS)	Positive direct effect of defence burden on growth but negative indirect effect through reducing saving. The net effect is negative.

4.2.5 The Barro Model

4.2.5.1 Theoretical Models

On the basis of Barro and Sala-i-Martin (1995)'s work, Aizenman and Glick (2003, 2006) provide a theoretical framework for the interaction between military expenditure and threats to account for the impact of military expenditure on economic growth. They attempt to explain that due to the non-linearity and omitted variable biases, the impact of military expenditure on growth is frequently found to be insignificant or negative. Aizenman and Glick (2003) hypothesize that:

> "The impact of military expenditure on growth is a non-linear function of the effective militarized threat posed by foreign countries and other external forces. Threats without expenditure for military security reduce growth; military expenditure without threats would reduce growth, while military expenditure in the presence of sufficiently large threats increases growth." (Page 2)

Thus, their conjecture can be written as:

$$\begin{aligned} \frac{\partial growth}{\partial m} &= a_1 + a_2 threat; a_1 < 0, a_2 > 0 \\ \frac{\partial growth}{\partial threat} &= b_1 + b_2 m; b_1 < 0, b_2 > 0 \end{aligned} \qquad (4.28)$$

where *growth* is the growth rate of real per capita GDP, *m* is the military burden, and *threat* is the level of a country's effective military threat. This suggests a basic growth equation specification of:

$$growth = a_1 + a_2(m)(threat) + b_1 threat + \beta X; \qquad (4.29)$$

$$a_1 < 0, b_1 < 0, a_2 > 0$$

Where X is a set of control variables and for simplicity, a_2 is constrained equal to b_2. The control variables include both traditional variables such as initial income, investment share and population growth rate and other variables like institutional, geographic and demographic characteristics.

In Aizenman and Glick (2003)'s specification, the direct effects of military expenditure and external threats on growth are assumed to be negative, while the interactive effect is positive. This innovative specification suggests that output is influenced by security or military expenditure relative to the external threat. This specification seems more plausible for many countries than the specification in which military expenditure affects output through technology. The Barro style model of the defence-growth nexus suggests that military expenditure induced by external threats should increase output, by increasing security; while military expenditure induced by rent seeking and corruption should reduce growth, by displacing productive activities.

4.2.5.2 Empirical studies

Stroup and Heckelman (2001) use an augmented version of Barro-style model and examine the influence of defence spending and military labour use on economic growth in 44 African and Latin American countries from 1975-1989. Fixed effect panel analyses give the empirical results that the impacts of defence burden and military labour use on economic growth are non-linear, with low levels of military spending and labour use enhancing economic growth but higher levels of military spending and labour use retarding growth.

Aizenman and Glick (2003) study the long-run impact of military expenditure on growth. They extend the Barro-style growth model to account for the impact of military expenditure on growth and the interaction between military expenditure and threats. The Barro-style growth equation for a cross-section of 90 countries over the period 1989-1999 is estimated. The interaction between external threats and military expenditure are included into the growth equation to allow for the non-linearity. The cross-sectional empirical results suggest that military expenditure and hostile external threats have adverse impacts on growth, while military expenditure in the presence of threats increases growth. This innovative specification suggests that output is influenced by security or military expenditure relative to the external threat.

Yakovlev (2007) investigates the growth effects of military expenditure, arms trade and their interaction in Barro growth models for 28 countries during 1965-2000. The periods are separated into seven non-overlapping 5-year periods from 1966 to 1995. Using fixed effects, random effects and GMM estimators, the panel estimating results indicate that higher military expenditure and net arms exports separately decrease economic growth. However, when a country is a net arms exporter, higher military expenditure is less damaging to economic growth.

The Barro style model of the defence-growth nexus (reviewed in Table 4.5) suggests that military expenditure induced by external threats should increase output, by increasing security; while military expenditure induced by rent seeking and corruption should reduce growth, by displacing productive activities (Aizenman and Glick, 2003). Interaction between military expenditure and other variables (such as arms trade and internal threats) can be added into Barro models as well. However, it is well known that the so-called Barro style growth models are too complex to be estimated explicitly and the theory is just used to suggest variables and the growth regression is unrestricted and *ad hoc* (Dunne Smith and Willenbockel., 2005).

4.2.6 The Augmented Solow Model

4.2.6.1 Theoretical Models

In this section, the augmented Solow growth model is briefly set out. Mankiw, Romer and Weil (1992, hereafter MRW) include human capital to the Solow (1956) neoclassical growth model. The relevant production function is:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} [A(t)L(t)]^{1-\alpha-\beta}, \quad 0 < \alpha+\beta < 1 \tag{4.30}$$

Where *Y(t)* denotes income, K is physical capital, L is labour and α and β are the elasticities of income with respect to physical and human capital, respectively. *A(t)L(t)* is the number of effective units of labour which grows exogenously at rate $n+g$. Let us define $y=Y/AL$, $k=K/AL$, and $h=H/AL$ as quantities per effective unit of labour. s_k and s_h are the fractions of income invested in physical capital and human capital, respectively. The transition equations are:

$$\begin{aligned} \dot{k}(t) &= s_k y(t) - (n+g+\delta)k(t), \\ \dot{h}(t) &= s_h y(t) - (n+g+\delta)h(t), \end{aligned} \tag{4.31}$$

The production function and the transition equations are based on the standard neoclassical assumptions including constant returns to scale, diminishing marginal product for a single varying output, the Inada conditions and the same depreciation rate, δ for physical and human capital. When the economy is at a steady state, $\dot{k} = \dot{h} = 0$ and we get the stationary values for $k^*$and h^*:

$$k^* = (\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta})^{1/(1-\alpha-\beta)}$$
$$h^* = (\frac{s_k^{\propto} s_h^{1-\propto}}{n+g+\delta})^{1/(1-\alpha-\beta)} \quad (4.32)$$

The Solow model gives the speed of convergence around the steady state:

$$\frac{dln\big(y(t)\big)}{dt} = \lambda\big[\ln(y^*) - \ln\big(y(t)\big)\big], \quad (4.33)$$

Where:

$$\lambda = (n+g+\delta)(1-\alpha-\beta). \quad (4.34)$$

Combined with the values of $k^*$and h^*, the steady-state transition equations and production function, get the representation of steady-state long-run growth of income per capita:

$$\ln\big(y(t)\big) - \ln\big(y(0)\big) = \big(1-e^{-\lambda t}\big)\frac{\alpha}{1-\alpha-\beta}\ln(s_k)$$
$$+\big(1-e^{-\lambda t}\big)\frac{\beta}{1-\alpha-\beta}\ln(s_h) \quad (4.35)$$
$$-\big(1-e^{-\lambda t}\big)\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) - \big(1-e^{-\lambda t}\big)\ln\,(y(0))$$

Thus, in the augmented Solow model, the growth of income depends on the initial level of income and the determinants of the ultimate steady state.

Based on the discussion of the economic effect of military expenditure and previous studies (Knight, Loayza and Villanueva, 1996), the augmented Solow model with military variable can be parameterized as:

$$growth = a_0 + a_1\, lny_0 + a_2 lnk + a_3 lnh \\ + a_4 \ln(n + g + \delta) + a_5 lnm \tag{4.36}$$

where *growth* is the growth rate of income per capita in the observational period, y_0 is the initial level of income per capita, *k* and *h* are, respectively investment and human capital proxy, *(n+g+δ)* is the growth rate of effective labour plus depreciation and *m* is military burden.

4.2.6.2 Empirical studies

Knight, Loayza and Villanueva (1996) extend the standard neoclassical Augmented Solow growth model by incorporating the effect of military spending on growth. The panel estimations for 79 countries during 1971-1985 are based on the following regression equation:

$$lny_{it} - ln\, y_{i,t-1} = \eta_i + \gamma_t + \alpha\, ln\, y_{i,t-1} + \beta_1 lnk_{it} + \beta_2 lnh_{it} \\ + \beta_3\, ln(n_{it} + g + \delta) + \beta_4 lnm_{it} + \beta_5 lnf_{it} + \beta_6 lnw_{it} + \varepsilon \tag{4.37}$$

where *ln* indicates a natural logarithm, *n* is the average population growth rate, *g* is the technological growth rate, δ is the rate of depreciation of the stock of physical capital ($g + \delta$ is assumed to be equal to 0.05), k is the physical investment ratio to GDP, *m* is the defence burden, *h* is a proxy for the ratio of human capital to GDP (percent of working-age population enrolled in secondary schools), *f* is a proxy of the degree of restrictiveness of the economy's international trade system, w is the proxy for the incidence of wars, γ_t is time-specific factors , η_i is country-specific factors and ε is a error term.

The panel data with 3 five-year intervals (1971-1975, 1976-1980 and 1981-1985) are estimated.The empirical results indicate that military burden as an explanatory variables has a negative and significant effect on economic growth. Furthermore, comparing the results with and without military burden in the estimations, it shows that inclusion of military burden reduces the absolute size for the estimated coefficients of physical investment, human investment and trade restrictions in the growth equation. Thus, military expenditure crowds out both types of investment and increases the intensity of trade restriction.

Murdoch and Sandler (2002a) use the neoclassical Augmented Solow growth model to empirically test for the influences of a civil war on steady-state income per capita of both home and neighbouring countries. Civil war variables, the spatial average of civil war (civil wars in neighbouring countries over the relevant sample period), and related death and duration of civil wars variables are incorporated into the growth equation. The data on pooled 85 countries for six non-overlapping 5-year periods from 1961-1990 are estimated and the empirical results show that civil war creates a significant negative impact on short-run growth within the country and its neighbours, although that negative impact is less clear-cut in the 25-year long run estimations.

Using similar growth equations, Murdoch and Sandler (2002b) examine the long-run and short-run growth effects of civil wars at home and in neighbouring countries for four regional groups of countries: 31 Africa, 14 Asia, 20 Latin America and a pooled 34 Asia and Latin America samples. Their empirical analyses are based on panel estimations for seven 5-year periods from 1961-1995. In the long-run, the host-country civil war's influence on economic growth is negative in all regions. The civil war in neighbouring countries has a negative effect on growth for the African, Asian and Pooled samples. In the short-run, 5-year intervals limit the performance of the civil war variables. The effects of civil wars in neighbouring countries are significantly negative for the African, Asian and Pooled samples. In general, civil wars can have strong negative impacts on economic growth at home and in neighbouring countries even the influences are region specific. The ability to rebound from conflict is also different in different regions where Africa has the greatest recovery ability.

Yakovlev (2007) uses the Augment Solow growth model to investigate the growth effects of military spending, net arms exports and their interaction for 28 countries during 1965-2000. Panel estimations are based on seven non-overlapping 5-year intervals from 1966 to 1995. He applied different estimators, such as fixed effect, random effects and GMM. The robust empirical results are found which reveal the fact that military spending and net arms exports have negative impacts on economic growth but their interaction has a positive impact on growth.

Different studies in Table 4.5 extend the neoclassical Solow growth model and examined the growth effects of the influencing variables such as military spending, civil war and arms exports. The empirical results of these military related impacts on growth are consistent and show a negative correlation between military spending and growth. Dunne, Smith and Willenbockel (2005) argue that the Augmented Solow model has fewer theoretical weaknesses but is too tight given the range of variables that have been found significant determinants of growth. Furthermore, it might be implausible that the main effect of the military spending is through technology. They suggest that military expenditure might influence output in an *ad hoc* way in the augmented Solow growth model.

Table 4.5 Review on the Barrow and Solow Literature

Author(s)	***Sample***	***Remarks***	***Main Conclusion***
Panel A: Barro model Studies			
1. Stroup and Heckelman (2001)	44 African and Latin American countries, 1975-1989	Panel estimation (fixed effect model)	Non-linear impacts of defence burden and military labour use on economic growth. Low levels of military spending and labour use enhance economic growth but higher levels of military spending and labour use retarded growth.
2. Aizenman and Glick (2003)	90 countries, 1989-1999	Cross-section estimation	Military expenditure and hostile external threats had adverse impacts on growth, while military expenditure in the presence of threats increased growth
3. Yakovlev (2007)	28 countries, 1965-2000	Panel estimation (fixed effects, random effects and GMM)	Higher military expenditure and net arms exports separately decrease economic growth. For a net arms exporter country, higher military expenditure was less damaging to economic growth.
Panel B: Augmented Solow model studies			
4. Knight, Loayza and Villanueva (1996)	79 countries, 1971-1985	Panel estimation (fixed effect model)	Negative effect of military burden on economic growth.
5. Murdoch and Sandler (2002a)	85 countries, 1961-1990	Cross-sectional estimation and panel estimation (fixed effect model)	Civil war created a significant negative impact on short-run growth within the country and its neighbours.
6. Murdoch and Sandler (2002a)	31 Africa, 14 Asia, 20 Latin America countries, 1960-1995	Cross-sectional estimation and panel estimation (fixed effect model).	Civil wars can have strong negative impacts on economic growth at home and in neighbouring countries.
7. Yakovlev (2007)	28 countries, 1965-2000	Panel estimation (fixed effects, random effects and GMM)	Military spending and net arms exports have negative impacts on economic growth but their interaction has a positive impact on growth.

4.2.7 The Causality Analysis of Military Expenditure and Economic Growth

Military expenditure is assumed to influence economic growth in the literature reviewed in this chapter, while in the analyses of the demand for military expenditure reviewed in chapter 3, a country's income level and growth are significant determinants of military expenditure. Military expenditure and economic growth can affect each other. Hence, causality analyses are needed to ascertain the presence and direction of causality relationship between military expenditure and growth empirically (Sandler and Hartley, 1995). There exist four different types of causal relationships between defence and growth: (1) unidirectional causality from military expenditure to economic growth which means defence influence economic growth; (2) unidirectional causality from economic growth which means greater economic growth or high level of income could determine military expenditure; (3) bi-directional causality between defence and growth; and (4) no causal relationship.

These causality relationships have been widely discussed in both cross-sectional and individual countries' studies. Chowdhury (1991) uses the Granger causality test to investigate defence-growth causal relationships for 55 LDCs during 1961-1987 and expresses defence variable as share of military expenditure in GDP. He finds that there is no causal relationship for 30 countries, causal relationship from defence to growth for 15 countries, from growth to defence for 7 countries and the remaining 3 countries have bi-directional relationship. Thus, the causality relationships between defence and growth cannot be generalized across countries. Kusi (1994) applies the Granger causality test to 77 LDCs for the period 1971-1988 or 1989. His results indicate that for 62 countries, there is no causal relationship. In 7 countries, defence Granger causes growth while in another 7 countries growth Granger causes defence. Only one country has a bi-directional causality relationship.

Dakurah, Davies and Sampath (2001) examine the causality relationship for 48 LDCs during 1975-1995 and incorporate the cointegration methods. Similarly, they find that the causality relationships between defence spending and economic growth cannot be generalized as well, where no causal relationship for 18 countries, causal relationship from defence to growth for 13 countries, from growth to defence for 10 countries and bi-directional relationship for 3 countries.

Lee and Chen (2007) apply recent developed panel cointegration techniques to examine the long-run causality relationships between defence and growth in a multivariate model. The multivariate model includes the real military expenditure per capita, real GDP per capita and real capital stock per capita. Using panel data for 27 OECD and 62 non-OECD countries during 1988-2003, their empirical results show that there is fairly strong evidence to support the hypothesis of a long-run relationship between GDP and military expenditure. There are long-run bidirectional causalities in both OECD and non-OECD countries.

Causality analyses are also examined by single country studies. Dunne and Vougas (1999) extend the standard Granger causality test by allowing for cointegration and examined the causal relationship between military expenditure and growth in South Africa over the period 1964-1996 in a VAR framework. They find the presence of causality from military expenditure to economic growth and military expenditure has a significant negative impact on growth in South Africa whereas the result is not apparent when using the standard causality test. Kollias, Naxakis and Zarangas (2004) also employ the Granger causality test incorporating cointegration technique to ascertain the causal relationship between defence and growth in Cyprus for the period 1964-1999. The empirical results indicate there are bi-directional causalities between defence spending and economic growth.

Lai, Huang and Yang (2005) investigate the causality relationship between defence spending and economic growth for China and Taiwan during 1953-2000. They consider other factors into the causality analysis which include per capita output, investment-output ratio, exports, imports, defence spending per capita and a rival's defence spending per capita. Based on the six-variable VAR model and a multivariate threshold model, the linear and non-linear relationships are examined, respectively. The empirical results of both models indicate that Chinese defence spending Granger causes economic growth and there are bi-directional causal relationships between Taiwan's defence spending and economic growth. Furthermore, Chinese defence spending growth Granger causes Taiwan's defence spending growth (one-way causality).

Karagianni and Pempetzoglu (2009) examine the existence of linear and non-linear causality between defence expenditure and economic growth in Turkey over the period 1949-2004. The results of linear Granger causality test indicate that there is a unidirectional linear causal relationship running from economic growth towards defence expenditure. However, the empirical results of the non-linear Granger causality test provide different causality relationship and show a unidirectional non-linear causal relationship from defence expenditure to economic growth.

So far, causality relationships between defence and growth have been investigated in different countries, for different periods and by different methodologies but the relationships cannot be generalised in the literature review presented in Table 4.6. Thus, although the Granger causality and related causality tests are useful to investigate the presence and direction of the defence-growth relationship, cautions seems needed. As suggested by Ram (1995), such Granger causality tests are sensitive to a wide variety of factors, including the sample period, number of observations, data frequency, lag-length choice, structural changes over the period, stationarity of the variables, and cointegration across the variables.

Table 4.6 Review on Causality Literature

Author(s)	***Sample***	***Remarks***	***Main Conclusion***	
Panel A: Cross-national Studies				
1. Chowdhury (1991)	55 LDCs, 1961-1987 Period varies by country	Granger causality test for each country Military expenditure measured as Defence burden	30 countries 15 countries 7 countries 3 countries	No causality Defence → growth Growth → defence Defence ↔ growth
2. Kusi (1994)	77 LDCs, 1971-1988 or 1989	Granger causality test for each country Military expenditure measured as Defence burden	62 countries 7 countries 7 countries 1 country	No causality Defence → growth Growth → defence Defence ↔ growth
3. Dakurah, Davies and Sampath (2001)	48 LDCs, 1975-1995	Cointegration and Granger causality test	18 countries 13 countries 10countries 7 country	No causality Defence → growth Growth → defence Defence ↔ growth
4. Lee and Chen (2007)	89 countries, 1988-2003	Panel cointegration and causality test	27 OECD 62 Non-OECD	Defence ↔ growth Defence ↔ growth
Panel B: National studies				
5. Dunne and Vougas (1999)	South Africa, 1964-1996	Vector Autoregression Model VECM		Defence → growth
6.Kollias, Naxakis and Zarangas (2004)	Cyprus, 1964-1999	Vector Autoregression Model VECM		Defence ↔ growth
7. Lai, Huang and Yang (2005)	China and Taiwan, 1953-2000	Multivariate Threshold Vector Autoregression Model	China Taiwan	Defence → growth Defence ↔ growth
8. Karagianni and Pempetzoglu (2009)	Turkey, 1949-2004	Linear and Non-linear Granger Causality test	Linear Non-linear	Growth → defence Defence → growth