Institutional and Macroeconomic Policy Dynamics in Transition Economies

A thesis presented

by

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to

The School of Economics
Faculty of Commerce
University of Cape Town

in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy

in the subject of

Economics

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June 2008

To My parents
Don Tilakapala Kularatne & Rukmani Jayapriya Kularatne
who made it all possible.

Abstract

This study is an investigation of some of the developmental challenges facing transition economies. The thesis provides empirical and theoretical analyses on some of the institutional and macroeconomic challenges experienced by transition economies along their developmental trajectory.

The thesis begins with an analysis of the reallocation of resources. Chapter 2 presents a model in which two groups in society are engaged in strategic interaction. Privileged members of society have the opportunity to allocate resources either to their own productive capacity, or to enhance the productive capacity of the disadvantaged. Redistribution to the disadvantaged can increase the productive capacity of society, but comes at the cost of rising political aspirations of the poor, which erodes the power of the rich. The results of the model derive possible political outcomes for society under which the rich will redistribute to the point of equality with the poor; conditions under which the disadvantaged face genocide; as well as the range of intermediate redistributive activity likely to be employed by the privileged.

Transition economies also face limited infrastructure development. This is especially true for countries in post-conflict situations. Increasing levels of infrastructure expenditure is argued to have a positive effect on growth. Chapter 3 analyses the impact of economic and social infrastructure on economic growth for a specific transition economy - South Africa. South Africa experienced a declining trend in physical infrastructure development. over the recent past. The econometric results find that

while economic infrastructure has a positive effect on output, social infrastructure has no effect. Crowding out effects arising from both economic and social infrastructure expenditure are also discovered. The data also reveals that both output and private investment have a positive effect on economic and social infrastructure expenditure.

The short term fluctuations in output, employment and labour productivity in South Africa are also investigated. The empirical evidence of negative correlation between employment and labour productivity contradicts the hypothesis of standard real business cycle theory. A model with monopolistic competition, sticky prices, and variable effort is shown to be able to account for the empirical findings. The findings indicate that technology shocks generate a negative comovement between labour productivity and employment in South Africa. In addition, the degree of monetary accommodation, returns to labour and the degree of price stickiness and imperfect competition affects economic fluctuations in employment and labour productivity due to technology and demand shocks. Moreover, they affect the response of prices, real money balances and real interest rates to a technology shock.

Evidence illustrating the relatively high volatility of real exchange rates in transition economies vis-à-vis developed economies in the recent past is the motivation for our study in Chapter 5. The Chapter considers the cross-country determinants of exchange rate volatility for a set of transition economies. The analysis focuses on the macroeconomic fundamentals of the economy and external factors to determine if they have an effect on real exchange rate volatility in transition economies in the long run.

Overall, the investigation finds that higher levels of reserves reduce volatility, and it is estimated that an appropriate level of reserves is approximately 4 $\frac{1}{2}$ months of imports. Volatility is increased by increased uncertainty and loose fiscal policy. In addition, a volatile terms of trade spills over into a volatile currency. From a policy perspective, whilst it is clear that prudent macroeconomic policy is the best course of action to reduce exchange rate volatility, the influence of external volatility on the exchange rate (over which the authorities have no control) should not be underestimated.

In general, the study investigates four macroeconomic and institutional challenges faced by transition economies. The study allows for the possibility of divergent economic and political outcomes to emerge among transition economies due to differences demography, resource allocation among groups in the society, infrastructure development, in the competitive structure of the economy, fiscal and monetary policy. These differences have a consequence on both the developmental outcomes in the long run and short run fluctuations in economic growth for these economies. Moreover, the importance of good governance in the form of prudent macroeconomic policy and sound institutional structures cannot be overstated.

Acknowledgments

Thanks go to my supervisors - Professor Johannes Fedderke and Professor Nicola Viegi - for getting me thinking about some of the issues tackled in this thesis. Their advice, constructive comments, guidance and suggestions has been invaluable. Further, the following individuals have provided useful suggestions on the chapters presented in this thesis.

Chapter 2 - Many thanks to Philippe Aghion, Robert Bates, Željko Bogetić, Paul Collier, Shakill Hassan, Soren Johansen, Tilakapala Kularatne, James Robinson, and participants at the World Bank ABCDE Conference (2008), at the conference on the Centre for the Study of African Economies in Oxford (2008), at the Economic Research of Southern Africa Workshop on Characterizing History by Numbers (2007), and at the staff seminars at the Department of Economics, Johannes Kepler University (2007) and the Department of Economics, University of Pretoria (2007) for their comments.

Chapter 3 - Thanks go to Naira Anders, David Canning, Roy Havemann, Peter Perkins, Richard Wade, participants at the World Bank ABCDE Conference (2008), at the Economic Research of Southern Africa Infrastructure Workshop (2006) and the staff seminar series at the School of Economics, University of Cape Town (2006) for their comments.

Chapter 4 - Thanks to Christopher Adam and seminar participants at the Economic Research of Southern Africa Macroeconomic and Growth Workshop (2007) held at the Reserve Bank of South Africa for their comments.

Chapter 5 - Thanks also go to Roy Havemann, Rangan Gupta and seminar participants of the staff seminar series at the Department of Economics, University of Pretoria (2007) and at the School of Economics, University of Cape Town (2008) for their comments.

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Chapter 1
Introduction

The characteristics that define an economy as a transition economy[1] are numerous. In general, a transition economy is considered to be in a transitional phase between developing and developed status. These economies are characterized by the changing and creating of institutions and fundamental changes in the role of the state. According to Havrylyshn and Wolf (1999), transition economies, in a broad sense, implement market reforms along with the reallocation of resources to their most efficient use, engage in macroeconomic stabilization policies, fiscal prudence, enforce rule of law and property rights.

According to the definition above, a number of economies may be labelled as transition economies. The origin of their developmental trajectory could be a transformation from a socialist, command economy towards a market-oriented economy like the Eastern European economies, a post-colonial African economy, a post-dictatorship Latin American economy, a heavily regulated Asian economy or an economically underdeveloped African state.[2]

The main characteristic of transition economies, from an economic point of view, is the complexity of challenges and changes that these economies experience.

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1 I use the term emerging economies and transition economies interchangeably.

2 Examples of some transition/emerging market economies are: Brazil, Chile, China, India, Mexico, South Africa, most South-East Asian economies, countries in Eastern Europe, parts of the Middle East and Africa.

The thesis analyses the four cornerstones of macroeconomic policy in transition economies. Therefore, to study transition economies, one needs to capture their complexity by analysing the impact of public policy on long run growth (Chapter 3), short run fluctuations in output, employment and labour productivity (Chapter 4), external constraints (Chapter 5), and most of all, the political economy of transition (Chapter 2).

In Chapter 2, the thesis considers a theoretical model of the political economy of conflict which are relevant to transition economies. Chapter 3 analyses the challenges of generating long-term growth for transition economies emerging from conflict. I focus on both economic and social infrastructure which is usually adversely affected due to conflict. Furthermore, I state that infrastructure expenditure is an aspect of public policy that has consequences for long term growth for the economy.

Chapter 4 analyses the short run fluctuations in transition economies which are affected by monetary and fiscal policy. I show that these short run fluctuations and the respective policy response has implications for long-term stability and growth. This is a continuation of Chapter 3 on the challenges of generating long term growth for transition economies. Chapter 5 completes the analysis by considering the external conditions that transition economies experience by estimating correlations between external shocks, internal policy and currency volatility.

The intention of the thesis is to provide a complete picture to enrich our understanding of the complex process of economic transformation.

1.1 Motivation

South Africa (SA) is a transition economy. It has characteristics of a developing and developed economy. The high level of inequality and infrastructure constraints[3] faced by South Africa are similar to developing countries while South Africa's financial markets are similar to developed economies.[4] Some of the institutional and macroeconomic challenges faced by SA are related to the high and in some cases rising levels of inequality, capacity constraints in the face of a growing economy, cyclical variation in output with adverse consequences for employment and general uncertainty in the economic prospects of the economy reflected in a volatile real exchange rate.

Currently, the literature does not adequately address these issues encountered by transition economies. This thesis fills a part of this gap by focusing on some of the broad themes of development in order to shed some light on the challenges experienced by transition economies along their developmental trajectory. The study outlines some of these challenges from political economy, specifically the reallocation of resources between different segments of society and possible conflict arising thereof, to long term public policy in the form of infrastructure development and then to short-term macroeconomic stabilization policy in the face of technology shocks

[3] Fedderke and Bogetić (2008) perform a benchmarking analysis on the quality of South Africa's infrastructure and show that although some of South Africa's infrastructure resembles that of a developing economy, other infrastructure such as some roads and the quality of private schools and hospitals are similar to that of a developed economy.

[4] See for instance Kularatne (2002) on the structure of the South African financial sector.

and, finally, to an open-economy framework by analyzing the impact of macroeconomic fundamentals on the volatility of the real exchange rate. More specifically, the issues we cover in the subsequent chapters are as follows.

A reallocation of resources between groups in society usually occurs during the transition from a developing to a developed economy. Chapter 2 provides a theoretical framework that allows for the reallocation of resources between two segments of society - the privileged and the disadvantaged. Each member of the privileged society, by definition, is assumed to have more resources than a representative individual of the disadvantaged group. The privileged agent has a choice of either allocating resources to their own productive capacity by extracting resources from the disadvantaged, or enhance the productive capacity of the disadvantaged by allocating their own resources to the disadvantaged. Redistribution to the disadvantaged can increase the productive capacity of society, but comes at the cost of rising political aspirations of the poor, which erodes the power of the privileged.

Thus the model explicitly rests on the expectation that the strategic interaction between the social groups is characterized by a *tension* between antagonistic conflict over resources, and the possibility of increasing the size of the social pie through an optimal distribution of resources between rich and poor. This tension may result in a wide range of conflict forms that is empirically observable. We present two contrasting case studies - South Africa and Sri Lanka. The two cases are useful in suggesting the core features of the model.

The possible equilibria generated by the model provide possible outcomes societies may realize. The results of the model account for varying degrees of intensity of conflict, from genocide to perpetual conflict (as experienced in Sri Lanka) to transfer of power (as in South Africa in 1994). A nonlinear relationship in the transfer of resources between the privileged and disadvantaged emerges. We find that the privileged maximize extraction (minimize redistribution) where the disadvantaged constitute either a small minority, or a large majority and/or the ratio of resources of the rich to the poor, is either low, or high. The results are robust to different specifications of the utility function. The implication of this model is that demography, initial resource distribution and the structure of the economy matter in determining the political outcome of economies.

The second challenge faced by transition economies this thesis addresses is limited infrastructure development. This is more keenly felt in countries in post-conflict situations. Inadequate infrastructure raises the price of moving goods and conveying services over distance. Capacity constraints due to limited physical infrastructure may be experienced by some rapidly growing transition economies. South Africa, is one such example of a country experiencing this. This places South Africa in an immediate competitive disadvantage. Chapter 3 analyses the impact of economic and social infrastructure on economic growth in South Africa.

South Africa is one example of a transition economy experiencing increasing pressures on her infrastructure stock. Therefore, South Africa provides an excellent

case study to test the model. Given that infrastructure development in SA has occurred in stages (by type of physical infrastructure) over the decades, we construct an index measuring the level of physical infrastructure. We examine the relationship between GDP, the economic infrastructure, social infrastructure and private investment rates. The research question we answer is: Does social and economic infrastructure lead growth or is it merely responding to increasing growth rates in South Africa?

The literature suggests that infrastructure investment is deemed to increase the growth potential of an economy by increasing the economy's productive capacity. Infrastructure development may affect output directly as an additional factor of production and/or indirectly by increasing the productivity of private capital. We develop a theoretical model that confirms this. The model also highlights the possible positive feedback effects from output and private investment to economic infrastructure.

However, public capital may "crowd out" private investment and therefore reduce GDP growth. Chapter 3 finds this to be true for both economic and social infrastructure expenditure in South Africa. Moreover, the results find that social infrastructure investment has no effect on output in South Africa. The analysis reveals positive feedback effects on economic and social infrastructure expenditure from shocks to GDP.

All economies, including transition economies, experience fluctuations in GDP growth in the short-run. Real business cycle models characterize these fluctuations in the economy as technology shocks resulting in variations in GDP growth and a

positive correlation between employment and labour productivity. Chapter 4 considers fluctuations in GDP, employment and labour productivity growth, for a particular transition economy - South Africa. We find negative comovement between employment and labour productivity from the 1990s onwards. This is contrary to standard business cycle theory. The implication is that technology shocks in South Africa may not be generating recognizable business cycles.

The salient question is: What is the characteristic of the South African economy (and perhaps other transition economies) that standard real business cycle models do not take account of? We suggest that transition economies, in the process of opening their economies, face less competitive pressure than developed economies. For example, the South African manufacturing industry has been plagued by high markups approximately twice as large as the US.[5] High markups in SA manufacturing arise from high concentration ratios[6] and monopolistic practices. This evidence indicates that the degree of imperfect competition in the South African manufacturing industry is higher than the US. Given that the standard real business cycle models assume perfect competition, it may be useful to analyze business cycles in transition economies by allowing for sticky prices and imperfect competition in the product market.

Therefore, the structure of transition economies may be consistent with new-Keynesian models characterized by monopolistic competition and sticky prices, al-

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5 See Fedderke, Kularatne and Mariotti (2007).

6 See for instance Fedderke and Szalontai (2005) and Aghion, Braun and Fedderke (2006).

lowing for variable effort. Chapter 4 uses the Gali (1999) new-Keynesian model which assumes monopolistic competition and sticky prices. Using this model, we find the implication for inflation, real money balances, real interest rate together with employment, output and labour productivity as a result of technology and demand shocks support the South African data.

A nuance of this analysis is the examination of the parameter values of the model which generate specific empirical results. For example, a demand shock has a positive effect on employment and labour productivity if and only if we have increasing returns to labour. The model and empirical results confirm the importance of monetary accommodation, the degree of price stickiness in the product market, the magnitude of the markup and returns to labour in determining the behaviour of employment and labour productivity in response to technology shocks. The results stress that standard real business cycle theory will be unable to explain macroeconomic fluctuations in employment, labour productivity, output, prices and the real interest rate in transition economies experiencing price stickiness, imperfect competition and a monetary policy regime that is unlike developed economies.

Chapter 5 presents evidence illustrating the relatively high volatility of real exchange rates in transition economies vis-à-vis developed economies. The higher volatility in the exchange rate is associated with three stylized facts. Firstly, the opening of transition economies is reflected in increasing proportion of their GDP being accounted for by exports and imports, together with private capital flows affecting

their balance of payments. Secondly, most of these economies have moved towards manufactured exports from primary commodity exports, making them more sensitive to exchange rate movements. Lastly, transition economies are subject to large nominal shocks because they have non-credible monetary institutions and weak fiscal position.[7] These nominal shocks are reflected in excessive exchange rate variability. Moreover, these economies face increased exposure to abrupt reversals in capital flows. The instability associated with short-term capital flows is reflected in the countries' exchange rate gyrations. Sudden capital outflows have resulted in the Mexican crisis of 1995 through to the Asian/Russian/Brazilian crises of 1997-98.

Exchange rate volatility adversely affects, among other things, private investment which consequently slows growth. Chapter 5 considers what factors affect exchange rate volatility in transition economies. It investigates the long run impact of a set of macroeconomic fundamentals together with external factors on real exchange rate volatility for a panel of transition economies. The estimation technique used to determine the relationship between real exchange rate volatility and the set of explanatory variables allows us to test if the particular panel of transition economies respond, in the long run, in a similar fashion to a change in a particular macroeconomic fundamental.

We find evidence that a deteriorating current account and fiscal balance, and increased terms of trade volatility increases real exchange rate volatility. Current

[7] See, for instance, Hausmann et al (2006).

account deficits indicate the inability of savings, both private and public, to meet private and public investment needs. Insufficient savings are indicative of budget deficits and/or high debt to GDP ratios. Thus the current account deficits are a symptom of macroeconomic imbalances. We also find a non-linear relationship between the level of reserves and currency volatility with a rising reserve level reducing volatility at a decreasing rate. The data reveals that the optimal level of reserves is 4 $\frac{1}{2}$ months of import cover. The main conclusion of the study advocates for good governance, efficient institutions and the creation of an enabling environment in order to influence the risk-adjusted return on investment and reduce the volatility of capital flows and, in turn, reduce currency volatility.

The chapters in this thesis trace some of the issues faced by transition economies. In general, the thesis provides a rationale for the institutional and macroeconomic dynamics experienced by transition economies along their growth path. It also offers a possible explanation why political and economic outcomes may differ amongst this group of economies. The importance of prudent macroeconomic policy by sound institutional structures to create a more equal and growing economy is emphasized.

Chapter 2
Characterizing Conflict Forms

2.1 Introduction

Most theories of conflict posit that resource transfers from elites to the disadvantaged represent an attempt to purchase social stability by foregoing some of the benefits of privilege. This Chapter suggests that such resource transfers carry the reverse benefits: a gain in the productive resources available to the elite, but at the cost of a loss in political influence and hence control over societies' resources and direction.

The notion that resource transfers are a means of buying political peace by elites is relatively wide-spread in the literature.[8] That such transfers, specifically human capital provision to the poor, might be motivated by productivity gains aligned with the self-interest of elites, while rarer, can also be identified in the literature.[9] But that the productivity gains of human capital transfers to the poor will be bought at the expense of a loss of influence by the elite and that it may be rational to forego influence for the sake of productive gain, to the best of our knowledge does not find expression in the literature.

In this Chapter we are explicitly concerned with the characterization of conflict forms. Specifically, what might come to account for the very wide range of

[8] See for instance Acemoglu and Robinson (2000) and Bertocchi and Spagat (2004).

[9] See for instance Bourguignon and Verdier (2000a) and Galor and Moav (2004).

conflict that is empirically observable, often with surprising dynamic developments? Societies that begin under auspices that suggest cataclysm reach peaceful accommodation; while others that should by all accounts bask in peace find themselves mired in long term blood-letting. This Chapter derives the possible political outcomes for society under which the rich will redistribute to the point of equality with the poor; conditions under which the disadvantaged face genocide; as well as the range of intermediate redistributive activity likely to be employed by the privileged.

We begin by sketching our motivation in constructing the theoretical model of the Chapter by considering two contrasting case studies - South Africa and Sri Lanka. The two case studies are useful in suggesting the core features of our model - the heart of which is the trade-off between the productivity gains for society and rising political aspirations of the poor associated with human capital transfers to them by social elites already outlined above. The model allows a wide range of feasible conflict forms, from complete accommodation to complete annihilation to emerge, and identifies the circumstances associated with each.

2.1.1 Motivation

In 1985 South Africa appeared well on the way to political cataclysm. The then South African president delivered a speech in August renouncing the opportunity of reforming the Apartheid state. By 1986 South Africa was in a state of emergency, with state repression in the form of detentions without trial, extrajudicial killings, and other

measures attempting to counter unprecedented levels of civil unrest in the schooling system, black residential areas, and in politically motivated industrial unrest.

Yet in October 1990, a new South African President released black political prisoners, unbanned black opposition parties that had been outlawed for 30 years, repealed Apartheid laws, and placed a moratorium on state repression. April 1994 saw the first fully democratic elections in South Africa, conducted essentially peacefully, leading to the inauguration of the first black President under one of the worlds' most liberal constitutions.

Unlike South Africa, Sri Lanka is currently mired in conflict.[10] The conflict waged in the North and East of the country is between the minority Tamils and majority Sinhalese. At first glance the hostilities between the two communities may be classed as an ethnic conflict. However, an important feature of Sri Lanka's conflict is the historical development of conflict *between* as well as *within* communities, giving birth to a twin civil war (Abeyratne 2004, Bardhan 1997, Stewart et al 2001, Stewart, and O' Sullivan 1999). Conflict is present not only between the Sinhalese and Tamils, but also within the Sinhalese community, erupting into an armed struggle in the 1980s. This conflict, which has been suppressed and is now non-violent, still ex-

[10] For definitional issues surrounding the term 'conflict' see Rule (1988).

ists.[11] The implication is that the current conflict is not simply rooted in differences in ethnicity.[12]

The South African case is a story of remarkable transformation - 'miraculous' in the eyes of many commentators - while the Sri Lankan case is just another example of a developing economy struggling with the pressures of attaining higher levels of economic growth heading towards political conflict.

Might one be able to explain why one country chose peace while the other chose war? If so, what are these factor(s) that result in divergent political outcomes for countries along their developmental trajectory? Are there lessons to be learnt from the experiences of these countries?

The modern political economy literature suggests at least four possible approaches to answering these questions.

The first locates political transitions in a long tradition which assigns the trigger for change to a moment of economic "crisis", and due to an underlying "class"

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[11] In 1971, there emerged an insurrection, organized by the youth of the Sinhala community to capture state power. The Sinhala community is the main ethnic group of the country accounting for nearly three-fourths of the total population. The Sinhala community is concentrated largely in the southern part of the country. The militant organization of the Sinhala youth, known as the JVP (Janatha Vimukthi Peramuna, or People's Liberation Front), after its first aborted attempt, dissolved temporally. The JVP arose again by the early 1980s and made their second attempt launching an armed struggle from 1986 to 1989 capture state power. The JVP continues as an important political force.

[12] Abeyratne (2004) suggests that "ethnicity could well be only a mobilization device rather than the root cause" of conflict. The intra- and inter-ethnic characteristics of conflict in Sri Lanka raises the question of how the elite is constituted in Sri Lanka. The elite in South Africa were (and to some extent still are) defined by race. In Sri Lanka it is not so simple to define the privileged. The privileged in Sri Lanka (post-independence) - were the aristocratic class - the so-called mandarins. This class of indigenous Sri Lankans occupied powerful positions in the administration under the colonial government - see Jayawardena (2002) and Abeyratne (2004).

conflict.[13] The approach receives full formal treatment in Acemoglu and Robinson (2001),[14] in which an elite and the poor of a society are engaged in a strategic interaction which can result in regime change. In nondemocratic regimes, the elite excludes the poor from political power, but face a revolutionary threat from the poor during economic downturns, since the cost of turmoil is lower during recession, while revolution offers the opportunity of moving to a democratic state in which the poor (as the majority) can enforce redistribution through the fiscus. The elite's defence against the revolutionary threat by means of preemptive redistribution of resources to the poor effectively raises the cost of revolt. Democratic states enfranchise the poor, and engage in redistribution through the fiscus. They also face the threat of instability, in the form of coups mounted by the former elite, where the level of redistributive taxation becomes sufficiently punitive to render the cost of a coup no longer prohibitive to the elite.

The crucial feature of the Acemoglu and Robinson (henceforth ARM) model is the degree of income inequality. Both nondemocracies and democracies can be consolidated only when inequality is sufficiently moderate, such that political instability increases in the degree of inequality.[15] Further, redistribution is greatest neither for very high nor under low degrees of inequality, but at intermediate levels of in-

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[13] The hypothesis is venerable, but see for example Haggard and Kaufman (1995), Przeworski et al (1996), and Rustow (1970).

[14] Earlier contributions include Acemoglu and Robinson (2000).

[15] Consistent with the empirical findings in Alesina and Perotti (1996) and Muller and Seligson (1987). Thus the model diverges from the modernization hypothesis of Lipset (1959), though it is consistent with the Acemoglu and Zilibotti (1997) suggestion that poor coutnries would have more volatile GDP and worse recessions.

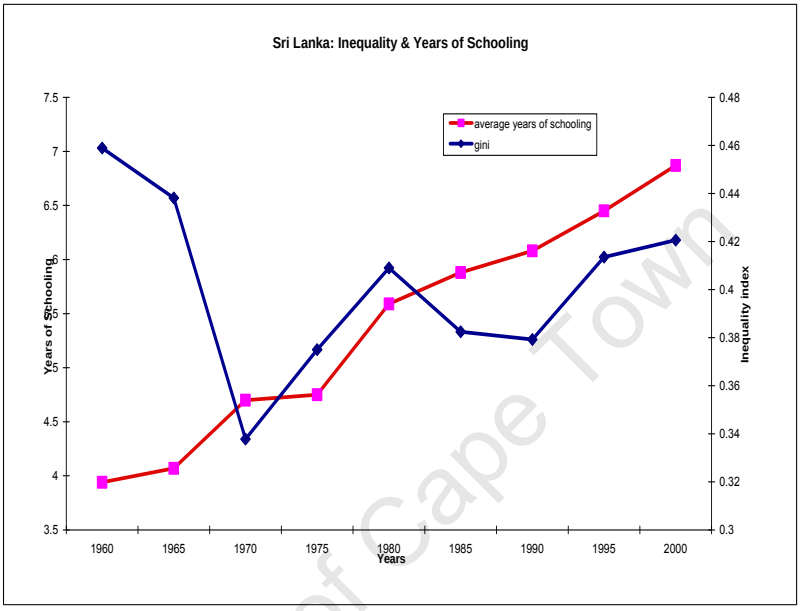
equality. The ARM claims that the elite will engage in a preemptive redistribution of resources to the poor in order to avoid a revolutionary threat by the poor, thus effectively raising the cost of revolt.

Attraction of the ARM framework is the explicit behavioural treatment of the strategic interaction between the social groups in a full dynamic setting, which captures the potential for both stability and instability of democratic and nondemocratic regimes alike, in effect an "endogenous" emergence of institutions and their degree of persistence.

While the original framework aimed at comparing the relative stability of European and Latin American democracies, Acemoglu and Robinson (2006a) contains an explicit application to the South African transition. The inference drawn is that the South African transition is attributable to declining income inequality after 1970, while the maximum costs of repression consistent with repression were rising. Based on the ARM framework, the symmetric reasons for the rising conflict in Sri Lanka should be rising levels of inequality and declining costs of repression.

However, in Sri Lanka, inequality has been declining since the 1930s with the introduction of universal franchise in 1931 in Ceylon. Active redistribution in Sri Lanka developed along the lines of a welfare state. The transfer of human capital through the welfare system to the general populace occurred post-independence and

thus relatively early.[16] This implies that (on the basis of the ARM model) conflict should have been avoided. Figure 2.1 and Table 2.1 illustrate the case.



Source: World Income Inequality Database and Barro-Lee.

Figure 2.1: Sri Lankan Average years of Schooling and Gini Coefficient

It is also not apparent that the ARM is adequate to the South African case study, for at least two reasons. First, as Figure 2.2 illustrates, evidence in favour of falling income inequality in South Africa is by no means clear post 1970,[17] with evidence of improvements occurring only after the start of the process of political transition. The measure of income inequality depicted in Figure 2.2 is consistent with other

[16] The transfer of human capital to the disadvantaged was manifested in free education from primary to university level (including free mid-day meals and milk at school, later free uniforms and textbooks) covering the entire country. This in turn is claimed to have resulted in a declining importance of class and ethnic identity formation (Hettige, 1992).

[17] Of course, the persistent difference in relative incomes is consistent with a rising share of total output attaching to the disadvantaged majority, who constitute arising proportion of the total population.

Human Development Record of Sri Lanka

Category	1960	1998
Infant mortality rate (per 1000)	71	16
Life expectancy at birth (years)	62	74
Primary school enrolment (%)	95	100
Adult literacy rate (%)	75	91
Human development index	0.48	0.73

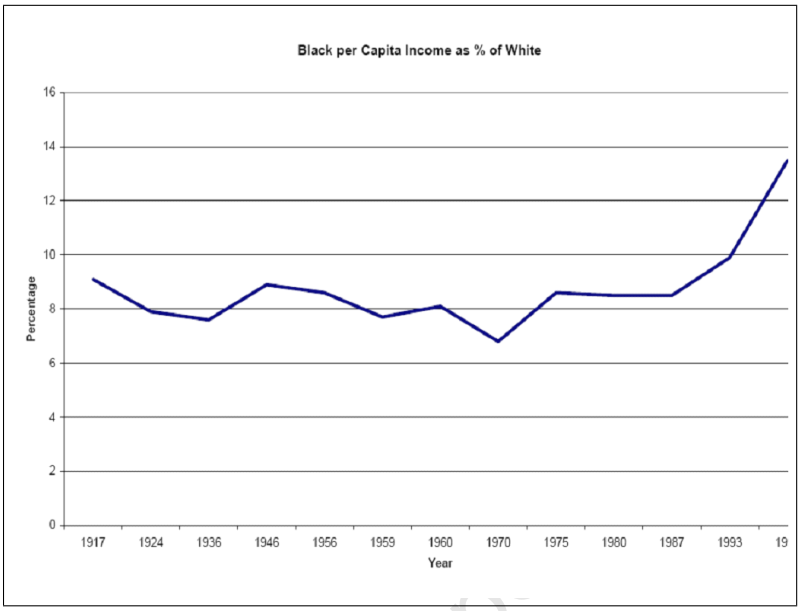
Source: World Bank, World Development Report (annual issues) and UNDP, Human Development Report (annual issues)

Table 2.1: Sri Lankan Educational Attainment

measures of income inequality in South Africa.[18] Second, and crucially, the transfer of human capital to the black population in South Africa began relatively early under Apartheid, with a strong increase at the latest during the 1970's - see the evidence of Figure 2.3.

Under the ARM, the justification for the rising human capital transfer in South Africa would be as an attempt by the white elite to pacify black political ambition through redistribution. But this is difficult to reconcile with the evidence. First, note that the transfer of the human capital precedes the spike in activism for political transformation of the 1980's - see the political instability index reported in Figure 2.4. One interpretation of this evidence is that expanding educational opportunity was

[18] See Bhorat, Leibbrandt, Maziya, Van der Berg and Woolard (2001). However, as Hoogeven and Özler (2003) show, the evidence in faovur of falling inequality and poverty post-1994 is also mixed, with considerable evidence pointing toward *rising* inequality.



Source: Bhorat et al (2001: 2)

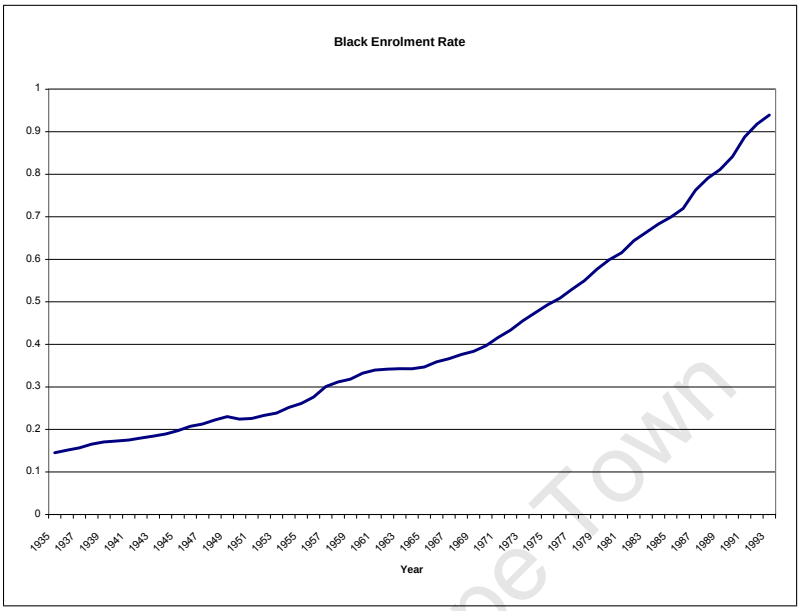
Figure 2.2: Ratio of Black to White Per Capita Income in South Africa

itself responsible for the rising, and ultimately uncontrollable political aspirations by the disadvantaged exposed to new ideas.[19]

Tellingly, for South Africa empirical evidence suggests that causality runs from increasing black secondary schooling output to political instability, with a robust positive sign, consistent with an hypothesis of rising political aspirations under expanding education - see the evidence reported in Fedderke and Luiz (2008).[20].

[19] The link is well established in the political science literature. One author states this link as follows: "Social and economic change … extend political consciousness, multiply political demands, broaden political participation. These changes undermine traditional sources of political authority and traditional political institutions … The result is political instability and disorder. The primary problem of politics is a lag in the development of political institutions behind social and economic change" (Huntington, 1968:5).

[20] Consistent with the argument in Wood (2000).



Source: Fedderke and Luiz (2002)

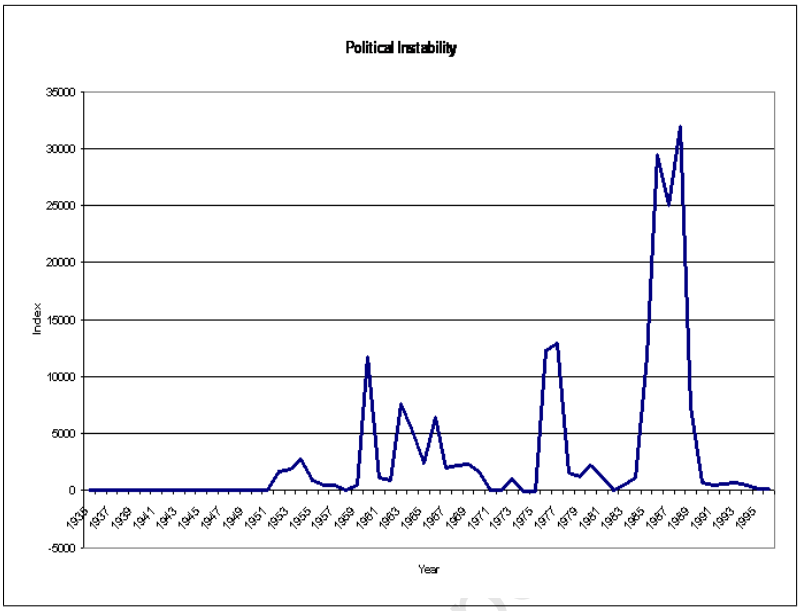
Figure 2.3: Black School Enrolment Rate

A symmetrical case can be made for Sri Lanka - see Abeyratne (2004), Wickramesinghe (1991).[21] The democratic political system of the country was instrumental in expanding the welfare state regardless of the fiscal deficit or the level of economic growth (Abeyratne, 2004).[22] This welfare transfer had the unintended consequence of increasing the productivity of the disadvantaged segment of Sri Lankan society.[23] But as neither the Sinhala nor the Tamil were politically, socially, culturally or economically homogeneous communities, there was a conflict of interests between different segments in each community (Abeyratne 1998, 2004, Kloos 1993). It is this

[21] See also Wickramesinghe (2001) and Wickramesinghe (2006).

[22] To a great extent, the political competition among political parties was instrumental in the initiation as well as the expansion of the welfare system (Alailima, 1997).

[23] The Singaporean Prime Minister at the time - Lee Kuan Yew - was full of praise for the welfare state that Sri Lanka had embarked on and was advocating for Singapore to employ the Sri Lankan model of development.



Source: Fedderke et al (2001)

Figure 2.4: Political Instability Index for South Africa

conflict of interests that is held to be responsible for the increasing instability of the Sri Lankan political system (Abeyratne, 2004).

What might account for the human capital transfer in the face of evidence that this was inconsistent with repressive and non-participatory political structures in South Africa? One answer lies in the fact that the human capital transfer was necessary for the productive needs of the economy - see the evidence presented in Fedderke (2006). The white elite transferred human capital in the face of a choice tension - rising political aspirations under rising human capital endowments of the disadvantaged black majority with associated rising costs of repression, against the improved

productive capacity of the economy under the improved efficiency of labour inputs into production.[24]

Conflict over land may arise in both South Africa and Sri Lanka but the motivation of such conflict arises as individuals gain knowledge of property rights as their endowment of human capital increases due to transfers from the privileged. Thus the catalyst for conflict is the transfer of resources, in this case human capital.

This *productivity-aspirations trade-off* is not captured in the ARM framework.

An alternative approach of conceptualizing conflict is provided by the Hirshleifer (1995) model of anarchy (henceforth HAM).[25] Under the HAM, agents are engaged in fight over a pool of resources, and each agent faces a choice of either allocating resources to the purpose of producing output, or to a fighting technology designed to extract resources from the other (equivalently: prevent extraction by the other agent). What is useful about the HAM is that it serves to characterize conflict, and identifies conditions under which perpetual conflict can be a stable outcome (essentially low efficiency of fighting technology), and can generate a range of intensity of conflict in the equilibrium solution (as the efficiency of fighting technology varies). By inference, there exist alternative outcomes in which stable non-conflictual equilibria emerge, but only under either the complete victory of one of the contesting agents, or as an explicit Hobbesian intervention by the state.

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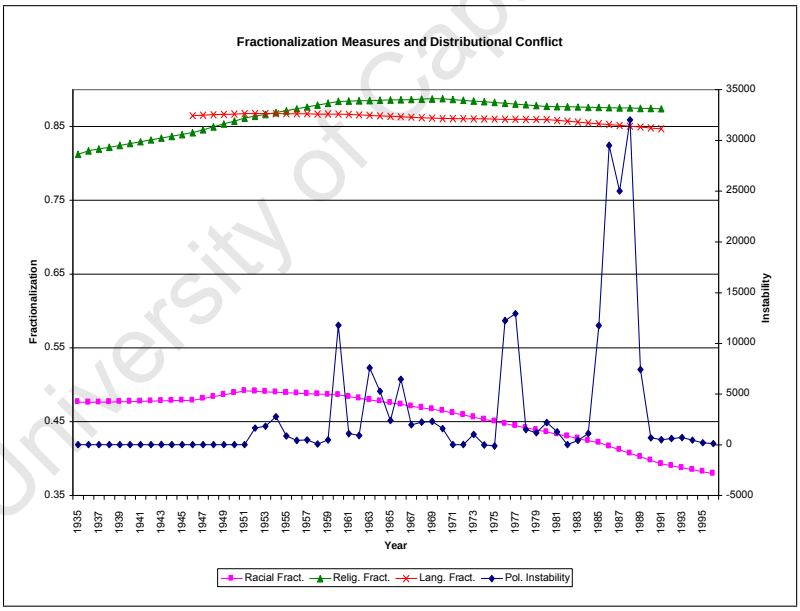
[24] Note that for Galor and Moav (2004), the complementarity between physical and human capital they suggest as crucial to the second phase of the industrial revoluion, has rendered the need for human capital transfers to the poor as pervasive, with the consequence of eliminating or at least attenuating social conflict substantially.

[25] There are a number of extensions of the framework, collected in Hirshleifer (2001).

The attraction of the framework lies in the fact that an obvious way of thinking of the South African transition might be of a protracted period of stable conflict between black and white, during which neither side had sufficiently decisive technology to ensure victory. However, steadily the balance of power might have swung to the black majority, either as their population preponderance grew over time (see for instance the racial fractionalization index[26] for South Africa reported in Figure 2.5), or as whites lost the technological advantage in the contest - perhaps through the force of extensive international technological and financial sanctions.[27]



Source: Fedderke, De Kadt and Luiz (2007)

Figure 2.5: Fractionalization in South Africa

[26] Fedderke, De Kadt and and Luiz (2007) calculate these fractionalization indicies by calculating the probability that any two individuals randomly selected froma sample are from the same racial group.

[27] See for instance the discussion in Welsh (2000).

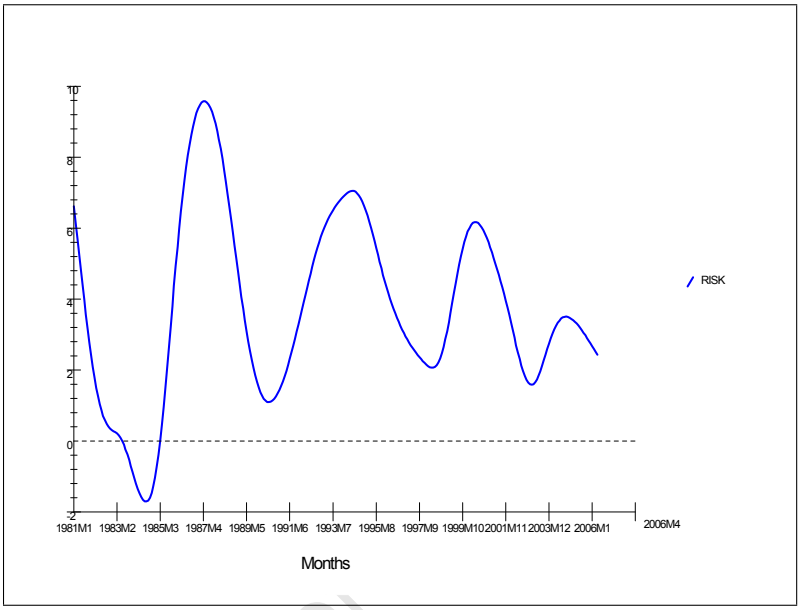
Similarly, the HAM methodology also appears attractive in defining the protracted Sinhala-Tamil conflict in arguing that no conclusion has been reached as neither side has a sufficient advantage in fighting technology. The methodology may also explain why the Sinhala youth rebellion of the 1980s was effectively suppressed, with the latter having insufficient military technology to engage in an armed struggle.

However, the HAM is also not satisfactory in capturing the South African case study experience. First, it is entirely unable to account for the possibility that agents may choose to redistribute resources to their "opponents". Under the ARM, the privileged can do so in the form of welfare (not productivity enhancing) payments, but under the HAM such active transfers are never feasible.[28] Likewise, for Sri Lanka, the welfare transfer to the disadvantaged majority by the aristocratic elite is not explained by the HAM model. Second, the political transition did not eliminate conflict - while political instability has fallen off dramatically, crime as a social pathology remains high, and financial markets show evidence of continued high risk premia attaching to South African financial instruments - see Figure 2.6 for a new measure of uncertainty, and Figure 2.7 for a comparison with the political instability measure of Figure 2.4. In Sri Lanka as well, the suppression of the Sinhala militant uprising has also not eliminated conflict completely.[29] Thus the transition is less a case of com-

[28] Unless one counts low defences against predation by one's opponent as an effective transfer.

[29] The JVP are still vociferous in their demands for a more equitable share of the country's output among its citizens using the trade unions and political marches to express their dissatisfaction with the status quo.

plete victory of one group over another, and more one of a continuation of history by other means.[30]



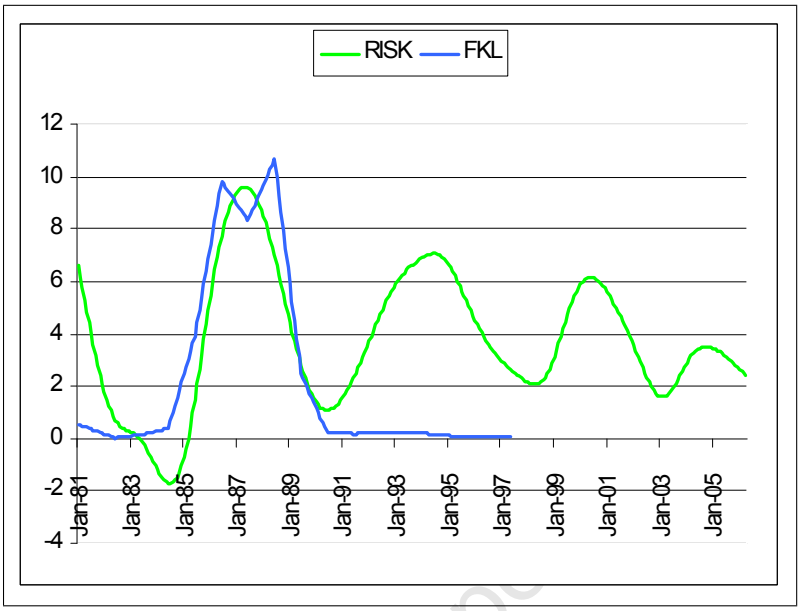
Source: Fedderke and Pillay (2007)

Figure 2.6: Theoretically Consistent Measure of Risk

The third conceptual framework useful to our question is provided by a model by Bourguignon and Verdier (2005)[31] (henceforth BVM) which explores the political economy of education and development. In this framework the political elite has an incentive to transfer human capital to the disadvantaged determined through

[30] In a framework that is reminiscent of the HAM, Bates et al (2007) discuss equilibria in both state and stateless societies where coercion (violence) may be employed to defend against and for predation. The implication is that coercion, if efficiently organized may be socially productive and a source of increased welfare. The model endogenously determines whether the state is predatory or developmental. While a suggestive extension, the model has incomplete purchase on the South African transition experience, since the state, through its coercion hindered transformation, rather than fostering it.

[31] The paper draws on a number of earlier contributions by the same authors, Bourguignon and Verdier (2000a,b).



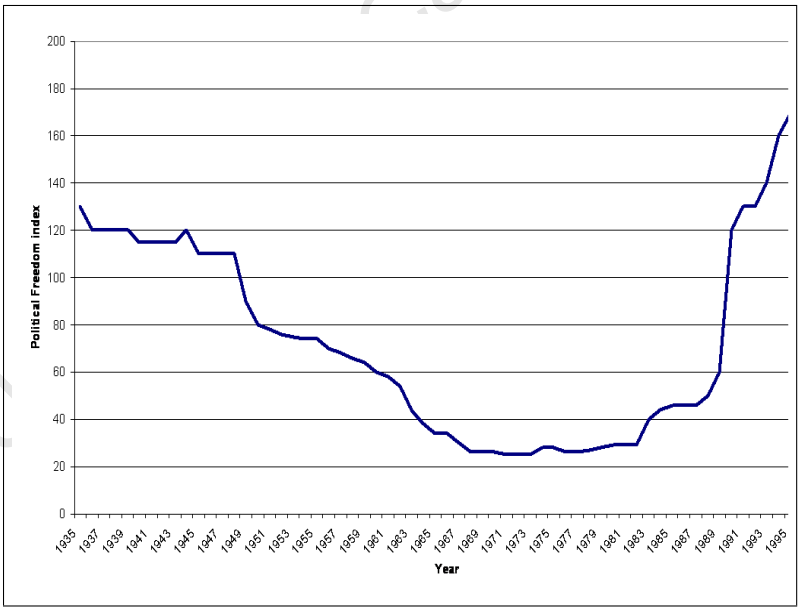
Source: Fedderke and Pillay (2007)

Figure 2.7: Comparing Risk Measures

a productivity gain realized by the poor. This fits the reason suggested above for the human capital transfers in South Africa, and the development of the Sri Lankan welfare state. Moreover, the transfer of human capital to the disadvantaged can result in their gaining access to political power. A particular concern in the BVM framework, is the impact of trade liberalization and the integration of international factor markets on the incentive of the privileged to transfer human capital to the poor - with liberalization introducing a non-monotinicity in the transfer of human capital by diminishing the incentive in the short run, raising it in the long run.

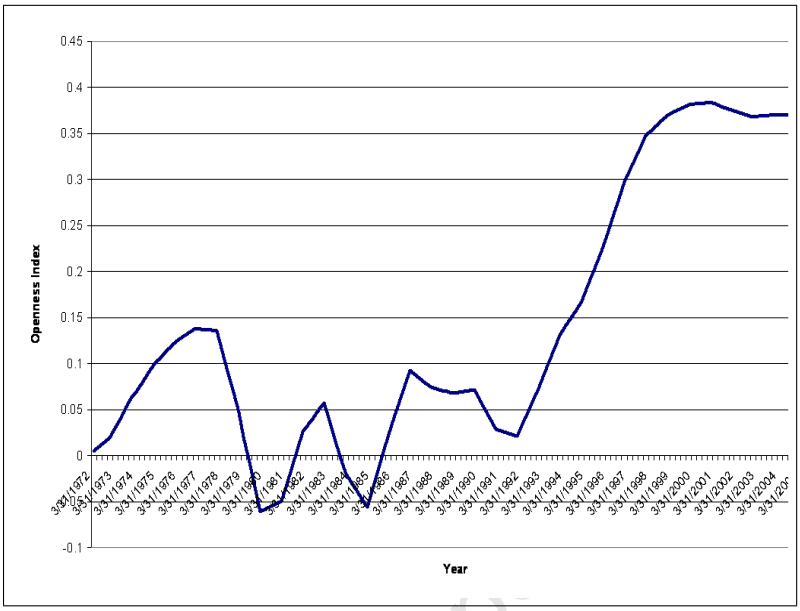
There is nevertheless a twofold and crucial divergence from the South African experience in the BVM. First, in the BVM the transfer of human capital typically leads to the political empowerment of the poor, since skills allow the exercise of

voting rights. Yet in South Africa over the period where increasing human capital was being transferred to the black majority in South Africa (recall again Figure 2.3), political rights were increasingly withdrawn from the black majority. Figure 2.8 reports a political rights index for South Africa, which shows that rights only began improving in South Africa well into the 1980s, after a few decades of human capital transfers. The human capital transfers did not issue in the realization of political rights - instead they led to increased aspirations for such rights, with the continued denial of the rights leading to the sporadic political upheaval detailed in Figure 2.4 above.



Source: Fedderke et al (2001)

Figure 2.8: Political Freedom Index

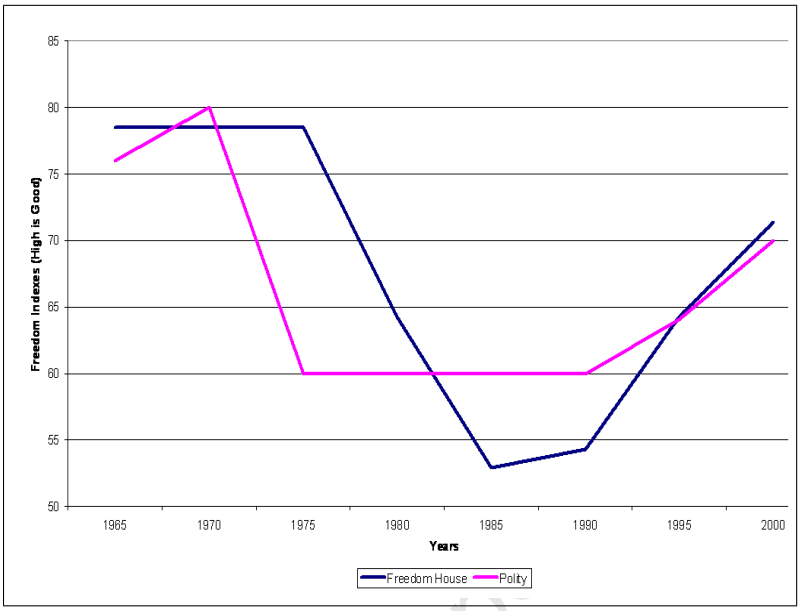


Source: Aron and Muellbauer (2007)

Figure 2.9: Openness Index for South Africa,

The continuous welfare transfers post-independence in Sri Lanka (especially human capital transfers via subsidization of education) along with universal franchise have led to increasing peoples' aspirations for increased political rights as indicated in the BVM model. However, as in South Africa, these aspirations did not translate into effective political rights. Instead, as with South Africa, increased restrictions on political participation were introduced and measures such as the change in the constitution to allow for a president with executive powers was introduced in 1977. See the evidence of Figure 2.10, which reports the Freedom House and Polity standardized measures of rights.

Second, the BVM framework is useful in that it allows for a changing income share between the rich and the poor over time. But the driver for this in the BVM



Source: Freedom House and Polity Standardized Scales

Figure 2.10: Rights in Sri Lanka

model is not the human capital transfer, but in the final instance a shift in relative prices between unskilled labour intensive manufactures, and skilled labour intensive manufactures that results from the process of trade liberalization.[32] It is the relative price change which leads to a reallocation of human capital. But in the South African instance it is not possible to argue that the reallocation of human capital is one related to changing rates of return across sectors. Figure 2.9 confirms that the openness of the South African economy has varied substantially over the 1970-2000 period,[33] but nevertheless, price cost margins both for the South African manufacturing sector as

[32] In Bourguignon and Verdier (2000a) inquality also plays a role - but for the South African context we have already dismissed this as a feasible driver.

[33] The index is due to Aron and Muellbauer (2007).

a whole, as well as for individual sectors has remained essentially constant over this period - see the evidence in Aghion et al (2006).

As indicated earlier, political pressure and not the relative price change was the cause of the reallocation of human capital through the welfare system in Sri Lanka. The country remained relatively closed from 1956-1977 with import substitution policies along with the continuation of a welfare state (begun post-independence) being strictly adhered to. Thus changes in relative prices resulting from trade liberalization could not be the cause of changing income shares between the 'mandarins' and the rest of the Sri Lanka populace. Moreover, political tension in Sri Lanka escalated into the twin civil war a few years after the introduction of the liberalized trade regime in 1977 (Abeyratne, 2004).[34]

An alternative to the ARM-type model of class conflict is provided by Galor and Moav (2004) - henceforth GaMM. In the GaMM an elite transfers human capital to the working class due to complementarity between physical and human capital. The consequence is that the conflict between capitalists (the elite) and workers (the poor) that characterized the first phase of the industrial revolution in Europe is overcome in the industrial revolution's second phase, since the working class realizes productivity, hence wage gains that render industrial conflict redundant.

[34] Although some political analysts have argued that the civil war in Sri Lanka is mainly a product of the distributional conseqeunces of trade liberalization (see Gunasinghe 1984, and Dunham and Jayasuriya 2000), the continued strong performance of the Sri Lankan economy despite the civil war is arguably due to its trade reform - see Stewart and O'Sullivan (1999: 374).

For the South African case the evidence does support the productivity pay-off to human capital, and hence the incentive to transfer human capital to the poor that the GaMM suggests. But as already pointed out above for the BVM, the human capital transfer in South Africa led to rising political aspirations, hence conflict and ultimately the overthrow of the political system, rather than an abatement of political tension. In Sri Lanka, the human capital transfer led to rising political aspirations and hence conflict.

While the first four frameworks by which one might characterize the South African transition and the Sri Lankan failure to exit conflict are theoretical, the fifth is empirical. Collier, Hoeffler and Rohner (2006)[35] (henceforth CHRM) undertakes an empirical examination of a range of potential drivers of civil war. Drawing on a variant of the HAM, the approach balances feasibility[36] against motivation.[37] The findings are that both feasibility and motivation do indeed matter. According to their estimations conflict is driven by: the level of per capita income, the presence of natural resources, population size, the degree of fractionalization, whether a country had been a French colony, the proportion of the population that is male and aged between 15 and 29, and the proportion of the country that is mountainous.

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35 See also Collier and Hoeffler (2006).

36 They cite the "Machiavelli Theorem" of Hirshleifer (2001): no profitable opportunity for violence will go unused. Feasibility includes financial (rebellion is expensive), military, and geographical dimensions.

37 Which can include grievance, predation as well as insanity.

Again, however, the framework does not cover the South African and Sri Lankan experiences well. For both countries, of the factors that prove significant in CHRM, only per capita income, population size, fractionalization and the proportion of young males in the population could plausibly account for the political transition: all other factors are fixed. Yet every one of these measures bar one in South Africa moved so as to increase, not decrease the likelihood of conflict: per capita income fell, population grew, young males grew more numerous - only fractionalization fell, and then only racial, and not linguistic or religious fractionalization. Unless we are therefore prepared to accept the uni-causal explanation, that it was the rising proportion of the black population that drove the transition, the CHRM framework is also incomplete as an account of South Africa's experience.

Conversely, in the case of Sri Lanka, income per capita has been rising post 1977 and thus the conflict should be subsiding and not escalating. The relative population sizes between the two groups has also remained relatively constant implying ethnic fractionalization has remained relatively fixed. Moreover, from 1956, with the introduction of Sinhala in education and administration, all Sri Lankans were compelled to learn Sinhalese.[38] This implies that linguistic fractionalization has declined reducing the probability of conflict in Sri Lanka according to the CHRM model.

[38] In addition, the Sri Lankan government in the 1960s introduced a district quota system which reduced the number of Tamil students entering the universities. This was because the Northern Tamils were perceived to have an undue advantage over the majority Sinhala students in the south on account of the number of good English schools set up by the American and British missionaries in the 19th century resulting in disproportionate admissions to universities, especially in the fields of medicine, engineering and natural sciences.

Only the proportion of young males (for both ethnic groups) in the population has increased (as in the case of South Africa).

Thus for South Africa two variables out of three pointed toward conflict, one toward peace, in Sri Lanka two variables out of three suggested peace, only one conflict. Yet the outcome was peace in South Africa, war in Sri Lanka. It follows that the CHRM does not readily account for the experience of our two case studies.

2.1.2 The Tasks of this Chapter

In this Chapter we therefore present a new theoretical framework to provide a characterization of conflict which might shed light on the divergent cases of South Africa and Sri Lanka. The model explicitly rests on the expectation that the strategic interaction between social groups is characterized by a tension between antagonistic conflict over resources, and the possibility of increasing the size of the social pie through an productively optimal distribution of resources between rich and poor. Required of the model is the ability to account for varying degrees of intensity of conflict, from potential eradication (genocide) to transfer of power, as in South Africa in 1994. Perpetual conflict (as experienced in Sri Lanka) is also rendered feasible.

As a mark of success in the modeling exercise, we are therefore looking for two distinct features to emerge:

- That conflict can cover a wide range of feasible intensities, from eradication to complete accommodation of opponents.

- That the strategic interaction between agents be characterized by a trade-off between an enhancement of productive capacity and rising political aspirations associated with resource transfers from the privileged to the disadvantaged.

The Chapter is structured as follows. Section 2.2 introduces the structural features of our model. Section 2.3 presents the core results, Section 2.4 very briefly considers some robustness checks of the results, Section 2.5 discusses the implications of the model, Section 2.6 analyses the model in terms of the South African and Sri Lankan experience and Section 2.7 concludes.

2.2 Foundations of the Model

Consider a society with two groups of individuals - the *privileged* (R) and the *disadvantaged* (P) where individuals belonging to a particular segment of society are assumed to be homogenous. Assuming no population growth, let the total population in the society equal $L = L^R + L^P$ where L^R and L^P equals the population of the privileged and disadvantaged segments of society, respectively.

Let π represent the ratio of the population of the disadvantaged to privileged segment of society:

$$0 < \pi = \left(\frac{L^P}{L^R}\right) < \infty \tag{2.1}$$

Segmentation of society (privileged versus disadvantaged) is based on the level of *per capita* human capital each section of society holds. Definitionally, the privileged are

endowed with more human capital *per capita* ($\bar{h}^R$) than the disadvantaged segment ($\bar{h}^P$) of society ($\bar{h}^R > \bar{h}^P > 0$). The initial level of per capita human capital of the disadvantaged ($\bar{h}^P$) can never equal zero. If it did equal zero, there would be no disadvantaged group in society. This would make modelling the problem a trivial exercise.

The privileged have the option to reallocate human capital between the two segments of society. This implies that the representative individual in the privileged segment of society may allocate (or expropriate from) a proportion, δ of their human capital endowment $\bar{h}^R$ to the disadvantaged segment. After redistribution privileged individuals thus hold $(1-\delta)\bar{h}^R > 0$ human capital, disadvantaged individuals hold $(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) > 0$. The δ constitutes a proportional tax *either* on the human capital resources available to the privileged section of society $(\delta > 0)$ *or* on the disadvantaged segment of society $(\delta < 0)$. Redistribution can be thought of as policies increasing expenditure on schooling, training and reskilling of the disadvantaged; extraction as policies that tax the poor in order to allocate the resources to the privileged.

Average per capita human capital for the entire society (h) is given by:[39]

$$0 < (\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) < h = \frac{\bar{h}^R + \pi\bar{h}^P}{(1+\pi)} < (1-\delta)\bar{h}^R \tag{2.2}$$

Average per capital human capital for the entire society (h) constitutes a poverty line that differentiates the 'haves' from the 'have nots' in terms of their respective holdings of human capital.

[39] Using the following definition of aggregate human capital for the entire country:
$H = H^R + H^P = \left[L^R(1-\delta)h^R + L^P\left(h^P + \frac{\delta}{\pi}h^R\right)\right]$

Given only that the privileged do not relinquish privilege:

$$-\pi\left(\frac{\bar{h}^P}{\bar{h}^R}\right) < \delta < \left(\frac{\pi}{1+\pi}\right)\left(1-\frac{\bar{h}^P}{\bar{h}^R}\right) < 1 \tag{2.3}$$

The upper bound value is given by the point at which redistribution reaches a level which reverses the relative endowment of human capital (thereby reversing privileged status), while the lower bound value is given by "complete" extraction of resources by the privileged from the poor. The upper and lower bounds of δ are illustrated in Figure 2.11, for alternative values of π, $\bar{h}^R/\bar{h}^P$.[40]

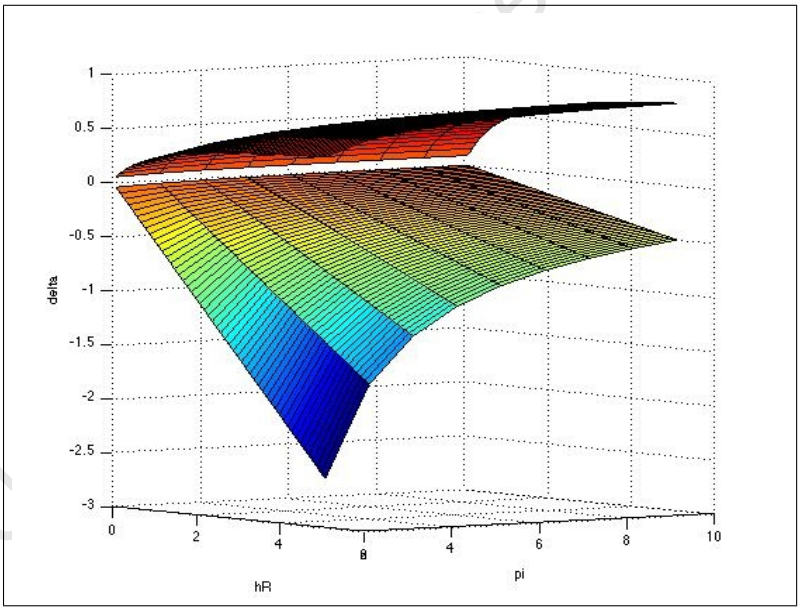

Figure 2.11: Upper and Lower bounds of delta

Crucial to the model is a concept of *power*. In one dimension the power of the privileged is absolute: they are sole arbiters of δ, which is their core choice

[40] Figure 2.11 normalizes on $\bar{h}^P$.

variable. But there is a further manifestation of power, which rests in the ability of the privileged to appropriate a proportion, ω, of the total output produced by the society. This proportion, which for the remainder of the Chapter is what we refer to as the power of the privileged, is determined by the endowment of human capital held by the rich relative to the social average, denoted (r). Equally, however, the poor are not passive. Specifically, any given level of relative human capital endowment held by the poor relative to the rich, denoted (ϕ), translates into an aspiration to exercise greater discretion over the allocation of resources in society. Aspirations might be thought of as disadvantaged individuals becoming more knowledgeable about rights of resistance to any prospective extraction, and being able to use their skills (human capital) to address collective action problems in resistance more effectively. In effect, the privileged are characterized by the fact that they exercise choice over the level of redistribution or extraction (δ). However, in allocating more human capital to the poor, they awake aspirations in the poor to power. The implication of this conception of power is that the relative distribution of human capital between the two sections of society matters as it determines the intensity of distributional conflict between the two sections of society.

Formally, let ω represent the privileged person's ability to claim a proportion of their own output (property rights) and their ability to acquire (extract) the output

of the disadvantaged individual's output.[41] Then:

$$\omega = r^{\phi} \tag{2.4}$$

$$where\ r = \frac{(1-\delta)\,\bar{h}^R}{\left(\bar{h}^R + \pi\bar{h}^P\right)} \tag{2.5}$$

$$and\ \phi = \left[\frac{\pi\bar{h}^P + \delta\bar{h}^R}{(1-\delta)\,\bar{h}^R}\right] \tag{2.6}$$

Given that both r and ϕ are defined by the relative holdings of human capital by rich and poor, it follows that both the aspirations of the poor, as well as the power of the rich depends on a distance measure between rich and poor.

Note that power (ω) decreases with respect to rising aspirations (ϕ). The ϕ parameter takes into account the relative number of human capital disadvantaged individuals and the extent of their poverty (relative endowment of human capital). We note that $\phi > 0$ and $0 < \omega < 1$, $\forall\ -\pi\left(\frac{\bar{h}^P}{\bar{h}^R}\right) < \delta < \left(\frac{\pi}{1+\pi}\right)\left(1 - \frac{\bar{h}^P}{\bar{h}^R}\right)$, $\pi > 0$ and $\bar{h}^R > \bar{h}^P > 0$.[42] Figures 2.12 and 2.13 illustrate variation in ω, ϕ, as the ratio of the poor to rich individuals (π), and the ratio of rich to poor per capita human capital ($\bar{h}^P/\bar{h}^R$) changes respectively.[43]

For the decision problem of the privileged, we define the utility function for the representative individual as:

$$U^R = \alpha \ln\left(c^R\right) + \beta \ln\left(c^P\right);\ \alpha + \beta = 1 \tag{2.7}$$

[41] Symmetrically, $1 - \omega$ represents the power held by a representative agent belonging to the disadvantaged segment of society.

[42] We also note that $\partial\phi/\partial\bar{h}^R < 0$, $\partial\phi/\partial\delta > 0$, $\partial\phi/\partial\bar{h}^P > 0$ and $\partial\phi/\partial\pi > 0$. Symmetrically, $\partial\omega/\partial\bar{h}^R > 0$, $\partial\omega/\partial\delta < 0$, $\partial\omega/\partial\bar{h}^P < 0$ and $\partial\omega/\partial\pi < 0$.

[43] Figures 2.12 and 2.13 normalizes on $\bar{h}^P$.

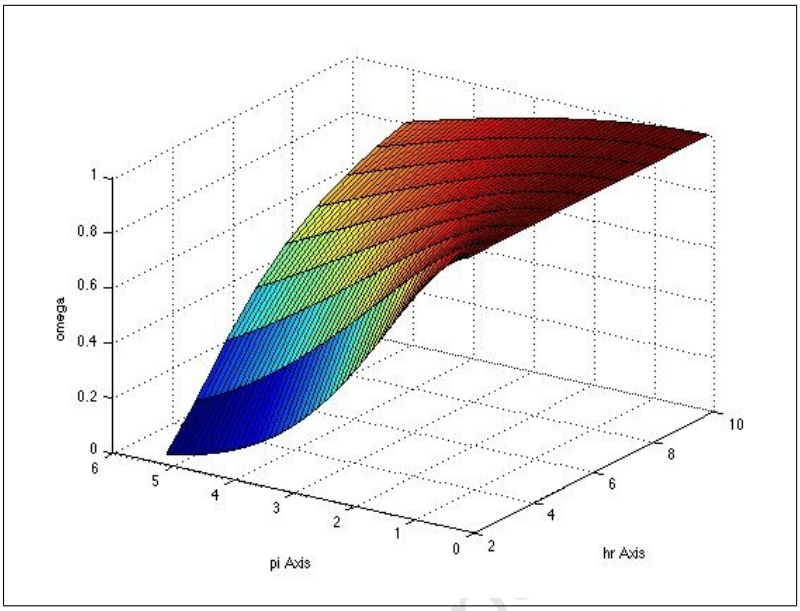

Figure 2.12: Power

where c^R, c^P denotes the privileged and disadvantaged per capita consumption respectively.

It remains to characterize the productive base of the economy. We distinguish between independent (separable) and interdependent production.[44] We associate the distinction with two forms of empirically observable production - agrarian and industrial. Under agrarian production, production units are separable, and can effectively attain sufficiency independently of one another. Industrial production, by contrast is defined as production under specialization, such that inputs into production are rendered complements, and reliant on trade with one another rather than self-sufficient. A stylized example would be two villages, which under agrarian production would

[44] Note that Hirschleifer (1995) employs only separable production, and ignores the possibility of interdependent production.

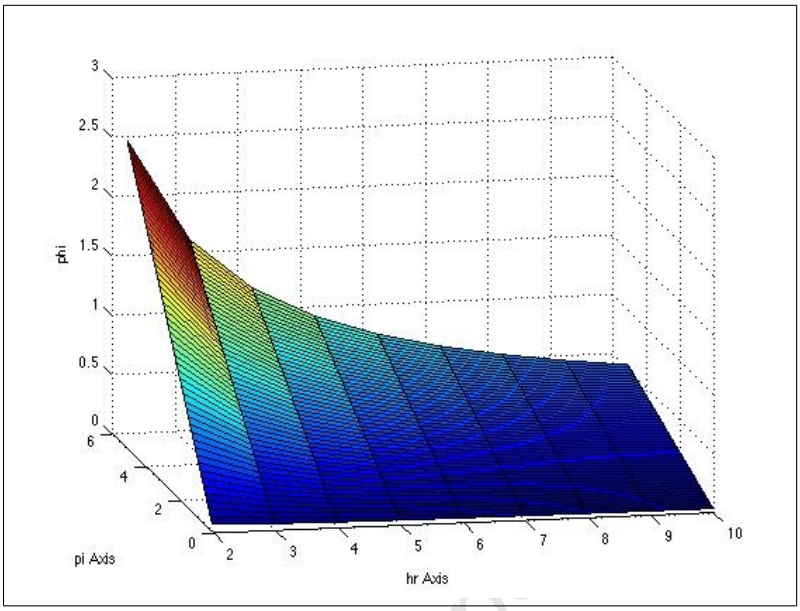

Figure 2.13: Aspirations

produce both steel and corn, while under industrial production comparative advantage would dictate the specialization of each village into the production of one of the two goods, with trade generating the exchange required by both for survival.

2.2.1 Independent Production

We use a simple growth model with human capital as the only factor of production. Assume that the two societies production of the privileged and disadvantaged societies are *not* interdependent. We obtain this feature by treating the production of the rich and the poor as additively separable:

$$Y = A\left\{L^R\left[(1-\delta)\,\bar{h}^R\right]^\theta + L^P\left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R)\right]^\theta\right\} \tag{2.8}$$

where Y denotes total output, A represents technology and θ represents returns to human capital, such that:

$$\theta \in \left\{ \begin{array}{c} > 1 \text{ represents increasing returns} \\ = 1 \text{ represents constant returns} \\ < 1 \text{ represents decreasing returns} \end{array} \right\} \tag{2.9}$$

Technology is symmetrical across the two groups. The groups differ only in their resource endowment, here human capital.

Let y^R, y^P represent the per capita output of the privileged and disadvantaged sections of society respectively. Hence:

$$\begin{aligned} L^R y^R &= \omega Y \\ &\Longrightarrow \quad y^R = \omega A \left\{ \left[(1-\delta)\, \bar{h}^R \right]^\theta + \pi \left[\bar{h}^P + \frac{\delta}{\pi} \bar{h}^R \right]^\theta \right\} \qquad (2.10) \\ L^P y^P &= (1-\omega)\, Y \\ &\Longrightarrow \quad y^P = (1-\omega)\, A \left\{ \left(\frac{1}{\pi} \right) \left[(1-\delta)\, \bar{h}^R \right]^\theta + \left[\bar{h}^P + \frac{\delta}{\pi} \bar{h}^R \right]^\theta \right\} \qquad (2.11) \end{aligned}$$

with average output of the entire economy of:

$$y = \frac{\left(y^R + \pi y^P \right)}{(1+\pi)} \tag{2.12}$$

The privileged maximize utility (2.7). Assume for the sake of simplicity that $\beta = 0$, so that the privileged care only about themselves, and not about the poor in their objective function. We generalize this assumption in Section 2.4. Under these conditions the problem facing the representative privileged agent is:

$$\underset{\delta}{Max} \ \ln \left(c^R \right) \tag{2.13}$$

subject to:

$$c^R = \omega A \left\{ \left[(1-\delta)\,\bar{h}^R \right]^{\theta} + \pi \left[\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R \right]^{\theta} \right\} = y^R \tag{2.14}$$

with first order condition:

$$A\theta\,(1-\delta)\,\bar{h}^R \left\{ \left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) \right]^{\theta-1} - \left[(1-\delta)\,\bar{h}^R \right]^{\theta-1} \right\} = k\frac{y^R}{\omega} \tag{2.15}$$

where $k = \phi + (1+\phi)\ln\left[\frac{\left(\bar{h}^R + \pi\bar{h}^P\right)}{(1-\delta)\bar{h}^R}\right] \geqslant 0$.

2.2.2 Interdependent Production

Continuing to use a simple growth model with human capital as the only factor of production, we now assume that the privileged and disadvantaged are dependent on one another, represented by their respective production interacting with one another. We obtain this feature by using a Cobb-Douglas form of the production function for the entire society:

$$Y = A\left\{ L^R \left[(1-\delta)\,\bar{h}^R \right]^{\gamma} \right\} \left\{ L^P \left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) \right]^{\mu} \right\} \tag{2.16}$$

where notation is defined as above and, γ and μ represent the elasticity of output with respect to human capital in the privileged and disadvantaged segments of society, respectively. Immediately:

$$(\gamma+\mu) \in \left\{ \begin{array}{c} > 1 \text{ represents increasing returns} \\ = 1 \text{ represents constant returns} \\ < 1 \text{ represents decreasing returns} \end{array} \right\} \tag{2.17}$$

Per capita output of the privileged and disadvantaged sections of society is now given by:[45]

$$y^R = \omega A\pi \left\{ \left[(1-\delta)\,\bar{h}^R \right]^\gamma \left[\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R \right]^\mu \right\} \tag{2.18}$$

$$y^P = (1-\omega)\,A \left\{ \left[(1-\delta)\,\bar{h}^R \right]^\gamma \left[\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R \right]^\mu \right\} \tag{2.19}$$

The decision problem defined by (2.13) is constrained by:

$$c^R = \omega A\pi \left\{ \left[(1-\delta)\,\bar{h}^R \right]^\gamma \left[\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R \right]^\mu \right\} = y^R \tag{2.20}$$

with relevant first order condition:

$$(1-\delta)\,\bar{h}^R \left\{ \left(\frac{\mu}{\pi}\right) \left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) \right]^{-1} - \gamma \left[(1-\delta)\,\bar{h}^R \right]^{-1} \right\} = k \tag{2.21}$$

where k is defined as for (2.15).

The model presented is a static model. It provides static equilibrium outcomes which allow for the allocation (or expropriation) of resources by the privileged in society to (from) the disadvantaged.[46] The mechanism of the model is one where by increased transfers to the disadvantaged group from the privileged group, although increasing the productive capacity of the privileged group, results in a loss of power for them due to rising aspirations of the disadvantaged group. This generates the non-monotonicity in the transfer of resources to the disadvantaged group.[47]

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[45] We normalize on L^R.

[46] A dynamic model would be an interesting addition, but beyond the scope of the propositions discussed in Section 2.3.

[47] For example, with respect to the intra-group conflict in Sri Lanka, the privileged Sinhalese mandarins transferred resources to the disadvantaged Sinhalese majority via subsidies to education and school feeding programs. This resulted in rising aspirations of the disadvantaged and the increase in conflict with the Sinhalese populace characterized by a Marxist uprising.

2.3 Three Core Results

We emphasize three results to emerge from our model, which shed light on the initial problem statement concerning the nature of conflict in different societies.

Specifically, we identify conditions that determine the intensity of conflict, the possibility of complete accommodation of the disadvantaged by the privileged, and finally a characterization of intermediate levels of conflict between obliteration and complete accommodation of the disadvantaged.

Proposition 1 (Genocide) *The privileged will eliminate the disadvantaged members of society provided that production is separable, and that constant or increasing returns to scale hold in production. Genocide will not emerge under interdependent production, nor under separable production provided that returns to scale are decreasing.*

Proof. We begin by showing that genocide is necessary under separable production and constant or increasing returns to scale. Genocide occurs under $\delta^G = -\pi\bar{h}^P/\bar{h}^R$, since this fully extracts the resources of the poor. For δ^G, $k\frac{y^R}{\omega} = 0$. For $\theta = 1$, $\left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R)\right]^{\theta-1} - \left[(1-\delta)\,\bar{h}^R\right]^{\theta-1} = 0$, such that δ^G is a solution to (2.15). For $\theta > 1$, $\left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R)\right]^{\theta-1} - \left[(1-\delta)\,\bar{h}^R\right]^{\theta-1} < 0$, such that (2.15) requires $\delta < \delta^G$, providing a corner solution.

It remains to show that genocide does not solve the decision problem under separable production and decreasing returns, or under interdependent production.

For $\theta < 1$, under $\delta = -\pi\bar{h}^P/\bar{h}^R$, $\left[(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R)\right]^{\theta-1} \rightarrow \infty$ as $(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R) \rightarrow 0$, while $k\frac{y^R}{\omega} = 0$, such that $\nexists\ \delta$ satisfying (2.15). Under (2.16), when $\left[\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R\right] \rightarrow 0$, $y^R \rightarrow 0$ and hence $c^R \rightarrow 0$. This eliminates genocide under interdependent production, regardless of returns to scale assumptions. ■

The intuition for the genocide proposition is straightforward. Under separable production, the only circumstances under which the rich stand to gain from redistribution to the poor, is under decreasing returns to scale. Given constant or increasing returns, the rich always gain from extracting additional resources from the poor, in order to allocate them to own production. By contrast, under decreasing returns to scale and separable production, there is a productivity loss that results from allocating resources from the poor to the rich. Provided that the power loss that attends redistribution is not too great, the rich stand to benefit from allocating productive resources to the poor, and recovering the loss through the extraction of resources from an increased level of production. By contrast, where production is interdependent, the rich simply cannot drive the poor to extinction, since this would eliminate the possibility to produce for themselves also.

The significance of the genocide proposition lies in its implications for the distinction between agrarian and industrial societies, and the forms of conflict that are associated with each. In effect it speaks to the puzzle noted in the introduction - that the form of conflict that we witness both within and between current societies is different from that which we have witnessed in most of human history. Current

sensibilities show a heightened awareness of the dangers of genocide - but attempts at the complete elimination of 'enemy' societies are hardly unique in human history. Cato's delenda est Carthago injunction, finally followed in the most literal manner is one illustration of many. To cite a few: Assyrian warfare in the eight and seventh centuries BC, which relied on the razing of cities, and the extermination or complete enslavement of their populations; the destruction of Troy and its defenders; Genghis Khan and Timur Lenk (Tamerlane) in their leadership of the Mongolian expansion; the destruction associated with the Crusades - on both sides, and often with disregard for the religious conviction of the vanquished; the persecution of the Hugenots in France, with the massacre of Saint Bartholomew (1572) and the revocation of the Edict of Nantes; the thirty years war in Germany, with its associated widespread and extensive destruction.

To be sure, modern conflict is often associated with cataclysmic human loss, often far exceeding in absolute terms that of earlier genocidal conflict in its sheer scale. World War II resulted in up to 60 million deaths. But this is simply a function of the scale of the conflict that industrial society makes possible. In proportional terms, even conflicts that have popular reputations as resulting in untenable casualties, are mild (in relative terms, of course) by comparison with the examples cited above in the context of agrarian conflict. Thus in World War I military deaths as a percentage of total mobilized, of the total male populations aged 15-49, and of the total population, were 12%, 2.7% and 0.7% for the Allies, and 15.7%, 11.5% and 2.6% for the

Central Powers.[48] Thus while the absolute numbers killed were unprecedented, the intensity of conflict did not approach the devastation of a Genghis Kahn. Despite the scale of the human cost resulting from the increased deployment of technology, and the scale of modern nation states, the most dramatic of modern conflicts nevertheless was not aimed at the elimination of the enemy - but at the incorporation of the resources the enemy controlled instead.[49]

How to conceptualize this difference? The present model provides a means of accounting for the difference. Agrarian societies with finite land resources face Malthusian conditions of decreasing returns to scale. Expansion of production of necessity requires the use of ever more marginal land, with associated decreasing returns to production. These conditions can be escaped only where there is geographical room for expansion - allowing for the reproduction of existing production in what is (for the expanding society) virgin territory, at the expense of incumbent occupants of the conquered land who must be eliminated in order to realize the constant returns to scale available to the victor.[50]

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48 See the discussion in Ferguson (1999).

49 It is important to bear in mind that the present framework is a means of characterizing forms of conflict under different resource configurations, and under alternative technologies of production. It is not a theory of genocide. For instance, pogroms and genocide aimed at Jews are arguably different. Antisemitism persisists across time, technology and cultures, and thus lies outside of the framework presented here.

50 (Lamb, 1927:1) writes of Genghis Khan that:

"when he marched with his horde, it was over degrees of latitude and longitude instead of miles; cities in his path were often obliterated, and rivers diverted from their courses; deserts were peopled with the fleeing and dying, and when he had passed, wolves and ravens often were the sole living things in once populous lands."

Our framework is able to capture this pattern. Under agrarian production, with separable production between two groups distinguished by their relative endowment of resources (human capital), the privileged society can postpone the realization of decreasing returns to scale (effectively mimic constant returns to scale) by the elimination of rival societies.[51] Under these conditions, the nature of conflict will be extreme in the sense that the object is the elimination of the rival society, though the technology of agrarian society may be such as to limit the scale at which the conflict can be conducted. Where there exist extensive geographic opportunities for expansion (the Eurasian steppes, the American west), conflict may be protracted and societies with inferior resources to the expansionary power may face extended periods of extreme destruction. However, as soon as the opportunity for unlimited geographical expansion is eliminated, diminishing returns become binding under agrarian production, and the incentive for the expansionary power is no longer the destruction of poorer societies, but rather their incorporation in order to limit the impact of decreasing returns to scale.

By contrast, under industrial production with complementarity of factors of production, of workers (the relatively disadvantaged) and managers (the privileged), destruction of resources no longer falls within the bounds of rational choice. Conflict can be aimed only at the incorporation of additional resources, not at their destruction.

[51] As long as the cost of fighting does not outweigh the loss due to redistribution

This model is applicable to the transfer of *any* resource. Therefore, the model is generic in the type of resource that is transferred. There is no distinction between the different types of resources that are transferred since they yield similar outcomes. what matters is the technology of production.[52]

The implication of the present discussion therefore is that the declining intensity (as opposed to scale) of conflict in history, the shift from attempts to obliterate enemies to more restrained objectives, is associated with one of two characteristics of the technology of production: either the move from constant to decreasing returns to scale under separable production, or the move from separable, to interdependent production.

Proposition 2 (Equalization) *The privileged will redistribute fully, ensuring equality of per capita human capital between the privileged and disadvantaged, provided that production is interdependent, and that* $\left(\frac{\mu}{\gamma}\right) \geq \phi$.

Proof. Full redistribution requires $\delta \geq \left(\frac{\pi}{1+\pi}\right)\left(1-\frac{\bar{h}^P}{\bar{h}^R}\right)$.

Under separable production, the proof to Proposition [1] shows that for $\theta \geq 1$, $\delta \leq \delta^G$, precluding full redistribution. For $\theta < 1$, from (2.15), since $\left[\left(\bar{h}^P + \frac{\delta}{\pi}\bar{h}^R\right)\right]^{\theta-1} - \left[(1-\delta)\,\bar{h}^R\right]^{\theta-1} = 0$ and $k\frac{y^R}{\omega} > 0$, $\nexists\ \delta$ satisfying (2.15).

For interdependent production, under $\delta = \left(\frac{\pi}{1+\pi}\right)\left(1-\frac{\bar{h}^P}{\bar{h}^R}\right)$, for the (2.21) condition, $\frac{\mu}{\pi} - \gamma = \pi + (1+\pi)\ln[1+\pi] > 0$, is sufficient, and $\frac{\mu}{\gamma} > \phi = \pi$ is necessary.

■

[52] See also Collier and Hoeffler (2006) which analyses democracy in resource-rich societies.

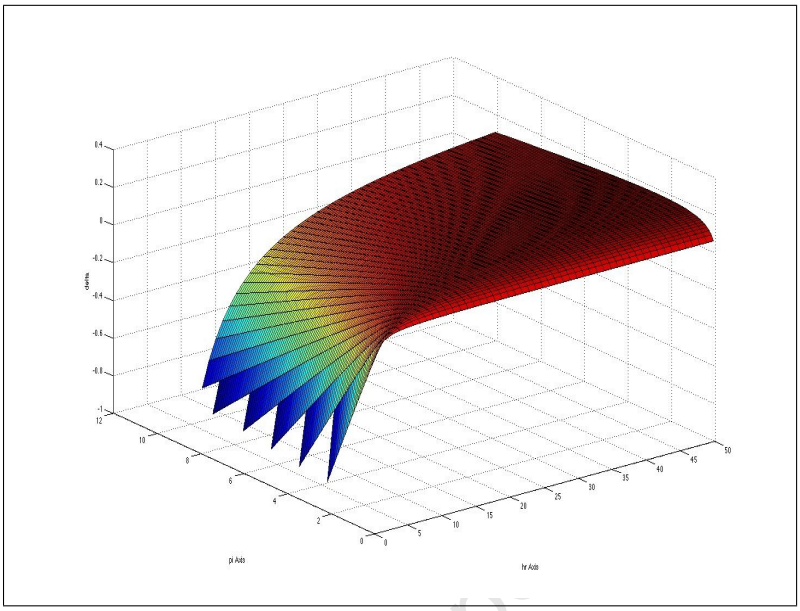
Intuition in this instance emerges from the trade-off between productivity gains to be realized from the redistribution of resources from the privileged to the disadvantaged, and the rising aspirations and associated power loss that result from the redistribution. What the present framework demonstrates is that where the relative productivity of the disadvantaged to the privileged (μ/γ) is sufficiently large relative to the level of aspirations in society (ϕ), the productive pay-off to the privileged in society may be sufficient to outweigh any loss in power resulting from the redistribution even to the point of equality in relative human capital.

The net result is that the privileged effectively trade away their relative power superiority in extracting final output, and share resources in society with the previously disadvantaged, in order to render society more productive. In effect, they extract a smaller proportion from a larger pool of resources realized through a human capital transfer to the poor. This then is the stylized South African case of incorporation of the poor into the elite.

Proposition 3 (Intensity) *The privileged maximize extraction (minimize redistribution) where (a.) the disadvantaged constitute either a small minority, or a large majority, and/or (b.) the ratio of the human capital of the rich to the poor, is either low, or high.*

Proof. Numeric optimization provides the evidence presented in Figures 2.14 and 2.15.

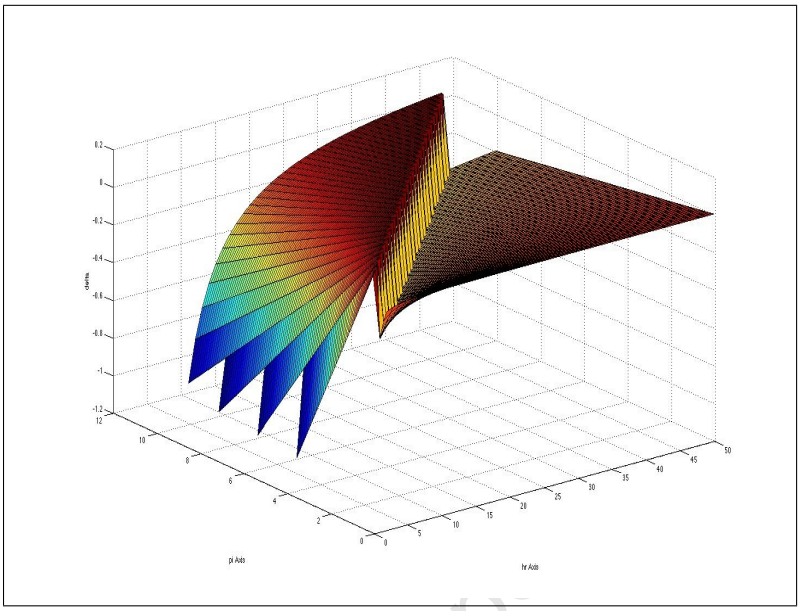
■



$\theta = 0.5$.

Figure 2.14: Separable Production

Here the trade-off between productive gain and aspirations binds. By contrast, where the disadvantaged constitute a very small minority, there is no real productive gain from redistributing resources to the poor. Where the disadvantaged constitute a sufficiently large majority, redistribution comes to represent a danger to the privileged, since rising aspirations of the poor erodes the power of the rich. Only in an intermediate range of the population proportions, does the productivity gain sufficiently compensate for the growth in aspirations and the associated loss in power, to merit a strong redistributive impulse on the part of the privileged. Figure 2.16 illustrates in cross section for any given ratio of privileged to disadvantaged human capital, for the case of interdependent production.



$\gamma = 0.25, \mu = 0.25.$

Figure 2.15: Interdependent Production

The trade-off is also apparent in terms of the ratio of the human capital of the privileged, to that of the disadvantaged. Where the ratio is low, the privileged attempt to extract further resources from the poor for themselves, to realize the associated productive gains for themselves directly. Equally however, where the ratio of privileged to disadvantaged human capital is sufficiently high, the disadvantaged constitute so marginalized a component of production, that the power of the privileged is virtually absolute, and they respond by extracting the maximum from the disadvantaged. In effect, the disadvantaged become the flotsam of society, with no aspirations at all, $\phi \to 0$, such that the extractive power of the privileged is virtually complete, $\omega \to 1$.[53] Proposition [3] implies that the population-weighted ratio of

[53] Contrast these findings with those of the BVM competitor model. The BVM model states that "if

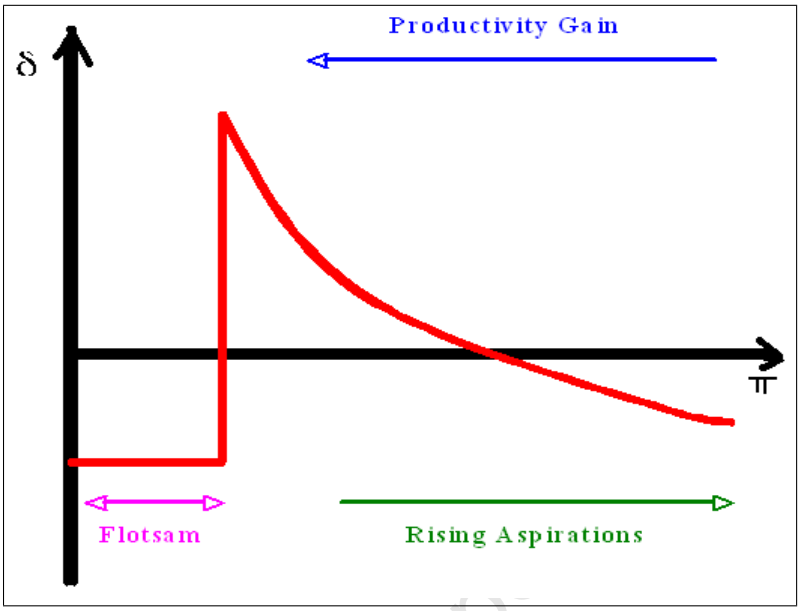


Figure 2.16: The Trade-off between Aspirations and Productivity Gain

poor to rich per capita human capital is crucial to the degree of extraction by rich or allocation to poor of human capital. That is, aspirations (ϕ) matters.

Therefore the equilibrium outcome of the model does vary if a society engages in industrial production as opposed to agrarian production. Thus the characteristic of

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the educated skilled workers are numerous enough, they will then be able to impose the redistribution of ...income in their favour" through a tax on capital. The difference in our paper is that the rich may decide to redistribute such that equality holds under interdependent production and under a very special case. In the BVM model complete redistribution is also possible under a very special case, i.e., if the tax on capital is not too high and if the net return on capital is large enough. One may think of the tax on capital enforced by the newly skilled workers in the BVM model as the power parameter for the disadvantaged. If the disadvantaged have enough power (or the rich have too little power) the productivity gain from redistribution of human capital is lost by the rich to the poor due to (in our paper) rising aspirations. In the BVM model however, the level of tax is not endogenously determined. The only thing that determines whether a tax is imposed or not is the number of unskilled the capitalists decide to educate. In this model, aspirations (tax on the privileged) rises with the relative number of poor people but there is always a tax on the rich as a result of a rising number of poor individuals as aspirations rise with π.

the production possibilities frontier, which is influenced by the type of production, affects the solution to the problem.

The three core results of our model that we have presented thus allow us to span a wide range of conflict intensities, from complete accommodation to complete elimination of opponents. Importantly, the models allow for the possibility that the elite of society will transfer resources to the disadvantaged in order to realize productive advantage, though there is a cost to be paid in the form of rising aspirations (hence conflict) of the poor under such transfers.

2.4 Robustness of Results to Alternative Objective Functions of the Privileged

We now consider the robustness of the propositions discussed above to two alternative conceptions of the objective function of the rich members of society. The two relevant questions here are: does it matter if the elite cares about the welfare of the poor (e.g. whether we have an 'altruistic' elite)? and does it matter whether we have a 'cultured' elite, in the sense that the advantaged members of society care about the inherent benefits that derive from human capital, as well as the benefit from income *per sê*?

First, using the utility function for the representative individual in either segment of society defined in Equation (2.7) we assume $\beta > 0$, and $\alpha > \beta$. This implies simply, and reasonably, that the privileged care more about their own utility than the

agent belonging to the disadvantaged society, though they do care about the poor to some extent. Checking for robustness of the propositions, we find the following:[54]

- The Genocide Proposition [1] still holds (though it becomes less likely that Genocide will occur);;
- The Equalization Proposition [2] still holds but at a *higher* level of aspirations. This implies that the privileged are willing to lose more power. Thus the required productive pay-off to the privileged in society is less than when the privileged are indifferent ($\beta = 0$).
- The Intensity Proposition [3] still holds.

Results are thus not sensitive to the presence of an 'altruistic', rather than purely self-interested elite - though conditions are undoubtedly improved in the presence of an altruistic elite.

Second, we also allow for the possibility that the utility function for the representative individual belonging to the privileged segment of society is:

$$U^R = \alpha \ln \left(c^R\right) + (1-\alpha) \ln \left((1-\delta)\, \bar{h}^R\right) \tag{2.22}$$

The above utility function indicates that the privileged value human capital in its own right (being able to appreciate Shakespeare adds to the value of life), thus adding to their utility. Checking for robustness of the propositions, we find the following:[55]

[54] Numeric optimization provides the evidence presented.

[55] Numeric optimization provides the evidence presented.

- The Genocide Proposition [1] still holds; However, genocide is now possible under decreasing returns to scale in human capital for the independent production function, as well as under constant and increasing returns;
- The Equalization Proposition [2] still holds but at a *lower* level of aspirations. This implies that the privileged are less willing to loose power.
- The Intensity Proposition [3] still holds.

The intuition is not difficult to understand here. A cultured elite needs more resources to allocate to cultural activity, and this comes at the cost of the poor.

The moral of the story is that the disadvantaged of society should prefer an elite which is narrowly focussed on the maximization of its monetary wealth - not an elite that appreciates theatre and opera in its own right. In short, the poor should strive for an altruistic and venal elite. However, there also exisits the possibility that under a venal elite, the extraction of resources from the disadvantage in society may occur sooner in venal societies or transfers to the disadvantaged are marginal in venal societies.

In our model, if we included different prices for goods sold to poor and rich, then prices would also matter in determining the steady state reached and hence the degree and nature of redistribution of human capital. This model assumes that prices are the same between goods consumed in rich and poor societies and the 'effective' level of human capital is equal to the actual quantity of human capital. That is, this

model abstracts from efficiency of human capital held by the poor and rich. If the rich and poor used their human capital allocation with varying degrees of efficiency in the production process, this too would affect the degree and nature of redistribution of human capital.

However, in broad terms we note that the results of the Chapter are robust to the possibility that the rich may care about the poor (though less than about themselves), and to the introduction of a cultured elite.

2.5 Implications of the model

In this section we explore the implications of the core mechanisms and predictions to emerge from the theoretical formulations presented above, as well as drawing some inferences for likely patterns of conflict that might be predicted from the model.

1. The model has two core mechanisms:

   (a) That political aspirations rise in the amount of human capital transferred to the disadvantaged. The evidence of Figure 2.13 suggests that aspirations (ϕ) may be convex in measures of human capital transfers (δ).

   (b) The privileged have an incentive to transfer human capital to the poor in order to raise the productivity of the poor, which in turn enhances the income and hence the consumption opportunities of the privileged. (In turn they pay a cost in the form of a power loss in the amount of human capital

transferred to the disadvantaged, which raises the aspirations of the poor, thereby lowering the proportion of total output that the rich can appropriate for themselves.)

2. The model has the core prediction that the transfer of human capital from rich to poor (δ), should decline as the ratio of the poor to the rich population in society (π) rises - subject to a potential non-linearity, such that at very low or very high ratios of disadvantaged to advantaged populations the advantaged members of society may cease transferring human capital to the poor. Thus a measure for human capital transfers should be concave in a measure of the ratio of poor to rich population.

3. It is possible to draw some inferences about the likely patterns of conflict that would be associated with the mechanisms of the model. Specifically:

   (a) We conjecture that conflict should be concave in measures of aspirations (ϕ). At low levels of aspirations, the poor do not have the means of mounting strong opposition to the advantaged of society. Conversely, where the human capital endowment of the poor is sufficiently high, the reason for conflict has disappeared, since the human capital endowment of the poor begins to approach that of the rich sufficiently to render conflict counter-productive.

(b) Since for our model, the primitives of aspirations are human capital transfers and the population ratios of poor to rich, the non-linearity of conflict in aspirations should be observable in the relation to human capital transfers (δ) and population proportions (π) also.

2.6 Does the model apply to the South African and the Sri Lankan experience?

The model draws general conclusions on the likelihood, intensity, and pervasiveness of conflict. By exploring the core predictions to emerge from the theoretical formulations presented above we discuss the possible reasons for the differing intensities of conflict (if conflict even exists) between South Africa and Sri Lanka. Since both economies do not only depend on agriculture and each segment of society depends on the other to some extent, the discussion focuses on interdependent technology of production. Thus, industrial production is evident in South African and Sri Lankan societies, since economic actors in both countries specialise in the production of different goods and services.

The model predicts that political aspirations rise in the amount of human capital transferred to the disadvantaged; Proposition 3 deals with the intensity of conflict.[56] Recapping it states:

[56] Recall Proposition [3] implies that the population-weighted ratio of poor to rich per capita human capital is crucial to the degree of extraction by rich or allocation to poor of human capital (ϕ).

Proposition 3 *The privileged maximize extraction (minimize redistribution) where (a.) the disadvantaged constitute either a small minority, or a large majority, and/or (b.) the ratio of the human capital of the rich to the poor, is either low, or high.*

For the South African case, the disadvantaged reflect a large proportion of the population (π) but the relative ratio of human capital of the poor ('blacks') to the rich ('whites') $\left(\frac{\bar{h}^P}{\bar{h}^R}\right)$ is relatively small. This implies that aspirations $\left(\phi = \pi\frac{\bar{h}^P}{\bar{h}^R} = \frac{H^P}{H^R}\right)$ although rising is not high enough to threaten the the power (ω) of the rich to such an extent that they become worse off, i.e., their share of total output $\left(y^R = \omega y\right)$ falls after the transfer of human capital to the poor. Moreover, the productivity gain outweighs the power loss of the transfer as the blacks constitute a large proportion of the human capital and therefore some transfer of human capital will generate relatively large returns to the output of the entire economy.

For the Sri Lankan case, since the relative ratio of human capital $\left(\frac{\bar{h}^P}{\bar{h}^R}\right)$ is close to 1 between the Sinhalese and Tamils, any redistribution of human capital between the two communities will result in one community gaining the advantage, i.e., power. Further, the Tamils constitute a minority of the population. Therefore the productivity gain from such a transfer yields low returns to productivity $(\pi < 1)$. Thus the productivity payoff *does not* outweigh the power loss. Thus tension arises over who controls the given resources of the country.

The salient point is that the conflict in Sri Lanka, which may now have developed into an ethnic war, has its roots in the distribution of resources and the relative population sizes of the two groups. It is immaterial that Sri Lanka has intra-ethnic conflict while conflict in South Africa is characterized by conflict between two racial groups. The trigger for the commencement or cessation of conflict is the the distribution of human capital and the demography of the society. This explains the dichotomy of the South African and Sri Lankan experience with respect to the results generated by the model and the degree of conflict as espoused by the model.

2.7 Conclusion

This Chapter has presented a model in which two groups in society are engaged in strategic interaction.

Privileged members of society have the opportunity to allocate resources either to their own productive capacity, or to enhance the productive capacity of the disadvantaged.

Redistribution to the disadvantaged can increase the productive capacity of society, but comes at the cost of rising political aspirations of the poor, which erodes the power of the rich. Results in the Chapter derives conditions under which the rich will redistribute to the point of equality with the poor; conditions under which the disadvantaged face genocide; as well as the range of intermediate redistributive activity and associated levels of conflict likely to be engaged by the privileged.

In doing so the Chapter presents a theoretically based diagnostic for the characterization of forms of conflict, in terms of likelihood, intensity, and pervasiveness. An extension to the model presented in Chapter 2 is to test the model on empirical data to determine if the model's parameters are a good predictor of conflict. A further extension to the the model is an investigation of the dynamic interaction of these competing groups in society. This will provide a description of the behaviour of a society from conflict to peace and vice versa.

Chapter 3
Impact of Economic and Social Infrastructure on Economic Growth

3.1 Introduction

Countries emerging from conflict face a myriad of challenges. One challenge is the rebuilding of their physical infrastructure.[57] Backlogs in infrastructure raise the price of moving goods and conveying services over distance. Deficiencies in logistics are also keenly felt in some transition economies like South Africa (SA). The importance of infrastructure for growth is widespread in the literature.[58] This Chapter investigates the impact of economic and social infrastructure investment on growth in South Africa.[59]

3.1.1 Motivation

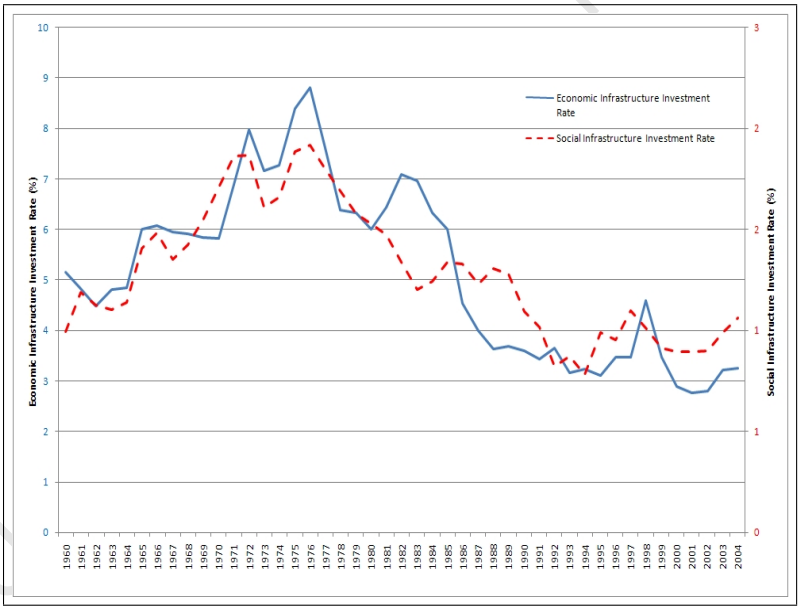
Infrastructure is crucial for a country of South Africa's size, with considerable concentration of production inland, and which is some distance from major industrial

[57] We define infrastructure as the system of public works in a country, state or region, including roads, utility lines and public buildings. Source: Handbook on Geographic Information Systems and Digital Mapping.

[58] See Gramlich (1994) and Fedderke and Garlick (2008) for a review of the main studies on the impact of infrastructure investment.

[59] We differentiate between economic and social infrastucture by using the South African Reserve Bank definition. Economic infrastructure represents items such as roads, bridges, dams, electricity and water supply. Social infrastructure represents schools and hospitals.

markets. An indication of limited infrastructure is logistics cost. South Africa's logistics cost is 15% of GVA whereas her trading partners have logistic cots of only 8.5% of GVA.[60] This puts South Africa at an immediate competitive disadvantage. The higher logistics cost in SA may be due to the declining levels of investment in economic infrastructure. Figure 3.1 supports this suggestion illustrating the deterioration of government gross investment rates in both economic and social infrastructure from the mid-70s.[61]



Source: South African Reserve Bank Bulletin

Figure 3.1: Economic and Social Infrastructure investment rate

[60] See Economic Infrastructure Framework Report (2005) of the Department of Trade and Industry, South Africa.

[61] Infrastructure investment rates are calculated by obtaining the gross investment in economic and social infrastructure investment as a percentage of Gross Value-Added (GVA). Data is obtained from the South African Reserve Bank (SARB) Quarterly Bulletin (2005).

Given these high logistic costs and pressure on SA infrastructure due to rising GDP growth, the South African government launched the Accelerated Shared Growth Initiative for South Africa (Asgi-SA). This policy emphasizes that inadequate infrastructure is a constraint to growth.[62] The extensive capital expenditure program the government commenced in 2006 is aimed at improving and increasing both the efficiency and network of country-wide infrastructure needs of the economy. In the same vein, the SA Cabinet has given its approval for Eskom and Transnet to undertake approximately R121-billion worth of investment by 2010 with a private sector target of R44-billion for both sectors – R23-billon for the energy system and an additional R21-billion for transport. It is estimated that approximately R107-billion would be needed between 2005 and 2009 to meet South Africa's growing energy needs. Eskom plans to meet 70% of this requirement, implying an investment of R84-billion over the next five years with the balance reserved for possible Independent Power Producer (IPP) entrants.[63] The planned rate of growth of the capital budget of government at between 15% and 20% per year is unprecedented in South African history.[64]

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[62] The other topics addressed in Asgi-SA are specific sector strategies, skills development, bridging the gap between the formal and informal economy with the ultimate elimination the informal economy, reducing institutional interventions and improving goverance, reducing the volatility of the currency and to ensure that fiscal and monetary policy work together to produce sustained and shared growth. For more details see SA government website http://www.info.gov.za/asgisa/asgisa.htm.

[63] See Engineering News, 26 October 2006 article.

[64] We emphasize that the growth in the government's capital budget is off a low base due to the steady decline of capital expenditure from the mid-1970s.

A plethora of studies have highlighted the importance of investment in infrastructure on growth. Infrastructure expenditure is deemed to increase the growth potential of an economy by increasing the economy's productive capacity via two possible channels. Infrastructure expenditure affects output directly, as additional factor of production, or indirectly by increasing the productivity of private capital. This implies that productive infrastructure and private capital are 'complements' in production. Thus, a rise in infrastructure capital raises the marginal productivity of private capital services so that, given the rental price of such services, a larger flow of private capital services and a larger stock of private assets producing them are demanded. The rise in the marginal product of capital increases private capital formation, raising private sector output further.

However, infrastructure expenditure need not necessarily have a positive effect on private investment. In fact, this effect can be negative if infrastructure and private capital are substitutes. From the investor's perspective, infrastructure capital acts as a substitute for private capital and 'crowds out' private investment.

One needs to test empirically when private and infrastructure stocks are complements or substitutes by estimating a system of equations that highlights the complex webs of association between private and public capital. This is crucial in understanding the role played by public capital in enhancing growth. Moreover, this analysis may need to be taken on a country-by-country basis because the various pe-

culiarities of each economy determine if public and private capital are complements or substitutes.

South Africa, being a middle-income country, provides an excellent case study on the impact of infrastructure on growth in aiding such transition economies. Given the fact that SA is currently embarking on increasing expenditure on economic infrastructure, there have been some studies undertaken on the impact of infrastructure expenditure on growth.[65] To what extent does social and economic infrastructure lead growth or is it merely responding to increasing growth rates as these transition economies attain higher growth rates?

Given that infrastructure development in SA has occurred in stages (by type of physical infrastructure) over the decades, a principal component analysis is conducted on various measures of physical infrastructure to draw a picture of actual physical infrastructure created over the years. This index provides a picture of the trends in infrastructure development over the recent past. This Chapter also estimates a Barro (1990) type growth model which includes social and economic infrastructure expenditure using South African data. The results indicate the presence of crowding out effects of economic and social infrastructure expenditure. Social infrastructure expenditure is also found to have no net effect on GDP in South Africa. The South African data confirms that the presence of feedback effects from GDP and private investment to economic and social infrastructure are positive and significant.

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[65] For example see Fedderke and Garlick (2008) for a review of the South African literature.

This Chapter proceeds as follows. Section 3.2 provides a theoretical exposition of the model together with an overview of the literature; Section 3.3 provides a brief historical review of the development of economic and social infrastructure in South Africa; Section 3.4 analyzes the characteristics of the data, the estimation technique with results and illustrates the impulse response of per capita output, private and public investment to a series of shocks; and lastly Section 3.5 concludes.

3.2 Impact of Economic and Social Infrastructure on Growth

3.2.1 Theoretical Background

The Chapter adapts the Barro (1990) theoretical model to underpin the interaction of economic and social infrastructure on growth. This model aims to disentangle the impact of public sector infrastructure investment from private sector investment in capital stock. From the theoretical literature, investment in infrastructure is argued to raise the marginal product of private capital used in production. A nuance this Chapter attaches to the Barro model (1990) is the inclusion of public investment in social infrastructure. Thus the Chapter is considering an economy in which infrastructure (economic and social) is used in the production of final output and is financed by a tax on output.

We construct an endogenous growth model, similar to Barro (1990), in which the government owns no capital and does not produce services but acquires private-sector output in order to provide (economic and social) productive services, which serve as inputs into the private-sector production process. The services are purchased under a balanced budget constraint, using a flat-rate income tax, τ, for the provision of economic and social infrastructure, respectively.

Assuming Cobb-Douglas technology, the labour-intensive production function is assumed to be:

$$y = Ag^{\alpha}k^{1-\alpha},\ 0 < \alpha < 1 \tag{3.1}$$

$$g = g_e^{\mu}g_s^{1-\mu},\ 0 < \mu < 1 \tag{3.2}$$

where y denotes output per worker, g denotes per capita government capital stock in infrastructure, $A > 0$ the level of technology and k private capital per worker.[66] Unlike the Barro (1990) model, we disentangle public investment into g_s and g_e, where each represents social and economic infrastructure capital stock per worker, respectively. We assume that economic and social infrastructure expenditure are complements with constant returns to scale in g_s and g_e.[67] We also assume constant returns to scale in k and g, and between g_s and g_e.

We also assume a Cobb-Douglass government production function since we expect government investment expenditure in economic and social infrastructure to

[66] Assume k incorporates physical, human and financial capital.

[67] We test if this is true for South Africa in the empirical model.

be complementary. It follows that the marginal products of $g_s$and g_e are:

$$dy/dg_s = A\alpha(1-\mu)(g_e/g_s)^{\mu}(k/g)^{1-\alpha} = \alpha(1-\mu)(y/g_s) > 0 \quad (3.3)$$

$$dy/dg_e = A\alpha\mu(g_s/g_e)^{1-\mu}(k/g)^{1-\alpha} = \alpha\mu(y/g_e) > 0 \quad (3.4)$$

From the government balanced budget constraint we have:

$$g = p_s g_s + p_e g_e = \tau y \quad (3.5)$$

where p_s and p_e represent the respective relative prices of g_s and g_e.[68] Barro (1990) sets prices equal to 1.

Suppose an infinitely-lived representative household's utility function is of the form:

$$U = \ln c_t \quad (3.6)$$

where c is consumption per worker at time t. Assume a constant rate of time preference, $\rho > 0$. Solving the representative household's maximization problem,[69] the steady-state growth rate, denoted by γ, is:

$$\gamma = (1-\tau)(1-\alpha)A(g/k)^{\alpha} - \rho \quad (3.7)$$

Using the balanced budget constraint, we can rewrite (3.7) as:

$$\gamma = \left[1 - \left(\frac{p_s g_s + p_e g_e}{y}\right)\right](1-\alpha)A\left[\frac{g_e^{\mu} g_s^{1-\mu}}{k}\right]^{\alpha} - \rho \quad (3.8)$$

[68] Relative to the price of output, which is set to equal the price of private capital.

[69] Assume the rate of depreciation of capital is zero.

It follows that:

$$\frac{d\gamma}{dg_s} = \frac{(1-\alpha)}{k}\left[A\alpha\left(1-\mu\right)\left(\frac{k}{g}\right)^{1-\alpha}\left(\frac{g_e}{g_s}\right)^{\mu} - p_s\right] \tag{3.9}$$

$$\frac{d\gamma}{dg_e} = \frac{(1-\alpha)}{k}\left[A\alpha\mu\left(\frac{k}{g}\right)^{1-\alpha}\left(\frac{g_s}{g_e}\right)^{1-\mu} - p_e\right] \tag{3.10}$$

Thus

$$\frac{d\gamma}{dg_s} > 0 \iff \frac{dy}{dg_s} > p_s \tag{3.11}$$

$$\frac{d\gamma}{dg_e} > 0 \iff \frac{dy}{dg_e} > p_e \tag{3.12}$$

A clear, theoretical link between output, government infrastructure and social investment follows. From (3.9) and (3.10), we observe that both economic infrastructure investment expenditure (g_e) and social infrastructure investment expenditure (g_s) can prevent diminishing returns to scale in private-sector capital (k) and raise the rate of growth of output (γ).

The results in conditions (3.11) and (3.12) are similar to the Barro (1990) result in that government intervention of this nature can raise economic growth only within limits. Once the marginal product of government social or economic infrastructure expenditure falls below price p_s or p_e respectively, further increases in g_s or g_e are harmful to economic growth, since the tax effect comes to dominate the capital productivity effect. The diminishing marginal product of economic and social infrastructure implies the existence of a plateau effect – with infrastructure capital reaching a maximum or socially optimal "plateau" level once the tax effect dominates the cap-

ital productivity effect.[70] However, unlike the Barro results the marginal cost of g_s and g_e is the price of g_s (p_s) and g_e (p_e). Therefore, increases in public capital results in positive economic growth if the marginal product of public capital is greater than its marginal cost.

Equally, the exposition identifies a possible source for a distinction between infrastructure and other physical capital – the indirect productivity effect of public infrastructure on private physical capital stock and vice versa.

This implies that any dg_e and dg_s affects the level of investment in private-sector capital stock, since $dy/dk = (1-\alpha) A (g/k)^{\alpha} = (1-\alpha)[y/k] > 0$.

This suggests that

$$\begin{aligned} \frac{d(dy/dk)}{dg_e} &= (1-\alpha)\alpha\mu A (g/k)^{\alpha} \left(\frac{1}{g_e}\right) = \frac{\alpha\mu (\partial y/\partial k)}{g_e} > 0 \\ \frac{d(dy/dk)}{dg_s} &= (1-\alpha)\alpha (1-\mu) A (g/k)^{\alpha} \left(\frac{1}{g_s}\right) = \frac{\alpha (1-\mu) (\partial y/\partial k)}{g_s} > 0 \end{aligned}$$

implying increasing the level of economic and/or social infrastructure expenditure increases the marginal product of private capital.

Under a model that introduces a rationale for distinguishing public from private capital, through productivity enhancement of private-sector capital, the expectation is not only of a direct growth rate impact of changes in public-service provision, but also of an indirect effect on output and growth through changes in the stock of private-

[70] This is similar to the Canning and Pedroni (2004) finding that certain types of infrastructure may exert a negative effect on growth when they evolve overprovision.

sector capital.[71] Thus to capture both the direct and indirect impacts of infrastructure investment, a systems approach to estimation appears to the most plausible.

3.2.2 Empirical Literature

There exist numerous studies on the impact of infrastructure expenditure on growth and/or productivity. The academic debate on public infrastructure was stimulated by Aschauer (1989). Hall and Jones (1999) also provide a detailed anlaysis on the positive impact of infrastructure expenditure on economic growth. Table 3.1 shows the results of various papers using a variety of methodologies in analyzing the impact of infrastructure.[72]

The various methodologies indicate that there do exist positive spin-offs from infrastructure expenditure on output, private investment and/or labour productivity. However, each econometric approach used to study the relationship between infrastructure expenditure and growth does yield results that diverge significantly in terms of either the magnitude of the effect of infrastructure expenditure on output and/or if a positive relationship is significant or not.

The production function approach adopted by Aschauer (1989) and Munnell (1990) captures public capital stock as an additional input factor in a production function. This approach yielded results 'that were just too good to be true' (Aaron,

[71] Note that $\frac{\partial^2(\partial y/\partial k)}{\partial g_e^2} < 0$ and $\frac{\partial^2(\partial y/\partial k)}{\partial g_s^2} < 0$. This may be a theoretical expanation for the crowding-out effect of government expenditure.

[72] See Fedderke and Garlick (2008) for a review of the South African literature on the impact of infrastructure investment on growth.

STUDY	AGREGATION LEVEL	DATA	CONCLUSIONS
Aschauer (1989)	US	Time series, 1949-85	Strong and positive relationship between productivity and public investment
Shioji (2001)	US & Japanese regions	Panel data, 1958-78	Infrastructure capital has a significant positive effect on long-run output in both countries
Shah (1992)	Mexico	Time series, 1970-87	Public infrastructure has positive multiplier effect on output
Rioja (1998)	7 Latin American countries	Time series	Infrastructure investment has sizeable positive effects on GDP and private investment
Ramirez (1998)	Chile	Time series, 1960-93	Public investment has a positive and highly significant effect on growth
Kneller, Bleaney & Gemmell (1998)	22 OECD countries	Panel data, 1970-95	An increase in productive expenditure significantly enhances growth
Ram (1996)	53 developing countries	Panel Data, 1973-80, 1980-85, 1985-90	Public investment appears more productive than private investment
Ford & Poyet (1991)	US	Time series, 1957-89	Public investment has a significant and positive effect on private output
Toen-Goet & Jongeling (1994)	US	Time series	Public investment on infrastructure has a significant and positive influence on output
Nourzad (2000)	12 developing/ developed countries	Panel Data, 1976-1989	Public capital exerts a positive and statistically significant effect on labour productivity
Devarajan et al. (1996)	43 developing countries	Time series, 1970-90	Total government expenditure has a positive but statistically insignificant effect on growth

Table 3.1: International studies on the Impact of Infrastructure Investment

1990). The most serious objections are related to the assumed causality between public capital and output, the specification and restrictiveness of the estimated model and the time-series characteristics of the data.

In addition to the production function approach a number of other approaches have been utilized to investigate the impact of infrastructure on economic performance. Examples of alternative approaches is the behavioural approach,[73] cross-

[73] Under the behavioural approach the flexibility of the functional form requires the database used

section growth regressions[74] and a class of models that examine the potential micro-economic impact, postulated by the Barro (1990)-type models. Employing some of these alternate models, Kessides (1993), Jimenez (1995), Munnell (1990), Murphy et al (1989) and Amsden (1989) find that infrastructure expenditure improves the productivity of private capital, or reduces the cost structure of the private sector, rather than the final growth impact of infrastructure. Lee, Anas and Oh (1999) provide empirical verification of this result.

The following issues need to be addressed when examining the impact of infrastructure development on growth. Firstly, the issue of the amount of services provided by the public capital stock needs to be investigated adequately. In all empirical research it is implicitly assumed that these can be proxied by the stock of public capital or the level of government investment spending, which may not be true. For instance, the amount of services provided is also determined by the efficiency with which services are provided from the stock of public capital. According to Munnell (1993) there is substantial room for improving the efficiency of infrastructure. Similarly, the researcher must allow for network effects, whereby the quality of the connections facilitated by infrastructure investments is separated from the level of the

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to contain sufficient information. Furthermore, the issue of causality is also problematic. Most studies following the behavioural approach conclude that public capital reduces private sector costs or increases private sector profits. However, the estimated effects are generally significantly smaller than those reported by Aschauer (1989).

[74] Problems associated with these cross-section regressions include biases due to omitted variables and reverse causation. Conclusions based on cross-section regressions, especially in a cross-section of heterogeneous countries, are often not very robust and this is also true for the outcomes with respect to the growth-raising effects of public investment.

public capital stock.[75] It may also make quite a difference whether the investment concerns infrastructure which previously did not exist at all, or simply an expansion of already existing capital.[76] Indeed, the evidence of Sturm, Jacobs and Groote (1995)[77] suggests that the former may be more important than the latter.[78]

Secondly, the concept of the stock of public capital includes rather diverging ingredients, like highways and streets, gas, water and electricity facilities. Most authors employ data in their analyses which are usually chosen depending on the availability of data without analyzing whether their conclusions are sensitive to the way the capital stock has been constructed. For instance, most data on the capital stock are constructed using the perpetual inventory method, in which assumptions about the expected life of the assets are crucial. Few authors experiment with different definitions of the stock of public capital, which indeed, sometimes lead to diverging outcomes (Sturm and de Haan, 1995; Garcia-Mil'a et al, 1996). Although some authors, including Aschauer (1989), differentiate between the total stock of non-military public capital and the stock of infrastructure, one may wonder whether this suffices. It is likely that regions and industries react differently to various types of public capital. Indeed, Pinnoi (1994) finds strong evidence in support of this view.

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75 See for instance Garcia-Mil'a et al (1996).

76 For example, is the gain to the economy greater if a new two-lane road is built as oppossed to a two-lane road turned into a four-lane road?

77 See also Sturm and de Haan (1995).

78 Even then, tarring a road when a gravel road would suffice given the climatic conditions and utilization of the road, may not have much impact on the ease of transportation on this road. Thus there is no definite answer to whether new infrastructure investment or simply an expansion of already existing capital is more beneficial to the economy.

Furthermore, the time it takes for public capital to affect GVA growth may be considerable. Thus, lag effects need to be incorporated into modelling infrastructure development on economic activity.[79]

The Vector Autoregressive (VAR) approach tries to solve some of these issues. An advantage of VAR models is that no *a priori* causality directions are imposed or other identifying conditions derived from economic theory are needed. This study will employ the Johansen Vector Error Correction (VECM) approach[80] to estimate the impact of social and economic infrastructure expenditure on per capita gross value-added (GVA) for South Africa.[81] The VECM methodology allows for the indirect and feedback effects of public capital on GVA to be accounted for by estimating a system of simultaneous relationships.

A variety of studies on the impact of infrastructure expenditure on growth have been conducted on South African data. One such study was instituted by the Development Bank of Southern Africa (DBSA).[82] Their report highlights three sets of econometric results for South African data, all of which employ Cobb-Douglas production function specifications. The DBSA's own study relates to the period 1967–1996, and controls for time and capacity utilization. The results indicate a strong, positive relationship between public-sector capital and output, although the ordinary

[79] Kamara (2007) uses Pool Mean Group Estimator and Generalized Method of Moments to account for the lag effects and endogeneity arising from regressing the infrastructure measures on growth.

[80] See Section 3.4.2 for a detailed description of this approach.

[81] In this paper, the term gross value-added (GVA) will be used interchangeably with gross domestic product (GDP).

[82] See Infrastructure: A foundation for development (1998). This is a Development Bank of Southern Africa publication.

least squares (OLS) estimates are spurious (elasticity of approximately 0.3). Using Engle-Granger cointegration estimation, the DBSA study also finds strong crowding-in effects of infrastructure on private-sector non-residential investment.[83]

Perkins, Fedderke and Luiz (2005) show that causality between infrastructure investment and economic growth appears to run in both directions. Specifically, they find a forcing relationship running from infrastructure fixed capital stock to GVA suggesting that infrastructure leads growth, though they also find evidence of potential simultaneity between infrastructure and output (GVA and locomotives; GVA and goods stock; goods vehicles and GVA; GVA and electricity), of output leading infrastructure (GVA and railway lines; GVA and coaching stock; GVA and rail passenger journeys; GVA and port cargo; GVA and SAA passengers; GVA and fixed phone lines), and of no association at all (GVA and rail carrying capacity; GVA and rail freight; GVA and international air passengers). Perkins, Fedderke and Luiz (2005) find weak evidence of feedback from output to infrastructure. In contrast, they find a strong evidence of infrastructure growth leading economic growth. Moreover, Fedderke and Bogetić (2008), using panel data for the SA manufacturing sector, find empirical links between infrastructure and productivity. Specifically, infrastructure affects output and total factor productivity directly.

Summarizing the literature, we come up with the following conclusions:

[83] The results of the Engle-Granger estimation will also be biased if there exist more that one cointegrating relationship. Given the presence of a bi-directional relationship between GDP and public investment in the literature, it is likely that there exists at least two cointegrating vectors in a regression that includes GDP and public capital investment.

1. Public capital probably enhances economic growth; and

2. We are less certain about the magnitude of the effect and direction of association between infrastructure and growth.

To provide an adequate examination of the South African evidence, given the empirical literature and theoretical formulation of the relationship between the economic growth and public infrastructure expenditure, the study will answer five salient questions regarding the impact of economic and social infrastructure expenditure on economic growth. They are:

1. Does there exist a legitimate association between economic growth and the infrastructure measures? If so, is it positively or negatively related to GVA?

2. Is the impact of the infrastructure measures on output direct or indirect?

3. Is the relationship between the infrastructure measures and growth non-linear?

4. Which dimension of the infrastructure measures - economic or social - affects economic growth in South Africa? If both affect per capita output growth, which dimension has a more prominent effect?[84]

5. What is the direction of association between the infrastructure measures, output and private investment?

[84] The net impact of public infrastructure investment on private investment and per capita GDP will be considered in Section.3.4.3.

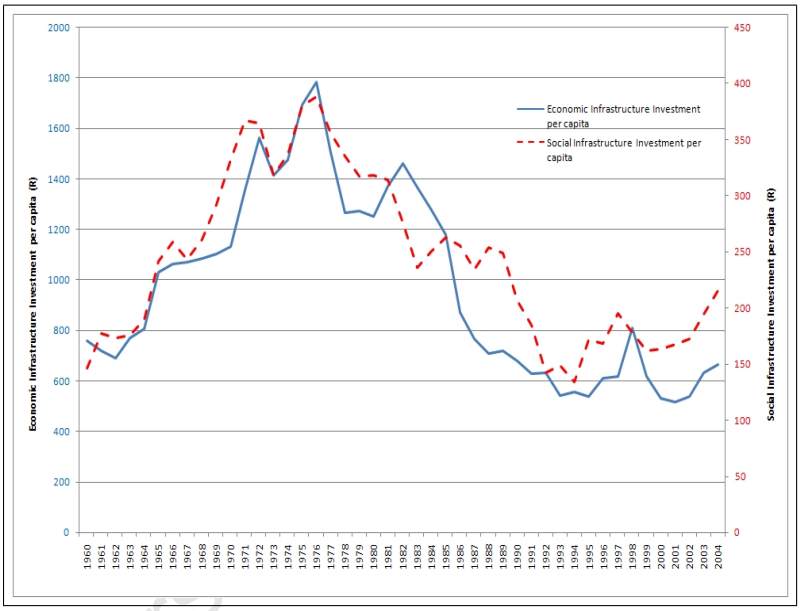
Based on the literature, the impact of infrastructure on economic growth may be affected by country-specific peculiarities. Therefore it is best to undertake this analysis on a country-by-country basis because the various peculiarities of each economy determine if public and private capital are complements or substitutes. We perform this analysis on South African data.

3.3 Economic and Social Infrastructure: A Brief History in SA

The South African Reserve Bank (SARB) publishes the economic infrastructure component of gross fixed capital formation for general government and public corporations. Examples of public corporations are Transnet (transport services such as rail and air), Eskom (electricity), and Telkom (until its listing in March 2003; Telkom provides telephone services). However, there has been a reclassification of these corporations from general government to public corporations. Consequently, the analysis which follows treats economic infrastructure of general government and public corporations together under the expression 'public sector'. While social infrastructure is defined by SA national accounts data as expenditure on infrastructure related to education and health care, specifically schools and hospitals. We use this data for our analysis.

National accounts data reveals that government investment in infrastructure has been declining over the last few years, leading to low levels of gross fixed capital for-

mation (GFCF) and GVA performance.[85] This has been exacerbated by poor coherence and coordination regarding economic infrastructure by the relevant government departments. Figure 3.2 depicts per capita economic and social infrastructure investment. Both series demonstrate a long-term deterioration from the mid-1970s.



Source: South African Reserve Bank Bulletin

Figure 3.2: Economic and Social Infrastructure investment in per capita terms

Real gross investment in economic infrastructure per capita fell from R1,783.50 in 1976 to R531.55 in 2000, a collapse of approximately 70 percent. Investment rates in gross economic infrastructure expenditure (for this period) fell from 8.81 percent of GVA to 2.89 percent of GVA, which lies well below the international benchmark of approximately three to six per cent identified by Kessides (1993). In 2002, 72% of

[85] The national accounts data are expressed in constant 2000 prices.

public-sector infrastructure investment consisted of transport, communication, power and water. The recovery of infrastructure investment in the 1990s and the subsequent slump were mainly the result of expansion programs by the telephone (Telkom) and electricity (Eskom) utilities to extend telephone lines and electricity to areas which were under-serviced, and the purchase of new aircraft by the national carrier (South African Airways).[86]

	Average Investment in Economic Infrastructure per capita (R)	Average Investment in Economic Infrastructure-to-GVA (%)
1960s	910.08	5.39
1970s	1414.97	7.14
1980s	1097.24	5.47
1990s	623.60	3.52
1994-2004	603.50	3.30
2000-2004	576.91	2.99

Source: South African Reserve Bank Bulletin

Table 3.2: Economic infrastructure investment

Table 3.2 depicts the decline in infrastructure investment between the mid-1970s and 2002 was part of an overall decline in gross fixed capital formation (GFCF) over the same period. The slowdown in infrastructure development between the mid-1970s to 2002 was accompanied by a decline in the country's savings and total in-

[86] Source: SARB annual economic reports, 1996–2000.

vestment rates. Furthermore, the share of government consumption in the economy grew.[87] The South African government attempted to prop up the apartheid state in the 1980s by increasing government consumption expenditure at the expense of infrastructure expenditure. The increase in government consumption expenditure increases output while the infrastructure expenditure rate declined. Mariotti (2002) states that government resources were redirected from investment to consumption in the 1980s and early 1990s, whilst during from the latter half of the 1990s, fiscal consolidation to reduce the budget deficit became a priority. The SA government cut back on infrastructure expenditure between 1998-2002.[88] In both cases, this had an adverse impact on infrastructure expenditure.[89]

Perkins, Fedderke and Luiz (2005) provides an extensive data set of physical infrastructure developments in South Africa since 1875.[90] The first wave of infrastructure development was railways over the 1875–1930 period, after which there was little change in the route - kilometre railway line distance – though rolling stock continued to increase. The second wave in infrastructure investment was in inter-city roads, which tapered off around 1940, after which the focus was on the paving of national and provincial roads. In the 1920s and 1930s growth in road traffic far ex-

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87 See Merrifield (2000).

88 In the 80s the budget deficit rises from an average of 2.9 percent between 1980 and 1986 to 4.9 percent in 1987 and 1994. Whilst post-1994, consumption and investment expenditure by government is constrained to reduce budget deficit. The result is a decline in the budget deficit from an average of 4.5 percent between 1995 and 1998 to 1.8 percent between 1999 and 2003.

89 Falling infrastructure investment may also have been a response to overcapacity in certain areas. This is explanation is supported by the findings of Perkins et al (2005).

90 See Perkins, Fedderke and Luiz (2005) for a detailed discussion on the historical development of infrastructure in South Africa.

ceeded growth in rail transport, and with the paving of roads after 1940 road traffic continued to grow faster than rail for the rest of the century. While ports constitute South Africa's oldest form of infrastructure, substantial expansion in port capacity was limited to the 1970s. The final phase of infrastructure development was in telephones and electricity. While the average growth rate for fixed phone lines dropped in the 1960s, it rose again in response to the introduction of information and cell phone technology.

A number of implications follow from the descriptive evidence. Firstly, South Africa's stock of economic infrastructure has developed in stages – with a series of sequential periods of infrastructure roll-out. Therefore, creating an index of physical infrastructure capital stock, may provide us with a more comprehensive picture of the role economic infrastructure plays in development.[91] We emphasize that neither increasing expenditure on infrastructure nor increasing the level of physical infrastructure implies there were improvements in infrastructure in the South Africa.

Apart from the national accounts data obtained from the SARB, the data set on which our analysis is based was compiled largely from the statistical publications of Statistics South Africa and its predecessors. Unfortunately the publication of most of the time series relating to infrastructure (e.g. rail, roads, ports, air travel, telephones) was discontinued by Statistics South Africa in the late 1980s and 1990s.[92]

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[91] This may be the reason why Perkins et al (2005) only finds some measures of physical infrastructure to have a positive effect over the anlaysed sample period.

[92] For the purpose of this study, the data was updated using the original data from Perkins et al (2005).

Figure 3.3 portrays the index of capacity utilization of railroad and road infrastructure.[93] The index incorporates different measures of rail infrastructure[94] per ton of freight and road infrastructure (both paved and unpaved) per vehicle. The declining trend in this index may imply one of two things. Either infrastructure capacity is being eroded or infrastructure is being more intensively. In South Africa in the early 1960s towards the 1970s, in response to rising GVA growth, the latter was the case. Roads were being altered so that vehicular transportation could be more efficiently utilized. Economic growth therefore appears to provide both the need for, and the resources to fund, various types of infrastructure. It is plausible that phases of infrastructure development took place both in response to changes in the structure of the economy, while also impacting on economic performance in their own right.

Perkins, Fedderke and Luiz (2005) also find that South Africa's economic infrastructure developed rapidly from the mid-1870s to the mid-1970s,[95] but that this was followed by a sharp slowdown from the late-1970s to 2002. The paper finds a significant long-run relationship between infrastructure and GVA in South Africa. More specifically, the results indicate that South Africa's GVA growth tends to drive growth in individual measures of infrastructure-related goods and services. International evidence suggests that there is a strong correlation between fixed investment

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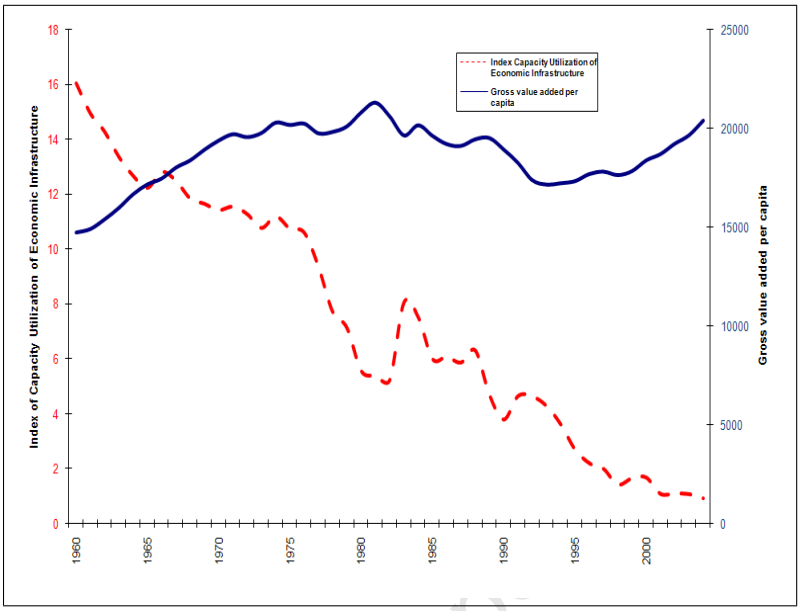
93 For the methodolgy used for the creation of the index of infrastructure see Appendix A.

94 Rail infrastructure measures include railway lines, locomotives and coaching stock.

95 The early boom in South Africa's infrastructure development was led by a need in the mining sector for adequate infrastructure to transport its factor inputs to the mines and its mineral output to the market.



Source: Perkins et al (2005)

Figure 3.3: Index Economic Infrastructure vs GVA per capital

and GVA growth. For example, countries such as Malaysia, South Korea and Chile have kept GDI as a percentage of GVA at levels higher than 20% for the last two decades and have experienced relatively strong and consistent growth.

Table 3.3 depicts a similar trend for social infrastructure expenditure in South Africa. In particular, real social infrastructure expenditure per capita declines from R388.08 in 1976 to R163.95 in 2000, representing a decline of approximately 60 percent. As a proportion of GVA, social infrastructure expenditure in 2004 was 1.06 percent of GVA. Figure 3.2 highlights an increase in social infrastructure expenditure from the year 2000, with social infrastructure expenditure per capita rising to R216.05 in 2004. This is in line with the government's renewed efforts to ensure its social obligations are met from 2000 onwards. The government has been on a

campaign to use its favourable fiscal position to generate social infrastructure, with a special emphasis on the rural areas.

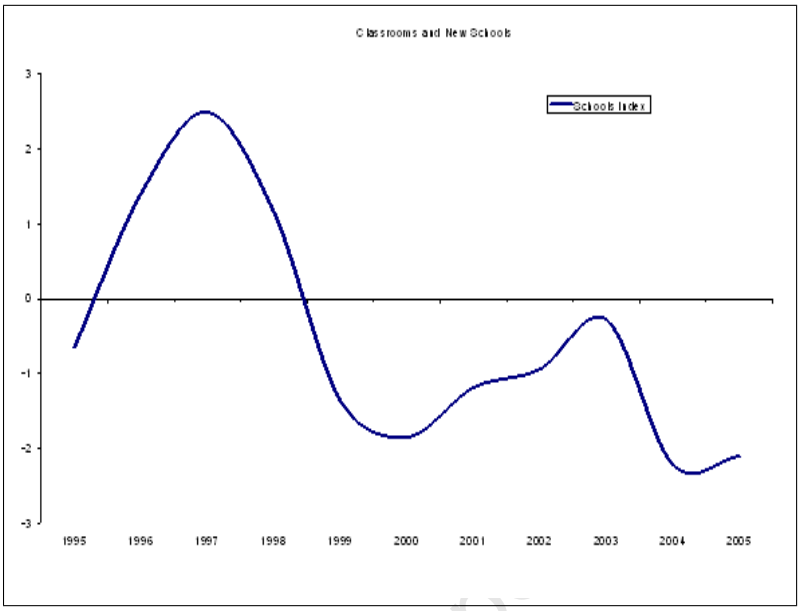
	Average Investment in Social Infrastructure per capita (R)	Average Investment in Social Infrastructure-to-GVA (%)
1960s	215.91	1.28
1970s	344.24	1.74
1980s	264.83	1.33
1990s	169.34	0.95
1994-2004	174.89	0.95
2000-2004	182.79	0.95

Source: South African Reserve Bank Bulletin

Table 3.3: Social infrastructure investment

Figure 3.4 highlights the decline in social infrastructure expenditure in the 1990s reflected by physical infrastructure in schooling. The Figure displays a composite index of new schools and classrooms built from 1995 to 2005.[96] The implication is that over the course of this period, fewer schools and classrooms have been built. This reflects the declining expenditure on social infrastructure depicted in Table 3.3. The reason for this is twofold. Either the South African government addressed South Africa's backlog in schools and classrooms over this period or the government reduced schooling infrastructure expenditure. Given the current need for

[96] For the methodolgy used for the creation of this see Appendix A.



Source: Human Sciences Research Council of South Africa

Figure 3.4: Composite Index of New Schools and Class Rooms

schools and classrooms in the rural areas of South Africa still exists, it is unlikely that South Africa has met its requirement for new schools and classrooms.

The empirical evidence along with the literature highlighted above on both social and economic infrastructure expenditure in SA argues that the SA government may have been spending mostly to cover depreciation of assets. Given the findings of literature on the link between infrastructure expenditure and growth, the responsiveness of government to the changing technological needs of the economy (with regard to the type of infrastructure development) is crucial if it wishes to grow the economy from a transition to a developed economy. From ports, to railways, to roads, to telecommunications, hospitals and schools, infrastructure may remain a prevailing enabler of growth.

3.4 Empirical Analysis

3.4.1 The Data

The sample period covers annual data from 1970 to 2004.[97] The variables employed by this study to measure the two dimensions of infrastructure expenditure are the economic and social infrastructure investment rate on real per capita GVA.[98] Faced with the need of ensuring an adequate representation of the economy in conjunction with a parsimonious specification to render the Johansen estimation technique manageable, we employ the conditioning explanatory variables displayed in Table 3.4 for the estimation:

Variable	Description	Source
$GVAP$	*Log of Gross Value−Added per capita*	*SARB*
$PRIVINR$	*Log of Private Investment Rate*	*SARB*
$SICR$	*Log of Social Infrastructure Investment Rate*	*SARB*
EIR	*Log of Economic Infrastructure Investment Rate*	*SARB*
$INSTAB$	*Interest rate differential between US and SA*	*SARB*
PC	*Log of Price of Capital*	*SARB*
$SAVR$	*Log of the Savings Rate*	*SARB*
$DEFGVA$	*Deficit−to−GVA ratio*	*SARB*
CTR	*Log of Corporate Tax Rate*	*National Treasury*
SKR	*Log of skills ratio*	*TIPS database**
$EconIndx$	*Index of Econonomic Infrastructure*	*Perkins et al* (2005)

* Trade and Industrial Policy Secretariat (TIPS)

Table 3.4: Data Description

[97] At the outset, it should be stated that for the Johansen methodology the sample size is small. This may be a shortcoming of the study but an unavoidable one because some of the variables we use in the study are only available from 1970.

[98] The data on investment in economic and social infrastructure includes expenditure by general government and public corporations.

Our measure of the private investment rate ($PRIVINR$) is restricted to fixed capital stock strictly defined by the gross investment in the stock of machinery and capital equipment as defined by the SARB. The investment rate is a crucial component of any growth regression. It captures the rate of augmentation of physical capital stock throughout the economy. Furthermore, to model the indirect impact of the infrastructure expenditure on per capita output via the private investment rate, an adequately specified investment equation is required.

A number of variables affect the investment rate in South Africa. For example, Fedderke (2004) finds investment to be adversely affected by uncertainty.[99] The presence of uncertainty is of concern to the investor due to the irreversibility of investment. We proxy for uncertainty using a the square of the long-term interest rate differential between the US and SA ($INSTAB$).[100] Fedderke (2004) uses a proxy to measure the marginal cost of investment - the real user cost of capital. It includes the price of capital of fixed capital stock (PC)[101] and the corporate tax rate (CTR). For South Africa, the paper finds the real user cost of capital to have a negative effect on the private investment rate.

[99] See also Kularatne (2002) and Mariotti (2002) where political instability is found to have an adverse effect on the private investment rate.

[100] Using the interest rate differential between South Africa and US to proxy uncertainty is highly correlated with the measure of political instability in South Africa constructed by Fedderke et al. (2001). Furthermore, the interest rate differential measuring uncertainty generates peaks and troughs that match historical developments in South Africa.

[101] The price of capital includes the sum of the opportunity cost of fixed capital stock (given by the interaction of the real domestic short term interest rate and the investment deflator) and the depreciation rate of capital stock.

Human capital is increasingly acknowledged as a necessary component of economic growth. For example, Romer (1986, 1990) shows that human capital is needed for the creation of knowledge-based goods. The findings conclude that human capital determines the rate of technological progress and, consequently, the long-run GDP growth rate.[102] Fedderke (2006) shows the quality of human capital has a positive effect on GVA in South Africa. Here we employ the skills ratio (SKR) to proxy for the quality of human capital.

In addition, we argue that the savings rate ($SAVR$) does not have a direct effect on output nor private investment in South Africa. This follows the Kularatne (2002) argument surrounding presence of credit rationing within the South African economy. Credit rationing implies that private firms may find it difficult to source working capital from financial intermediaries for investment projects. This finding is supported by the World Bank Report (2000). The Report finds a significant proportion of large firms in South Africa finance 100 percent of their working capital from retained earnings. However, rising savings rates allows the government to finance infrastructure expenditure by being able to borrow relatively cheaply. Therefore, we hypothesize that rising savings rates should have a positive impact on economic infrastructure expenditure.

The evidence on the effect of government expenditure on growth is mixed. Barro (1991) and Fischer (1993) found that government consumption expenditure

[102] See Hanushek and Kimko (2000) and Mankiw, Romer and Weil (1992) and Aghion and Howitt (1992).

has a negative impact on economic growth. While Kormendi and Meguire (1985) find that the mean growth rate of the ratio of government spending to output has a positive effect. Barro (1990) claims that government expenditure may have a positive effect on GDP up to a certain level beyond which it will be negative. Since Mariotti (2002) argues that government consumption to GDP threshold level in South Africa has not been reached even at 12 percent of GDP, the possibility exists that government consumption expenditure, at its current rates has a positive effect on GDP. We use the budget deficit ratio as proxy for government expenditure.

Univariate Time Series Characteristics of the Data

The univariate time series characteristics of the data are reported in Table 3.5. Statistics are the augmented Dickey-Fullers. All the variables are found to be non-stationary.[103]

The Johansen Full Information Maximum Likelihood (FIML) Vector Error Correction Mechanism (VECM) cointegration technique will be applied. This estimation technique is well established in the literature, so the subsequent section will only summarize this technique.

3.4.2 Johansen VECM Estimation Technique

[103] Integrated of order 1 ($\sim I(1)$).

Variable	∼I(0)	∼I(1)
$GVAP$	-1.56985	-3.3460^{*}
$PRIVINR$	-1.10349	-4.8235^{*}
EIR	-0.77145	-5.1151^{*}
$SICR$	-1.18181	-5.6011^{*}
SKR	-1.92950	-7.0739^{*}
$SAVR$	-0.14652	-6.0510^{*}
PC	-2.39856	-6.1123^{*}
CTR	-1.27574	-5.5342^{*}
$INSTAB$	-1.39963	-5.9685^{*}
$DEFGVA$	-2.38237	-5.9271^{*}

*indicates significance at the 5% level

Table 3.5: Augmented Dickey-Fuller Test Statistics

Methodology

To estimate a structural model for the linkages between economic and social infrastructure and other macroeconomic variables the Chapter employs the Johansen estimation technique.[104] This technique is based on estimating a Vector Error Correction Mechanism (VECM). The discussion of this methodology will be brief as this technique is well established.

In the VECM framework, for which, in the case of a set of k variables, we may have cointegrating relationships denoted r, such that $0 \leq r \leq k-1$. This gives us a k dimensional VAR:

$$z_t = A_m z_{t-1} + ... + A_m z_{t-m} + \delta + \upsilon_t \tag{3.13}$$

where m denotes the lag length, δ a set of deterministic components and υ a Gaussian error term.

[104] See Johansen (1991) and Johansen and Juselius (1990).

Re-parameterization provides the VECM specification:

$$\Delta z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + \Pi z_{t-k+1} + \delta + \upsilon_t \tag{3.14}$$

The existence of r cointegrating relationships amounts to the hypothesis that:

$$H_1(r) : \Pi = \alpha\beta' \tag{3.15}$$

where Π is pxp, and α, β are pxr matrices of full rank. $H_1(r)$ is thus the hypothesis of reduced rank of Π. Where $r > 1$, issues of identification arise which requires the use of economic restrictions on the loading matrix (α), the matrix representing the short run dynamics, Γ, and/or the cointegrating space, β.[105]

Model

The empirical literature and theoretical model highlight the complex webs of association between private, public capital and output. Infrastructure expenditure is deemed to increase the growth potential of an economy by increasing the economy's productive capacity by either affecting output directly, as additional factor of production, or indirectly by increasing the productivity of private capital. Model [3.16] incorporates the presence of both the indirect and feedback effects in the relationship between the infrastructure measures- social and economic infrastructure, real per capita GVA and the private investment rate based on the theoretical model.

[105] See Pesaran and Shin (1995a,b), Pesaran, Shin and Smith (1996), Johansen and Juselius (1990) and Wickens (1996).

From theory, we would expect $r = 3$ as there exists the possibility that while economic infrastructure investment rate indirectly affects per capita output, feedback effects are present from per capita output and private investment. This is supported by Canning and Pedroni (2004) and the work of Perkins *et al.* (2005). The signs and restrictions on the long run parameters are on the basis of *a priori* economic theory discussed in Section 3.4.1.

We have no *a priori* evidence to zero restrict the effect of the price of capital (PC) and the corporate tax rate on the economic infrastructure investment rate.

$$\Pi z_{t-k+1} = \alpha\beta' \times \begin{bmatrix} GVAP \\ PRIVINR \\ EIR \\ SICR \\ SKR \\ SAVR \\ PC \\ CTR \\ INSTAB \\ DEFGVA \end{bmatrix} \tag{3.16}$$

where $\alpha = \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} & \alpha_{1,3} \\ \alpha_{2,1} & \alpha_{2,2} & \alpha_{2,3} \\ \alpha_{3,1} & \alpha_{3,2} & \alpha_{3,3} \\ \alpha_{4,1} & \alpha_{4,2} & \alpha_{4,3} \\ \alpha_{5,1} & \alpha_{5,2} & \alpha_{5,3} \\ \alpha_{6,1} & \alpha_{6,2} & \alpha_{6,3} \\ \alpha_{7,1} & \alpha_{7,2} & \alpha_{7,3} \\ \alpha_{8,1} & \alpha_{8,2} & \alpha_{8,3} \\ \alpha_{9,1} & \alpha_{9,2} & \alpha_{9,3} \\ \alpha_{10,1} & \alpha_{10,2} & \alpha_{10,3} \end{bmatrix}$ and $\beta = \begin{bmatrix} 1 & -\beta_{1,2} & -\beta_{1,3} \\ -\beta_{2,1} & 1 & -\beta_{2,3} \\ -\beta_{3,1} & -\beta_{3,2} & 1 \\ -\beta_{4,1} & 0 & 0 \\ -\beta_{5,1} & 0 & 0 \\ -\beta_{6,1} & 0 & -\beta_{6,3} \\ 0 & \beta_{7,2} & \beta_{7,3} \\ 0 & \beta_{8,2} & \beta_{8,3} \\ 0 & \beta_{9,2} & \beta_{9,3} \\ -\beta_{10,1} & -\beta_{10,2} & -\beta_{10,3} \end{bmatrix}$

While the estimates of the cointegrating vectors indicate the directions of association that maintain long run stationarity in each system, they offer no information about the speed of adjustment of the variables to deviations from their common sto-

chastic trend. The size and sign of each error correction term (ECT), α_{ij}, represents the direction and speed of adjustment of the system to its long run equilibrium after a shock.

Furthermore, the error correction model will provide us with the relationship between the rate of change in infrastructure investment rate variables and the per capita GVA growth rate and describes the behaviour of the economy away from the long run equilibrium growth path.

We first test for the number of possible relationships in the model by establishing the number of cointegrating vectors.

Johansen maximal and trace eigenvalue statistics

Table 3.6 reports the Johansen trace test statistics and their respective p-values for the model.[106] We observe the presence of three cointegrating vectors at the 10 percent significance level. This indicates the possible existence of three equilibrium relationships.

$Null$	$Trace\ statistic$	$p-value$
$r=0$	318.026	0.000^{*}
$r=1$	224.047	0.006^{*}
$r=2$	169.122	0.052^{*}
$r=3$	127.901	0.117

* denotes significance at 10%

Table 3.6: Johansen trace statistic

[106] Given the small sample size, we use the small sample corrected trace statistic and p-values.

Johansen VECM Estimation Results

The three equilibrium relationships are estimated by means of the Johansen FIML are shown in Table 3.7.[107]

	(1) GVAP	(2) PRIVINR	(3) EIR
$GVAP$	1	-7.32	-1.60
		$[-5.79]$	$[-4.30]$
$PRIVINR$	-0.89	1	-0.41
	$[-10.23]$		$[-2.97]$
EIR		2.15	1
		[11.29]	
$SICR$	-0.28		
	$[-4.40]$		
SKR	-0.48		
	$[-3.96]$		
$SAVR$			-0.52
			$[-5.87]$
PC		0.48	0.23
		[6.02]	[9.26]
CTR		1.14	
		[4.82]	
$INSTAB$		0.17	0.02
		[8.69]	[2.59]
$DEFGVA$	-2.37		-2.35
	$[-4.62]$		$[-3.45]$
$CONSTANT$	-13.01	82.61	17.00
	$[-32.68]$	[6.49]	[4.46]

t-statistics in parentheses

Table 3.7: Johansen results

Equations [1], [2] and [3] in Table 3.7 provide the three cointegrating relationships for output per capita (GVAP), the private investment rate (PRIVINR) and the economic infrastructure investment rate (EIR), respectively. The structural model of the cointegrating relationships support some of our *a priori* expectations in Model [3.16]. Unlike Model [3.16], we find that the direct effect of the economic infrastructure investment rate and the savings rate on per capita output, the direct effect of the corporate tax rate on the economic infrastructure investment rate and the direct

[107] Note that one needs to pre-multiply all the coefficients in Table 3.7 by -1 so that the cointegrating relationship is of the form: $\mathbf{Y_t} = \boldsymbol{\alpha} + \boldsymbol{\beta}\mathbf{X_t} + \boldsymbol{\varepsilon_t}$.

effect of the deficit to GVA ratio for the private investment rate are all statistically insignificant.[108]

As depicted in equilibrium relationship [1], rising private investment rates increases per capita GVA by 0.89 percent. The determinants of private investment is depicted in cointegrating vector [2]. The findings of Fedderke (2004) are supported by the equilibrium relationship [2] in that uncertainty (INSTAB), the price of capital (PC) and the corporate tax rate (CTR) have a negative effect on the private investment rate. The fact that investment is irreversible results in uncertainty adversely affecting both the private and economic infrastructure investment rate.[109] Since government policy affects the corporate tax rate and the price of capital (by affecting the interest rate), the finding supports the theory that imprudent government policy may have an adverse effect on not only, the private investment rate but also the economic infrastructure investment rate as depicted in the cointegrating vector [3].

There are also feedback effects from per capita output to private investment.[110] This implies that rising levels of per capita GVA, indicate growing demand for goods and services. This encourages greater investment.

Romer (1990) discusses the importance of human capital in the creation of knowledge-based goods. These goods increase the growth rate of the economy. Equation [1] supports this finding - a one percent increase in the skills ratio increases

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108 Section 3.4.3 analyzes the net effect on the variables in the model to a shock to a particular variable.

109 See equilibrium relationship [3].

110 See cointegrating vector [2].

per capita output by 0.48 percent.[111] Fedderke (2006) also finds a positive effect on GDP in the quality of human capital for South Africa.

The direct, positive impact of rising savings rate on the economic infrastructure investment rate conforms to our hypothesis in Section 3.4.1. The absence of a direct effect of the savings rate on private investment supports Kularatne (2002) argument of credit rationing within the South African economy.

Our estimation results suggest that both per capita output and the private investment rate have a positive effect on the economic infrastructure investment rate. However, the economic infrastructure investment does not affect per capita output directly and has a negative, direct effect on the private investment rate. The latter contradicts our hypothesis in Model [3.16]. A possible explanation for the contradiction is that private investment may be 'crowded out' by increases to public expenditure on infrastructure. In this case, private and public capital may be substitutes.[112]

The relationships suggest that investment in economic infrastructure, in the recent past, appears to be more a response to growth and rather than lead growth. As capacity became more constrained with rising growth rates, SA appears to have been faced with limited capacity in infrastructure. The SA government appears to have responded by increasing the investment rate in economic infrastructure.

Social infrastructure on the other hand has a direct, positive effect on per capita output. From cointegrating vector [1], a one percent increase in the social economic

111 Recall that the skills ratio is a proxy for the quality of human capital.

112 See also Section 3.1.1 for the discussion on crowding out of private capital by public investment.

infrastructure results in a 0.28 percent increase in per capita output. A possible explanation is that increasing expenditure on hospitals and schooling infrastructure would provide a more productive labour force by improving the quality of the labour force.

Interestingly, increases to government expenditure relative to its revenue (measured by the deficit to GVA ratio - DEFGVA) has a direct positive effect on per capita output and the economic infrastructure investment rates. This suggests that increasing government deficit stimulates the economy by increasing aggregate demand.[113]

Impulse response analysis is necessary to determine the impact of a shock to a particular variable on the other variables in the cointegrating system. This will provide a more accurate picture of the net effect of a particular shock on the entire system. Therefore in the following section we consider the reduced form coefficients on particular variables for a set of specific shocks.

3.4.3 Impulse Response Analysis

The theoretical model in Section 3.2.1 suggests that increases in economic and social infrastructure expenditure has a positive effect per capita GVA growth if the marginal product of capital for economic and/or social infrastructure is greater than their respective marginal cost. Furthermore, the theoretical model highlights the possibility of infrastructure expenditure indirectly affecting per capita output via private

[113] See Mariotti (2002) on a possible nonlinear relationship between government consumption expenditure and growth.

investment. Therefore we analyze the net response of per capita output and private investment rate to shocks to economic and social infrastructure investment rate.

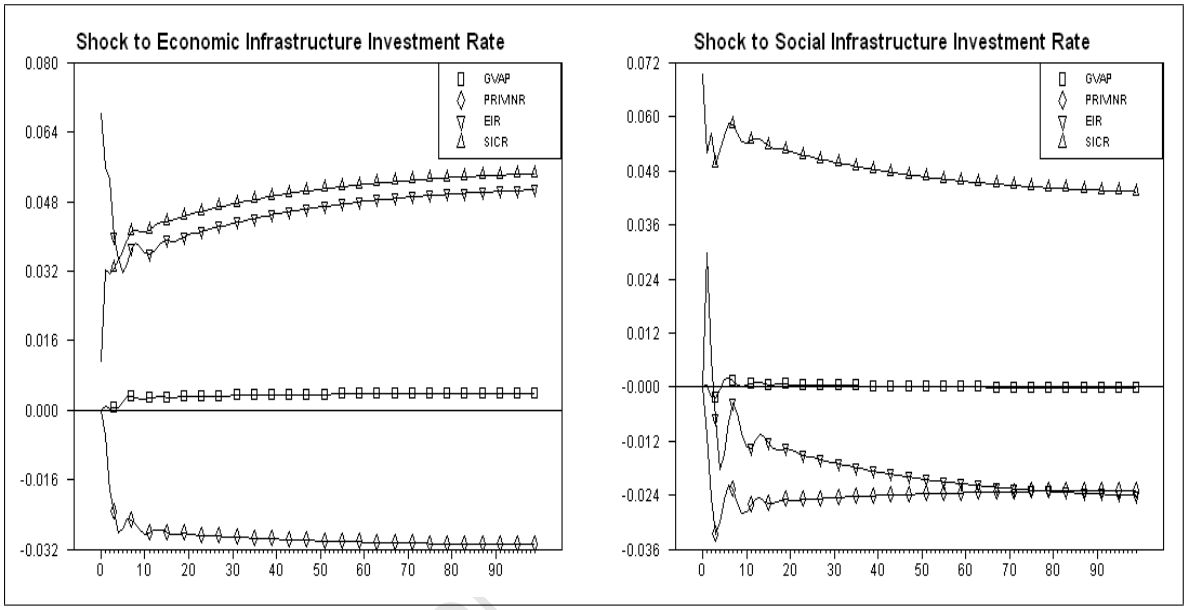

Figure 3.5: Impulse Response: Shock to Economic and Social Infrastructure

Figure 3.5 portrays the effect of a one standard deviation shock to the economic infrastructure investment rate.[114] This shock causes an initial increase in the economic infrastructure investment rate by 6.84 percentage points, stabilizing to 5.08 percentage points after 20 years. Social infrastructure investment expenditure also increases by 5.45 percentage points. This suggests that expenditure on economic in-

[114] See Canning et al. (2004) on performing impulse response analysis using a 1 standard deviation shock is common in the economic literature when analysing empirical models. It provides one with a standardized gauge on the relative importance of each variable and its impact on other variables in the model.

frastructure such as roads are a prerequisite to social infrastructure such as schools and hospitals.

However, while economic infrastructure expenditure increases GVA per capita by 0.39 percentage points, it decreases the private investment rate by 3.10 percentage points. A possible explanation for this is that economic infrastructure expenditure may be crowding out private investment in South Africa.[115] Kamara (2007) also finds the presence of crowding out of private investment by public infrastructure investment for a panel of sub-Saharan African countries. Moreover, a shock to the social infrastructure investment rate also crowds out private investment. This is reflected by a decrease in the private investment rate by 2.29 percentage points. Figure 3.5 also suggests that a positive shock to social infrastructure reduces economic infrastructure investment. For South Africa, rising expenditure on social infrastructure by the government may imply less funds for expenditure on economic infrastructure.

Figure 3.5 provides evidence that a shock to the social infrastructure investment rate has no effect on per capita output. We offer two possible explanations for this result. The first is that crowding out effect on private investment due to a shock to social infrastructure negates any positive effect of increasing social infrastructure on GVA. The second possible explanation is that social infrastructure expenditure in South Africa may be ineffectual. Although, on average, the social infrastructure

[115] Recall Equation [2] in Model [3.16] shows that economic infrastructure investment rate has a negative, direct effect on the private investment rate.

investment rate is 1.29 percent, the impulse response analysis suggests that this expenditure has not produced a positive effect on per capita output.[116]

The suggestion given above for the negative response of the private investment rate to shocks to economic and social infrastructure investment rate (in Figure 3.5) is that infrastructure expenditure crowds out private investment. The crowding out theory is supported for the South African data by Figure 3.6. The Figure shows that a one standard deviation shock to the deficit to GVA adversely affects the private investment rate and per capita GVA, reducing each by 0.59 percentage points and 0.03 percentage points, respectively. Figure 3.6 does portray positive effects on economic and social infrastructure investment expenditure for a shock to the deficit to GVA ratio. The suggestion is that the South African government may be increasing the budget deficit to finance infrastructure expenditure.

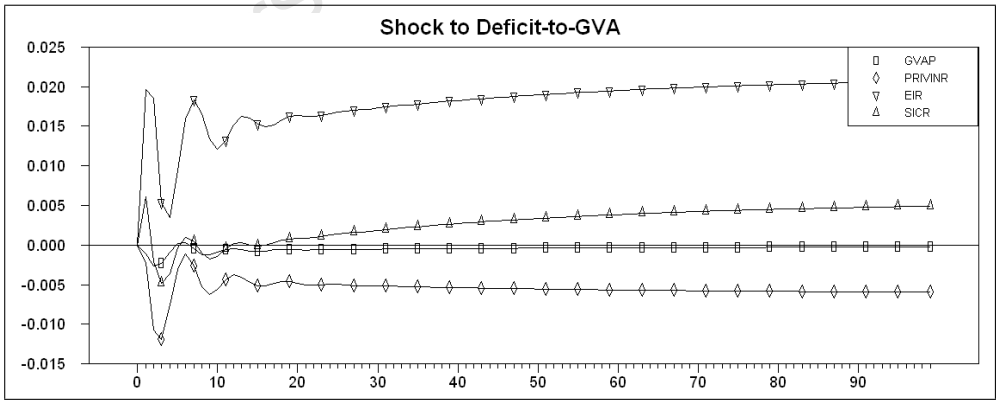

Figure 3.6: Impulse response: Shock to Deficit to GVA ratio

[116] Given that South Africa's capital expenditure on education and health accounts for 15 percent of total capital expenditure, the impulse response analysis implies that this expenditure has no effect on GDP per capita. See National Treasury (2005) National Budget Review.

In addition, Model [3.16] suggests the existence of feedback effects from per capita output and private investment to economic infrastructure investment. The theoretical model also purports that increases in private capital stock increases the marginal productivity of economic and social infrastructure capital stock. Consequently, increasing expenditure on economic and social infrastructure. This is supported by the impulse response analysis depicted in Figure 3.7. The Figure depicts the feedback effect of shocks to per capita GVA and the private investment rate on economic and social infrastructure investment rates. A shock to the private investment rate has a greater effect on economic infrastructure investment rate than social infrastructure investment rate. Specifically, the economic infrastructure investment rate increases by 8.67 percentage points while the social infrastructure investment rate increases by only 3.29 percentage points. A possible explanation for this is that as private investment rises there is greater need for economic infrastructure (such as roads) by the private businesses, more so than hospitals and schools. The need for economic infrastructure by growing private firms is because these firms may need roads and railroads to transfer their goods to market and reduce their logistic costs as they expand their market.

Figure 3.7 also shows that a one standard deviation shock to per capita GVA results in a positive effect on private and public infrastructure investment rates. In particular, a 1.25 percentage point increase, 2.93 percentage point increase and 2.58 percentage point increase in the economic and social infrastructure investment rates,

and the private investment rate, respectively. This is in line with our theoretical prior of increase in output increasing the marginal product of both public and private capital and thus investment both types of capital.

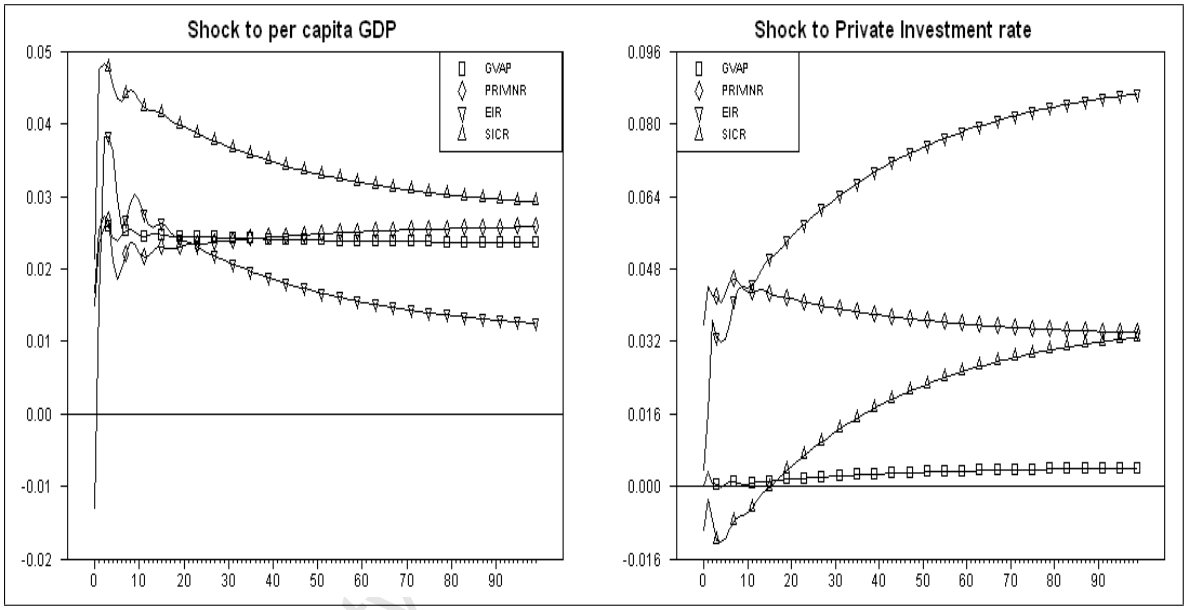

Figure 3.7: Impulse response: Shock GVA per capita and Private Investment

3.5 Conclusion

South Africa belongs to the group of transition countries. Such countries are generally in transition from developing to developed nations. Therefore the results of the effect of economic and social infrastructure on the growth path experienced by SA is an interesting one. Furthermore, the nature of the effect of economic and social infrastructure both on output and private investment is key to understanding the role

government can play in both stimulating and enabling a conducive environment for such transition economies.

The findings of the Chapter suggest that while expenditure on economic infrastructure has a positive effect on per capita output, social infrastructure expenditure has no net output effects. The two possible reasons the Chapter proposes is that either social infrastructure expenditure is ineffective or that the crowding out of private investment by increases in social infrastructure investment negates any positive effect of such spending on GDP. Economic infrastructure investment is also found to crowd out private investment in South Africa. However, the feedback effects from rising output and private investment to economic and social infrastructure are positive. This implies that as the economy grows, individuals demand more and better roads, schools and hospitals.

We have shown the quantity of economic infrastructure has a positive effect on per capita output. It remains to be explored how quality matters.[117] Kamara (2007) gives a lead.

[117] By quality we mean the services rendered by such physical infrastructure must be efficient and required.

Chapter 4
Technology Shocks, Employment and Labour Productivity

4.1 Introduction

Chapter 3 considers the importance of productive public expenditure in determining the developmental trajectory of transition economies in the long run. However, economies experience short-term fluctuations in GDP growth rate. The fundamental framework to analyze economic fluctuations is the Real Business Cycle (RBC) developed by Kydland and Prescott (1982). RBC models are developed under the assumption of a competitive equilibrium in a neoclassical growth model framework, augmented with a labour-leisure choice and exogenous technology shocks. This model, developed to consider GDP fluctuations in the US - a developed economy, finds a high positive correlation between labour productivity[118] and employment. The source of that correlation lies at the root of the mechanism underlying macro fluctuations in these models: it reflects the shift in the labour demand schedule caused by technology shocks (and, to a less extent, the induced capital accumulation), combined with an upward sloping (and less variable) labour supply.[119]

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[118] Throughout this Chapter the terms 'labour productivity' and 'productivity' will be used interchangeably.

[119] See also Christiano and Eichenbaum (1992), Sims (1989,1996), Watson (1993) and Rotemberg and Woodford (1996)

This Chapter suggests that this traditional RBC framework for analyzing GDP fluctuations may not be valid for transition economies as these economies experience a higher degree of imperfect competition and price rigidity. Moreover, since developed and transition economies may have quite different monetary policy objectives, the response of the monetary authority in transition economies to shocks may vary significantly, affecting the variations in employment, labour productivity and output in these economies. Thus monetary policy may influence the dynamics of employment, labour productivity and output to shocks.

Given that different transition economies face different degrees of imperfect competition, price rigidity and monetary policy objectives, we focus our analysis on a specific country - South Africa (SA). South Africa, being a middle-income country, provides an excellent case study. SA has features of a developed and developing economy. She has a well developed financial sector[120] with a developing manufacturing sector that is faced with a high degree of imperfect competition.[121]

4.1.1 Motivation

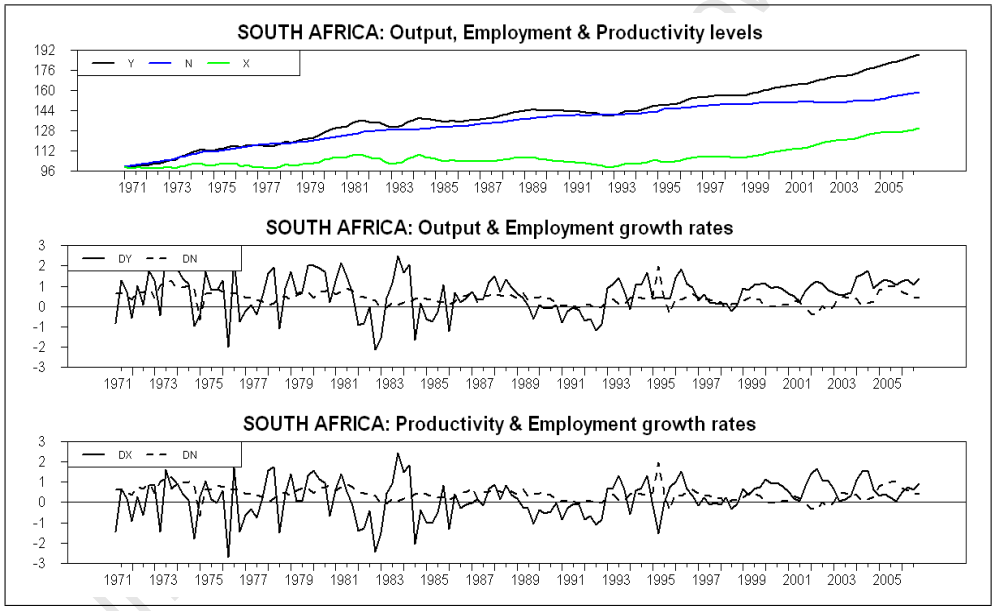
Figure 4.1. displays the evolution of level and growth rate in output, employment and labour productivity in South Africa from $1971q1 - 2006q4$.[122] The data is col-

[120] See for instance Kularatne (2002).

[121] See for instance Fedderke, Kularatne and Mariotti (2007) and Aghion, Braun and Fedderke (2006).

[122] The baseline series for labour productivity (X) was constructed by subtracting the log of employment (N) from the log of GDP (Y). The quarter-on-quarter growth rate in output (DY), employment (DN) and labour productivity (DX) is also calculated.

lected from Statistics South Africa (StatsSA)[123] and the South African Reserve Bank Bulletin (SARB). Figure 4.1 reveals no discernible pattern of business cycles. Given that a salient finding of the traditional RBC literature is a high positive correlation between labour productivity and employment, we consider the correlation coefficient between employment and labour productivity for South Africa. Table 4.1 compares the correlation between employment, GDP and labour productivity in South Africa.



Sample: 1971q1-2006q4

Figure 4.1: Employment (N), output (Y) and labour productivity (X)

We discover the following:

1. Correlation coefficient between employment and labour productivity is

   * statistically insignificant (-0.16) for the entire sample;and

[123] Only employment data is collected from StatsSA as the SARB employment series has an unexplained break in the year 2000.

UNCONDITIONAL CORRELATION			
	$cor(y,n)$	$cor(y,x)$	$cor(x,n)$
$1971q1-2006q4$	0.22^{*} (0.097)	0.93^{*} (0.148)	-0.16 (0.104)
$1971q1-1994q1$	0.35^{*} (0.125)	0.96^{*} (0.138)	0.06 (0.090)
$1994q2-2006q4$	0.08 (0.102)	0.75^{*} (0.141)	-0.60^{*} (0.277)
$1970s$	0.98 (0.890)	0.86 (0.634)	0.72 (0.666)
$1980s$	0.23^{**} (0.133)	0.98^{*} (0.284)	0.03 (0.141)
$1990s$	0.32^{*} (0.099)	0.87^{*} (0.183)	-0.19 (0.341)
$2000s$	0.17 (0.114)	0.61^{*} (0.172)	-0.68^{*} (0.089)

* at 5% significance; ** at 10% significance

Table 4.1: Unconditional correlation between growth rates of Y, N and X

- $*$ negative and statistically significant for the period $1994q2-2006q4$[124] and $2000s$;

2. Procyclical employment for the entire sample; and

3. Procyclical labour productivity for the entire sample.

From the preliminary evidence, point (1) is at odds with real business cycle theory where a positive significant correlation coefficient between employment and labour productivity is to be expected. In particular, Table 4.1 indicates that pre-$1994q2$, the correlation coefficient between productivity and employment was positive (though insignificant) whereas, in the post-democratization phase (post-$1994q2$), this correlation became negative and significant. This is contrary to standard RBC theory.

[124] The sample is dissected in $1994q2$ because 1994 represents the year in which South Africa underwent a democratic transition. It is also the period when more stringent (and some would argue) more inflexible labour market regulation was passed by parliament.

Motivated by the evidence and given that the RBC model claims a positive correlation between employment and labour productivity due to a technology shock, we use a simple bivariate (employment and labour productivity) structural Vector Autoregression (VAR) model to decompose employment and labour productivity into its technology and non-technology (demand) components. The identification of a technology shock is performed by assuming that *only technology shocks have a permanent effect on the level of labour productivity*. This bivariate VAR model finds a negative correlation between employment and productivity for a technology shock and a positive correlation between these variables for a demand shock. The bivariate VAR provides evidence that the South African data does not conform to the traditional RBC finding.

This study seeks to identify a suitable model to explain the data. Any model can be designed to correspond to the empirical data. The crucial requirement is that the assumptions of the chosen model needs to represent the features of the economy it is modelling.

Given that the South African manufacturing sector is faced with sticky prices, high concentration ratios and imperfect competition reflected by the prevalence of high markups,[125] we argue that a new-Keynesian business cycle model would be more suited to explain the fluctuations in output, employment and labour productivity in South Africa. We propose that the Gali (1999) is able to account for the

[125] See for instance Fedderke, Kularatne and Mariotti (2007) and Aghion, Braun, Fedderke (2006).

variations in these variables. The Gali (1999) model is a richer model than the bi-variate model since it allows for the affect of a technology and/or demand shock on a more representative model of the economy by including employment, output, labour productivity, inflation and real money balances in the model.

An alternative possibility for the negative comovement between labour and employment productivity may be explained by a lagged response of one of the variables. This implies that the classical real business cycle model of Kydland and Prescott (1982) may still hold true for the South African data. Given the findings of high markups, monopolistic competition and high concentration ratios in the South African manufacturing industry by Fedderke, Kularatne and Mariotti (2007) and Fedderke and Szolantai (2005), the Gali (1999) model appears to be an appropriate model to use as the assumptions of the Gali model match some of the characteristics of South African industry since classical real business cycle models assume perfect competition.

Institutional failure may also cause the negative comovement between labour and employment productivity. However, this is is unlikely as South Africa has a strong institutional structure that has grown in strength. For example, post-1994 the independence of the South African Reserve Banks is a statutory requirement.

The Gali (1999) model provides the following economic interpretation for the negative correlation between employment and output due to a technology shock. In equilibrium, aggregate demand (and, consequently, the demand faced by each indi-

vidual producer) is determined by the level of aggregate real balances. With sluggish price adjustment and limited monetary accommodation, the short-run response to a positive technology shock is associated with little or no change in the real money supply. Accordingly, the increase in aggregate demand (and desired output) will fall short of the increase in multifactor productivity, inducing firms to decrease the quantity of labour employed. Hence, technology shock will generate a negative correlation between employment and productivity. Moreover, we find that the degree of monetary accommodation by the central bank affects the dynamics of employment and labour productivity. We suggest that the adoption of the inflation targeting regime in 2000 is change in the monetary policy regime and this may have affected the response of employment and labour productivity to a technology shock.

On the other hand, the Gali (1999) model states that an increase in aggregate demand and output arising from a monetary expansion will be partly met by higher unobserved effort, in addition to higher 'measured' employment. We find that, if the response of effort is large enough, an increase in labour productivity will ensue. In that case monetary shocks will generate a positive comovement between employment and productivity.

A nuance of this Chapter is that it analyses the possible values of the parameters in the model that generate specific variations in employment, output, labour productivity, inflation and real money balances in the data. We argue that this analysis provides insight on the degree of monetary accommodation and the returns to

labour for South Africa. It also allows one to determine the inflationary impact of a demand and/or technology shock.

The structure of the Chapter is as follows: Section 4.2 analyses a bivariate VAR model; Section 4.3 provides a description of the multivariate model together with a theoretical analysis of the possible parameter values in the model; Section 4.4 provides an analysis of the link between the models parameters and monetary policy in South Africa; Section 4.5 provides the impulse response of output, employment, labour productivity, real money balances, the real interest rate and the inflation rate to a technology shock; and Section 4.6 summarizes the main conclusions.

4.2 A Two-Variable VAR analysis

4.2.1 Methodology

Gali (1999) decomposes employment and labour productivity into its technology and non-technology components using a bivariate VAR analysis. The identification of a technology shock is performed by assuming that *only technology shocks have a permanent effect on the level of labour productivity*.[126] Further, the two types of shocks are assumed to be orthogonal to each other. Gali (1999) represents this idea formally as follows.

[126] Gali (1999) decomposition is unlike the Blanchard and Quah (1989) decomposition, where technology shocks may only have permanent effects on output and not employment.

Let $[\Delta x_t, \Delta n_t]'$ be a vector representing the first difference of labour productivity (x_t) and employment (n_t). Then we can represent this vector as a distributed lag of both types of disturbances:

$$\Delta q_t = \begin{bmatrix} \Delta x_t \\ \Delta n_t \end{bmatrix} = \begin{bmatrix} C^{11}(L)\, C^{12}(L) \\ C^{21}(L)\, C^{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^z \\ \varepsilon_t^m \end{bmatrix} = \mathbf{C}(L)\varepsilon_t \tag{4.1}$$

where ε_t^z and ε_t^m represent technology and non-technology shocks over time.[127] Assuming only technology shocks have a permanent effect on output, we impose $C^{12}(1) = 0$.

Estimates of the $\mathbf{C}(L)$ matrix is obtained from a reduced-form VAR representation of $[\Delta x_t, \Delta n_t]'$.[128] They are then used to formulate *estimates* of conditional correlations from the following formula:

$$\hat{\rho}\,(\Delta x_t, \Delta n_t \mid i) = \frac{\sum_{j=0}^{\infty} \hat{C}_j^{1i}\, \hat{C}_j^{2i}}{\sqrt{\hat{\sigma}^{2}\,(\Delta x_t \mid i)\, \hat{\sigma}^{2}\,(\Delta n_t \mid i)}} \tag{4.2}$$

where $i = z, m$. The conditional variances of productivity and employment growth are $\hat{\sigma}^{2}\,(\Delta x_t \mid i) = var\,(\Delta x_t \mid i) = \sum_{j=0}^{\infty} \left(\hat{C}_j^{1i} \right)^2$ and $\hat{\sigma}^{2}\,(\Delta n_t \mid i) = var\,(\Delta x_t \mid i) = \sum_{j=0}^{\infty} \left(\hat{C}_j^{2i} \right)^2$, respectively.

The above formulation requires labour productivity and employment to be non-stationary. Table 4.2 confirms employment and labour productivity are nonstationary series for the South African data for the period $1971q1 - 2006q4$.

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[127] To differentiate the technology and non-technology shocks from one another, Gali (1999) assumes that they are orthogonal to one another, i.e., $E\varepsilon_t^z \varepsilon_t^m = 0$.

[128] See Gali (1996) for a detailed exposition on the reduced-form VAR structure.

Variable	$\sim \mathbf{I(0)}$	$\sim \mathbf{I(1)}$
n	-2.12	-3.48^{*}
x	1.48	-5.14^{*}

* denotes rejections of the null of a unit root at the 95% critical value

Table 4.2: Augmented Dickey-Fuller Test Statistics

4.2.2 Graphical Representation of the Bivariate Decomposition

Panels 1 and 2 in Figure 4.2 display disaggregated employment and output into its technology and non-technology components.[129] From Panel 1 in Figure 4.2. We observe that although the comovements of the technology components of GDP and employment are not negligible, the patterns displayed by the two series hardly coincide with "recognizable" business cycles in South Africa. The positive comovement of GDP and employment, with respect to its technology components (which is generally viewed as central characteristic of business cycles), seems hardly present. However, when considering the non-technology components of output and employment, "recognizable" business cycles are visible.

Considering the growth rates in labour productivity and employment for the sample, Panel 1 in Figure 4.3 shows (once again) that no distinct relationship is visible between employment and labour productivity growth. Further, from Figure 4.3 the following is clearly noticeable:

- Negative relationship between labour productivity and employment growth when comparing the technology components of the two variables (Panel 2); and

[129] A VAR with 4 lags to obtain estimates of the $\mathbf{C}(L)$ matrix is constructed.

- Positive relationship between labour productivity and employment growth when comparing the demand components of the two variables (Panel 3).

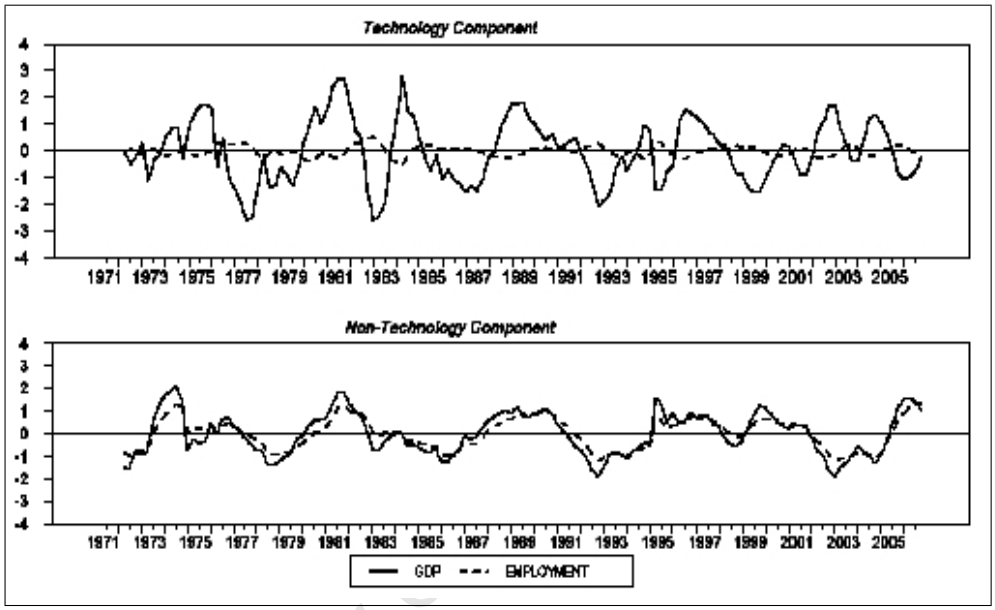

Figure 4.2: Growth rate in Y and N by its demand and technology components

4.2.3 Conditional correlation

Using the constructed bivariate VAR model, Table 4.3 considers the unconditional and conditional correlation[130] coefficients between labour productivity and employment growth rates calculated using Equation 4.2. We observe, for the period $1971q1-2006q4$, the conditional correlation between employment and labour productivity is negative for a technology shock and positive for a demand shock. Furthermore,

[130] Conditional on whether we consider the demand or technology components of labour productivity and employment growth.

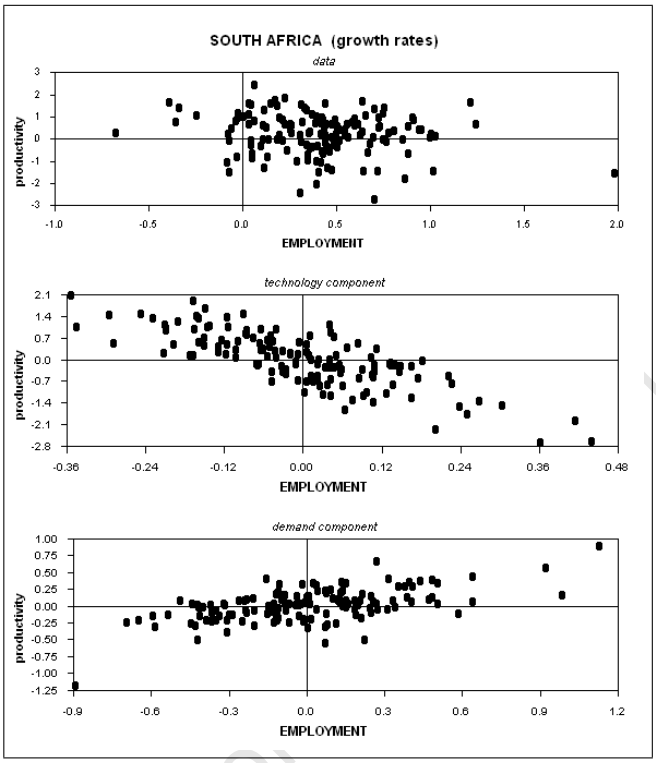

Figure 4.3: Productivity-Employment: Demand and technology components

the conditional correlation between employment and labour productivity for technology and demand shock is positive for the period $1971q1 - 1994q1$ and negative for $1994q2 - 2006q4$. This result indicates that the dynamics of employment and/or labour productivity in response to demand and technology shocks may have altered in South Africa over the period. One of the possible reasons for this difference is a change in the structural parameters underlying the South African economy. There are many possible reasons for the change in the structural parameters.[131]

[131] See Section 4.3 for a detailed analysis on possible parameter values.

EMPLOYMENT & LABOUR PRODUCTIVITY	GROWTH RATE
1971q1-2006q4	
UNCONDITIONAL CORRELATION	-0.16 (0.104)
CONDITIONAL CORRELATION	
Technology	-0.79^{*} (0.141)
Demand	0.58^{*} (0.140)
1971q1-1994q1	
UNCONDITIONAL CORRELATION	0.06 (0.090)
CONDITIONAL CORRELATION	
Technology	0.07 (0.078)
Demand	0.10 (0.113)
1994q2-2006q4	
UNCONDITIONAL CORRELATION	-0.60^{*} (0.277)
CONDITIONAL CORRELATION	
Technology	-0.83^{*} (0.170)
Demand	-0.05 (0.385)

* at 5% significance

Table 4.3: Employment-labour Productivity Correlations

This preliminary analysis on the basis of the bivariate VAR model on the South African business cycle indicates that RBC theory is unable to adequately account for trends in employment and labour productivity in South Africa. This implies that one (or more) of the assumptions of RBC models must be violated.

The question arises: What is the characteristic of middle-income transition economies (and other economies which display this relationship between labour productivity and employment) that RBC models do not take account of?

A stylized fact regarding transition economies is that they typically lack a sufficiently large market size which might allow them to exploit the economies of scale open to developed economies. This is because transition economies are in the process

of opening their economies and therefore unable to acquire the benefits of a larger world market.[132] Thus transition economies face less competitive pressure than developed economies. For example, the South African manufacturing industry has been plagued by high markups approximately twice as large as the US.[133] High markups in SA manufacturing arise from high concentration ratios and monopolistic practices.[134] All this evidence indicates that the degree of imperfect competition in the South African manufacturing industry is higher than the US. Standard real business cycle models assume perfect competition and therefore do not acknowledge the possibility of markups and their effect on business cycle dynamics. Thus the importance of sticky prices is overlooked by standard real business cycle literature.

Standard real business cycle theory demand (non-technology) shocks generate negative comovement between employment and labour productivity.[135] For the South African data, we have shown a positive comovement between employment and labour productivity in response to a demand shock. One possible reason is that the returns to labour influence a firms hiring decisions when faced with a demand shock.[136] This indicates that the returns to labour in transition economies may differ significantly from developed economies due to differences in skill level and structure of the labour

[132] See for instance Ricci et al (2008) state that the share of world trade for emerging countries rose by 27 percent in 1990 to 37 percent in 2004.

[133] See Fedderke, Kularatne and Mariotti (2007).

[134] See for instance Aghion, Braun Fedderke (2006) and Fedderke and Szalontai (2005) on the prevalence of high concentration ratios in the South African manufacturing industry.

[135] See for instance Hansen and Wright (1992) and Christiano and Eichenbaum (1992). The latter argue,for the classical RBC model, demand shocks would shift the labour supply curve and generate the desired negative correlation between employment and labour productivity.

[136] Fedderke and Mariotti (2002) discuss returns to labour in SA economy.

force. Consequently, this will have an effect on employment dynamics in response to shocks. Standard real business cycle literature fail to consider the impact of returns to labour.

The empirical evidence and structure of the South African economy suggest that the evidence seems to be at odds with the assumptions of standard RBC models, while being consistent with new-Keynesian models characterized by monopolistic competition, sticky prices, and variable effort. In the face of monopolistic competition and sticky prices, the implications for inflation, real money balances, real interest rate together with employment, output and labour productivity due to technology and demand shocks are more complex and may differ considerably from standard real business cycle literature. Therefore, a simple bivariate VAR decomposition is inadequate to capture all these complexities.

The theoretical model we adopt should incorporate the effects of both these types of shocks on these variables and investigate the extent to which monetary accommodation, the degree of price stickiness in the product market, the magnitude of the markup and returns to labour affect the economy's response to technology and non-technology shocks. We propose that in the next section that the Gali (1999) new-Keynesian business cycle model does exactly this. We discuss this model in the following section and apply it to the South African data by estimating a five-variable VAR. Furthermore, a nuance to the Gali (1999) model is inclusion of conditions un-

der which certain observed behaviour between output, employment, labour productivity and prices are plausible when we account for demand and technology shocks.

4.3 A Multivariate Model: Theoretical Analysis

The model developed by Gali (1999) is a general equilibrium monetary model with sticky prices and unobserved variations in labour effort. The model assumes shocks emanate from two possible sources: technology and monetary shocks. Nominal price rigidities are introduced by assuming that firms have to set their prices before shocks are realized. The model also allows for monetary accommodation, i.e., the monetary authority may respond in a systematic fashion to technology shocks. Such a policy is feasible if the government wishes to stabilize prices, output and/or employment. Thus money supply in the model can either be exogenous or endogenous in the model.

4.3.1 Setup

The setup of the model is as follows:

A. Household's problem

The representative household maximizes:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log C_t + \lambda_m \log \frac{M_t}{P_t} - H(N_t, U_t) \right\} \tag{4.3}$$

subject to the budget constraint:

$$\int_0^1 P_{it} C_{it}\, di + M_t = W_t N_t + V_t U_t + M_{t-1} + \Pi_t \tag{4.4}$$

for $t = 0, 1, ... M$ and Π_t represent nominal money holdings and profits while H is the disutility form work which is a function of hours (N) and effort (U) defined as

$$H(N_t, U_t) = \frac{\lambda_n}{1+\sigma_n} N_t^{1+\sigma_n} + \frac{\lambda_u}{1+\sigma_u} U_t^{1+\sigma_u} \tag{4.5}$$

W and V denote the prices of an hour of work and a unit of effort, respectively whilst $\beta \in (0, 1)$ is the discount factor. $\lambda_n, \lambda_u, \sigma_n$ and σ_u are positive constants. Effort measures the quality of hours worked. Hours worked together with effort represent the effective labour used by the each firm. Thus, using this formulation, both the quantity and the quality of labour matter in the production of output.

The unit price of good i is given by P_{it} and

$$P_t = \left(\int_0^1 (P_{it})^{1-\varepsilon} \, di \right)^{\frac{1}{1-\varepsilon}} \tag{4.6}$$

is the aggregate price index (P_t) while C_t is a composite consumption index defined by:

$$C_t = \left(\int_0^1 (C_{it})^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{4.7}$$

where C_{it} is the quantity of good i consumed in period t and $\epsilon > 1$ represents the constant elasticity of substitution between goods consumed. Thus $\int_0^1 P_{it} C_{it} \, di$ represents the total expenditure on goods $i \in [0, 1]$ by the household.

The first order necessary conditions (FONCs) are:

$$C_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\varepsilon} C_t \tag{4.8}$$

$$\frac{1}{C_t} = \lambda_m \left(\frac{P_t}{M_t}\right) + \beta E_t \left[\frac{1}{C_{t+1}} \frac{P_t}{P_{t+1}}\right] \tag{4.9}$$

$$\frac{W_t}{P_t} = \lambda_n C_t N_t^{\sigma_n} \tag{4.10}$$

$$\frac{V_t}{P_t} = \lambda_u C_t U_t^{\sigma_u} \tag{4.11}$$

An interpretation of the FONCs is as follows. FONC (4.8) indicates that each household decides how much to consume (C_t) given the aggregate price (P_t) at each time period and allocates demand for a particular good i in proportion to its relative price $\left(\frac{P_{it}}{P_t}\right)$. The intertemporal optimality condition (4.9) provides the expected discounted return that must hold if the household forgoes one unit of consumption at time t. Thus the trade-off between present and future consumption depends on the expectation of future marginal utility, the rate of return,[137] $\left(\frac{P_t}{P_{t+1}}\right)$, and the utility gained in time period t from holding more real money balances as consumption is forgone. The two intratemporal optimality conditions state that the marginal rate of substitution between consumption and hours worked (4.10), or between consumption and effort (4.11), equals the real hourly wage rate and real 'payment' for effort, respectively.

B. Firm's problem

[137] The ratio of prices $\left(\frac{P_t}{P_{t+1}}\right)$ is equivalent to the gross interest rate $1 + R_{t+1}$.

There is a continuum of firms distributed uniformly on the unit interval. Each firm is indexed by $i \in [0,1]$, and produces a differentiated good. The production function for each firm is:

$$Y_{it} = Z_t L_{it}^{\alpha} \tag{4.12}$$

where L_i is the quantity of effective labour used by the firm i, given by:

$$L_{it} = N_{it}^{\theta} U_{it}^{1-\theta} \tag{4.13}$$

where $\theta \in (0,1)$. Z is a measure of aggregate technology whose growth rate $\eta_t \sim iid\ N(0, s_z^2)$, where

$$Z_t = Z_{t-1} \exp(\eta_t) \tag{4.14}$$

The firm maximizes:

$$\max_{P_{it}} E_{t-1}\{(1/C_t)\left[P_{it}Y_{it} - W_t N_{it} - V_t U_{it}\right]\} \tag{4.15}$$

subject to[138]:

$$\frac{U_{it}}{N_{it}} = \left(\frac{1-\theta}{\theta}\right)\frac{W_t}{V_t} \tag{4.16}$$

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\varepsilon} C_t \tag{4.17}$$

The firm i sets price P_{it} (price at which it will sell good i at date t) at the end of period $t-1$, given aggregate price P_t. Once V_t and W_t are realized given the state

[138] The first budget constraint (4.16) is the solution to the firms cost minimization problem by firm, i.e., assume firm chooses N_{it} and U_{it}, given W_t and V_t, once uncertainty is realized.

The second budget constraint (4.17) is from the fact that it is optimal for each firm i to satisfy the demand for its product (4.8) if marginal cost is less than price - P_{it}.

of the world (which is dependent on the shock) in period t, the firm chooses N_{it} and U_{it}.[139]

The FONC is:

$$E_{t-1}\{(1/C_t)\left[\alpha\theta P_{it}Y_{it} - \mu W_t N_{it}\right]\} = 0 \tag{4.18}$$

where $\mu = \frac{\varepsilon}{\varepsilon - 1} > 1$ is the associated markup set by firm i.

Assuming certainty, (4.18) will reduce to

$$\frac{\mu W_t}{P_{it}} = \frac{\alpha\theta Y_{it}}{N_{it}} = (M\,\text{arg}\,inal\ product\ of\ hours\ worked) \tag{4.19}$$

Thus we can define the price of good i at time t (P_{it}) as:

$$P_{it} = (\mu * W_t)\ /\ (M\,\text{arg}\,inal\ product\ of\ hours\ worked) \tag{4.20}$$

For South Africa, Fedderke, Kularatne and Mariotti (2007), using the Solow residual to calculate markup, find the markup for SA manufacturing is approximately twice as large as the US. This implies that the degree of monopolistic competition is much higher in South Africa than it is in the US. Aghion, Braun and Fedderke (2006) argue that higher past mark ups in SA manufacturing are associated with lower current productivity growth rates and lower current employment.. This has implications for the behaviour of the economy to technology and non-technology shocks.[140]

C. Money supply

[139] It is assumed that the firm can observe effort.

[140] Note Roeger (1995), and Oliveira Martins and Scarpetta (1999) show that with $\mu > 1$, we overestimate the Solow Residual.

The monetary authority follows a money growth rule of the form:

$$M_t^s = M_{t-1}^s \exp(\xi_t + \gamma\eta_t)$$

where $\xi_t \sim iid\ N(0, s_m^2)$ and orthogonal to the sequence of technology shocks $\{\eta_t\}$ at all leads and lags. The model allows for the central bank to respond to technology shocks in order to stabilize prices, output and employment. Thus $\gamma \left(\gtreqless 0\right)$ represents a policy parameter.[141]

D. Characterizing equilibrium

Definition 1 *Given the households initial nominal money holdings* (M_0^s) *and the stochastic processes* $\{M_t^s\}$ *and* $\{Z_t\}$*, a* ***symmetric equilibrium*** *(where each firm* i *charges the same price* P_t*) is an allocation,* $\{C_t, N_t, U_t, Y_t, \Pi_t\}_{t=0}^{\infty}$*, price system,* $\{P_t, W_t, V_t\}$ *and government policy parameter* (γ) *such that:*

- $\{C_t, N_t, U_t, \Pi_t, M_t^s\}$ *solves the household's problem (4.3) subject to the sequence of budget constraints (4.4);*
- $\{P_t, Y_t, N_t, U_t\}$ *solves the firm's problem (4.15) subject to (4.16) and (4.17) with* $\{Y_t, N_t, U_t\}$ *being demand determined.*
- *equilibrium in the money market implies that:*

$$\frac{M_t}{M_{t-1}} = \exp(\xi_t + \gamma\eta_t) \text{ for all } t$$

[141] If $\gamma = 0$, we assume that money supply for this economy is exogenous.

- *labour market clears such that effective labour is given by:*

$$L_t = (AN_t^{\varphi})^{\frac{1}{\alpha}} \text{ for all } t \tag{4.21}$$

where $A = \left(\frac{\lambda_n(1-\theta)}{\lambda_u \theta}\right)^{\frac{\alpha(1-\theta)}{1+\sigma_u}}$ *and* $\varphi = \alpha\theta + \alpha(1-\theta)\left(\frac{1+\sigma_n}{1+\sigma_u}\right)$.

- *output market clears such that:*

$$Y_t = AZ_t N_t^{\varphi} = C_t = \Phi \frac{M_t}{P_t} \tag{4.22}$$

From (4.22) we see that φ *represents the return to hours worked (labour) and* $\Phi = \lambda_m^{-1}\left[1 - \beta e^{\frac{1}{2}\left(s_m^2 + \gamma^2 s_z^2\right)}\right]$ *represents the velocity of circulation of money which is constant as a consequence of the* iid *assumption on growth rate of money.*[142]

This implies that:

$$\left(\frac{P_{it}}{P_t}\right) = \left[\frac{\Phi\left(\frac{M_t}{P_t}\right)}{C_{it}}\right]^{\frac{1}{\varepsilon}} \tag{4.23}$$

Thus the demand for good i *is* $C_{it} = \Phi\left(\frac{P_{it}}{P_t}\right)^{-\varepsilon}\frac{M_t}{P_t}$ *indicating that a higher relative price for good* i *reduces relative consumption. It also implies that an increase in real money balances results in an increase in relative price.*[143]

4.3.2 Model Dynamics

[142] Φ represents the velocity of circulation of money which is constant as a consequence of the iid assumption on growth rate of money. Gali (1999) assumes that the velocity of circulation money cannot be negative, i.e., $\beta e^{\frac{1}{2}\left(s_m^2 + \gamma^2 s_z^2\right)} < 1$

[143] It can be shown the indirect utility function for this model exhibits constant marginal utility of income so that the problem of choosing output, employment and prices looks like the conventional monopolist problem.

Equilibrium dynamics

Gali (1999) obtains a set of expressions for the equilibrium levels[144] of prices (p_t), output (y_t), employment (n_t), and labour productivity (x_t)[145] in terms of the exogenous driving variables - monetary (ξ_t) and technology (η_t) shocks:

$$\Delta p_t = \xi_{t-1} - (1-\gamma)\eta_{t-1} \tag{4.24}$$

$$\Delta y_t = \Delta\xi_t + \gamma\eta_t + (1-\gamma)\eta_{t-1} \tag{4.25}$$

$$n_t = \frac{1}{\varphi}\xi_t - \frac{(1-\gamma)}{\varphi}\eta_t \tag{4.26}$$

$$\Delta x_t = \left(1-\frac{1}{\varphi}\right)\Delta\xi_t + \left(\frac{(1-\gamma)}{\varphi}+\gamma\right)\eta_t + (1-\gamma)\left(1-\frac{1}{\varphi}\right)\eta_{t-1} \tag{4.27}$$

The model depicts how an unanticipated monetary shock ($\xi_t > 0$) has a transitory impact on output (4.25), employment (4.26) and labour productivity (4.27).[146] However, from (4.24) we observe that a change in the level of nominal money balances changes the inflation rate and thus permanently, and proportionately, affects the price level, with a one period lag.[147] Moreover, in response to an unanticipated monetary expansion, output and employment unambiguously rise, reverting back to

144 Letters in lower case depict natural logarithm of each variable.

145 Recall that labour productivity is the log difference between output and employment (hours) between $x = y - n$.

146 The model results indicate that money is non-neutral in the short-run.

147 The lagged effect of price level to a monetary expansion is due to the prevalence of sticky prices in the model. Woodford (2000) finds a similar result where monetary shocks only permanently affect the price level but not any of the real variables.

their original level after one period.[148] Kularatne (2007) shows the converse holds for a contractionary monetary shock occurring in the South African economy.

The model displays a temporary positive effect on labour productivity based on an unanticipated monetary expansion if there exists "short-run increasing returns to labour" (SRIRL), i.e., $\varphi > 1$.[149] For SRIRL to hold the following are required:

1. A sufficiently 'productive' effort (i.e., low θ);

2. A sufficiently low elasticity of effort's marginal disutility relative to that of employment (i.e., $\sigma_u \ll \sigma_n$); and/or

3. A sufficiently high elasticity of output with respect to effective labour input, (i.e., high α).

The above imply that there are high returns (i.e., high α) to the firm from employing extra labour (N rising) as they are relatively productive (i.e., $\theta \longrightarrow 0$) and that workers are willing to work longer hours if the disutility arising from putting more effort is relatively much less than the disutility from working longer hours as the tendency for workers to shirk then is much less (i.e., $\frac{\sigma_u}{\sigma_n} \longrightarrow 0$). Thus SRIRL imply that labour productivity will rise in response to a monetary expansion together with rising employment (although both effects are temporary). In contrast, an in-

[148] Note $\varphi = \alpha\theta + \alpha(1-\theta)\left(\frac{1+\sigma_n}{1+\sigma_u}\right) > 0$ for the assumed parameter values of α, θ, σ_n and σ_u.

[149] From (4.22) we see that when $\varphi > 1$, the marginal product of hours increases at an increasing rate. If the economy experiences constant short-run returns to labour ($\varphi = 1$), a demand shock has no effect on labour productivity.

crease in aggregate demand and output arising from a monetary expansion will be partly met by higher unobserved effort, in addition to higher "measured" employment.[150] If the response of effort is large enough, an increase in labour productivity will ensue. In that case, monetary shocks will generate a positive comovement between employment and labour productivity.

The model purports that the effects of a positive technology shock ($\eta_t > 0$) has a permanent, one-for-one effect on output (4.25) and labour productivity (4.27). The same shock will have a (permanent) negative effect on the price level (4.24) if the degree of monetary accommodation is not too strong (i.e., $\gamma < 1$). Moreover, if the latter holds, then a positive technology shock will have a negative, though transitory, effect on the level of employment.[151]

The reasoning for this is as follows: Consider, the case of constant exogenous money supply ($\gamma = 0$).[152] Then the combination of a constant money supply and predetermined prices implies (from equilibrium condition (4.22)) that real balances (and, thus, aggregate demand) remain unchanged in the period when the technology shock occurs ($\Delta Z > 0$). Since condition (4.22) must hold and $\left(\frac{M_t}{P_t}\right)$ remains unchanged, each firm will thus meet its demand by producing the same level of output Y_t. Thus each firm will require less less labour input (N_t), and a decline in employment will

[150] This result is true if and only if the substitution effect outweighs the income effect such that labour finds it more beneficial to subsitute work for leisure. See Hansen and Wright (1992) regarding labour market predictions of the RBC models.

[151] That is if $\eta_t > 0$ and $\gamma < 1$, then $\Delta n_t < 0$.

[152] Gali (1999) shows it applies to the case when there exists an endogenous monetary response. The monetary policy rule will affect the level of prices permanently and the short-run dynamics of output, employment and productivity.

be observed ($\Delta N < 0$).[153] In addition, unchanged output and lower employment will lead to an unambiguous increase in labour productivity in response to the same shock. In the following period, firms adjust their prices downward (since marginal cost is lower from Equation (4.20)), aggregate demand and output will go up as real money holdings rise. Thus employment returns to its original level. The sign of the associated change in labour productivity depends again on whether the change in output is more or less than proportional to the change in employment, which, in turn, determines whether the immediate response of labour productivity to a technology shock overshoots. Overshooting occurs given the following conditions are satisfied:

$$Overshooting\ of\ productivity \Longleftrightarrow \left\{ \begin{matrix} \varphi<1\ and\ \gamma\in[0,1) \\ or \\ \varphi>1\ and\ \gamma\in(1,\infty) \end{matrix} \right\}$$

Table 4.4 shows that the qualitative effects on employment, prices, output and labour productivity due to a technology shock will remain unchanged even when there exists some monetary accommodation, i.e., $\gamma \in [0, 1)$. If the monetary authority decide to lessen the initial adverse impact on employment of a positive technology shock, $(\gamma > 1)$, the choice of the monetary policy rule will only have a permanent effect on prices, but it will affect the size and/or the dynamic pattern of the responses of output, employment and labour productivity. In particular, Gali (1999) notes that the "monetary authority will face a trade off between employment and price volatil-

[153] This decline in employment is depicted in other models that do not assume sticky prices. See Rotemberg (1996), King and Wolman (1996) and Calvo (1983), Hairault, Langot and Portier (1995), and Cooley and Dwyer (1995). Some of these models assume a positive technology shock induces a small rightward shift in labor demand, which is more than offset by a relatively larger leftward shift in labor supply indicating that the wealth effects may dominate the substitution effects. The latter is unlikely to be the case for developing economies with relatively low real wages.

ity" and the magnitude of unanticipated output change will also be erratic. Siu (2004) states that with sticky prices, a benevolent government must balance the shock absorbing benefits of state-contingent inflation against its resource misallocation costs.

RESPONSE OF PRICES, OUTPUT, EMPLOYMENT & PRODUCTIVITY							
$\varphi=\alpha\theta+\alpha(1-\theta)\left(\frac{1+\sigma_n}{1+\sigma_u}\right)$	γ	Δp_t	Δy_t		Δn_t	Δx_t	
		$t-1$	t	$t-1$	t	t	$t-1$
$0<\varphi<1$	$\gamma\in[0,1)$	<0	>0	>0	<0	>0	$<0^*$
	$\gamma=1$	$=0$	>0	$=0$	$=0$	>0	$=0$
	$\gamma>1$	>0	>0	$<0^*$	>0	$>0 \iff \varphi>\frac{\gamma-1}{\gamma}$ $<0 \iff \varphi<\frac{\gamma-1}{\gamma}$	>0
$\varphi=1$	$\gamma\in[0,1)$	<0	>0	>0	<0	>0	$=0$
	$\gamma=1$	$=0$	>0	$=0$	$=0$	>0	$=0$
	$\gamma>1$	>0	>0	$<0^*$	>0	>0	$=0$
$\varphi>1$	$\gamma\in[0,1)$	<0	>0	>0	<0	>0	>0
	$\gamma=1$	$=0$	>0	$=0$	$=0$	>0	$=0$
	$\gamma>1$	>0	>0	$<0^*$	>0	>0	$<0^*$

* indicates overshooting

Table 4.4: Response to a technology shock

Analysis of covariances

Gali (1999) finds the unconditional covariances for output, employment and labour productivity to be the following:

$$cov(\Delta y_t, \Delta n_t) = \frac{2s_m^2+(1-\gamma)(1-2\gamma)s_z^2}{\varphi} \tag{4.28}$$

$$cov(\Delta y_t, \Delta x_t) = \frac{2(\varphi-1)s_m^2+(\gamma+\varphi-1)s_z^2}{\varphi} \tag{4.29}$$

$$cov(\Delta n_t, \Delta x_t) = \frac{2(\varphi-1)s_m^2}{\varphi^2} - \frac{(1-\gamma)[(2-\varphi)+2\gamma(\varphi-1)]s_z^2}{\varphi^2} \tag{4.30}$$

Firstly, from (4.29) irrespective of the degree of accommodation of monetary policy (i.e., the value of γ), SRIRL ($\varphi > 1$) is a sufficient condition for labour productivity to be procyclical, independent of the relative importance of the two shocks, s_m^2 and s_z^2.

Secondly, from (4.28), with some monetary accommodation $\left(\gamma \in [0, \frac{1}{2})\right)$ and/or if exogenous monetary shocks are a sufficiently important source of fluctuations relative to technology shocks (i.e., $s_m^2 \gg s_z^2$), then employment growth should be procyclical.[154]

Focusing attention on the sign of the comovement between employment and labour productivity growth, (4.30)shows that with some short-run increasing returns to labour, $\varphi \in (1, 2)$, and a not too strong endogenous monetary response, $\gamma \in [0, 1)$, the unconditional comovements between labour productivity and employment are positive and thus follows RBC theory. Thus, the magnitude of the SRIRL (size of φ), the extent of monetary accommodation (the policy parameter γ), and the relative importance of shocks (s_m^2 versus s_z^2) determines the unconditional comovements between labour productivity and employment.

However, when considering the conditional covariances (conditioning on the nature of the shock - technology or monetary) we have the following:

$$cov(\Delta n_t, \Delta x_t \quad | \quad m) = \frac{2\,(\varphi - 1)\, s_m^2}{\varphi^2} \tag{4.31}$$

$$cov(\Delta n_t, \Delta x_t \quad | \quad z) = -\frac{(1-\gamma)\,[(2-\varphi)+2\gamma\,(\varphi-1)]\, s_z^2}{\varphi^2} \tag{4.32}$$

[154] From Table 4.1, the South African data for this sample indicates a statistically significant correlation coefficient of 0.22.

However, under the same assumptions ($\gamma \in [0,1)$ and $\varphi \in (1,2)$), the two Equations - (4.31) and (4.32) - imply conditional comovements between employment and labour productivity growth are of opposite signs. That is, conditional on positive monetary (demand) shocks being the source of fluctuations, the sticky price model predicts a positive correlation between employment and labour productivity growth.[155] In contrast, a positive technology shocks generates negative correlation between employment and labour productivity growth. Figure 4.4, provides conditions under which, for a positive technology shock, we may expect to the covariance between employment and labour productivity positive and negative, respectively.

From Figure 4.4 we conclude the following:

$$If\ \ (\gamma = 0) \cap (\varphi > 2) \Rightarrow cov(\Delta n_t, \Delta x_t | z) > 0 \tag{4.33}$$

$$If \left(\frac{1}{2} < \gamma < 1\right) \cap (\varphi > 0) \Rightarrow cov(\Delta n_t, \Delta x_t \mid z) < 0 \tag{4.34}$$

$$If\ \ (\gamma > 1) \cap (cov(\Delta n_t, \Delta x_t | z) < 0) \Rightarrow \varphi < 1 \tag{4.35}$$

From (4.35), when the monetary authorities follow an accommodative monetary policy, it is still possible to have negative comovement in labour productivity and employment growth due to a technology shock if the economy experiences short-run decreasing returns to labour, $(\varphi < 1)$. Further, (4.34) indicates that irrespective of the returns to labour, even if monetary policy is relatively accommodative $\left(\frac{1}{2} < \gamma < 1\right)$,

[155] This is true *iff* $\varphi > 1$, i.e., there are SRIRL.

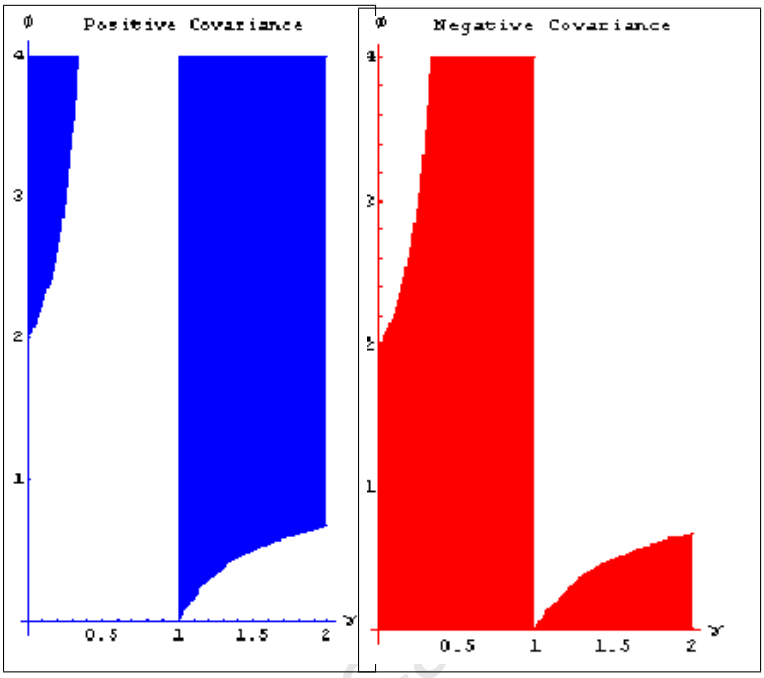

Figure 4.4: Technology Shock: Employment and Productivity

a technology shock will generate negative comovement between employment and labour productivity. Moreover, from (4.33), it is only possible to generate the classical RBC result of positive comovement between employment and labour productivity when money supply is exogenous ($\gamma = 0$) if there are sufficiently large short-run increasing returns to labour ($\varphi > 2$).

These predictions are in contrast with the prediction of standard RBC models where, technology shocks are a source of a positive comovement between employment and labour productivity, while non-technology shocks generate a negative comovement.[156] Therefore, the two classes of models have very different implica-

[156] See Christian and Eichenbaum (1992).

tions regarding the responses of employment and labour productivity to each type of shock. The exact dynamics of the model depend on the value of the returns to labour (φ) and monetary policy response (γ) parameters.

Summary

The main conclusions of this model are:

1. Technology shocks will generate a negative comovement between the employment and labour productivity variables[157] while the opposite will is true arising from demand shocks. The economic reasoning is as follows: The model is constructed such that in equilibrium, aggregate demand is determined by the level of aggregate real money balances. This implies that with sticky price adjustment and limited monetary accommodation, the short-run response to a positive technology shock is associated with little or no change in the real money supply. Thus the increase in aggregate demand (and desired output) will be unable to meet the increase in multifactor labour productivity due to a positive technology shock. This induces firms to decrease output and hence the quantity of labour employed. The result: a technology shock will generate a negative correlation between employment and labour productivity.

2. An increase in aggregate demand and output arising from a monetary expansion will be partly met by higher unobserved effort, in addition to higher "measured"

[157] Basu et al (2004) finds a similar result.

employment.[158] If the response of effort is large enough, an increase in labour productivity will ensue. In that case monetary shocks will generate a positive comovement between employment and labour productivity.

4.4 The Relationship between Policy Parameters and Monetary Policy in South Africa

For example, recall from Table 4.3 for the period $1971q1 - 1994q1$,the conditional correlation between employment and labour productivity in response to a technology shock is positive.[159] There may exist three possibilities for this result:

1. The South African economy pre-1994 may have followed standard RBC theory in its response to technology shocks. This implies relatively flexible prices so that a rise in output due to a technology shock is matched by a fall in prices (in the same period). This increases aggregate demand and firms increase output to meet that demand by hiring more workers. Furthermore, since marginal product of labour increases with the technology shock, firms hire more workers and employment rises;[160]

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[158] This result is true if and only if the substitution effect outweighs the income effect such that labour finds it more beneficial to subsitute work for leisure. See for instance Hansen and Wright (1992) regarding labour market predictions of the RBC models.

[159] The conditional correlation coeccient is statistically insignificant. The significance test may not have enough power due to lack of sufficient obervations for this subsample. Bootstrapping to obtain the correct standard error will provide a more accurate test of significance.

[160] Labour hours rise if and only if the substitution effect outweighs the income effect for the agents labour-leisure choice.

2. The second possibility is that South African economy does operate in an environment of sticky prices between $1971q1 - 1994q1$ with the monetary authority in South Africa responding aggressively to technology shocks by instituting expansionary monetary policy ($\gamma > 1$). The policy makers are able to negate the the possible decrease in employment due to a technology shock by adhering to this monetary policy rule. When $\gamma > 1$, Equation 4.32 is positive.[161]

3. The third possibility (based on Equation (4.32)) is that the South African economy operating in an environment of sticky prices between $1971q1 - 1994q1$ with the monetary authority following an exogenous money supply rule or with very little intervention in the economy in response to monetary shocks $\left(0 \leqslant \gamma < \frac{1}{2}\right)$ and with the economy experiencing relatively high SRIRL $(\varphi > 2)$.

From research conducted on mark-ups and monopolistic competition in South Africa by Fedderke, Kularatne and Mariotti (2007) and Aghion, Braun and Fedderke (2006) we conclude that the first explanation on the probable cause of the positive correlation between labour productivity and employment is unlikely to be the case. It is more likely that prices continue to be sticky from $1971q1 - 1994q1$ due to monopolistic behaviour and the monetary authority aggressively engaged in an accomodative

[161] This result is contingent on the magnitude of the returns to labour (φ). If the economy experiences constant or increasing returns to labour then this result will hold. Under decreasing returns to labour, this may not always be true.

monetary policy to smooth out any shocks the economy may have experienced.[162] Moreover, Aaron and Muellbauer (2007) show that increased openness of the South African economy, fostered greater competition and therefore reduced mark-ups post 1994.

Moreover, Table 4.3 highlights the unconditional and conditional correlation (conditional on either a technology or non-technology shock) between employment and labour productivity are negative for the sub-sample $1994q2 - 2006q4$. The negative conditional correlation (conditional on the technology shock) implies the presence of sticky prices and a less aggressive monetary policy regime. Indeed, from the year 2000, a policy of inflation targeting was implemented by the Reserve Bank. By doing so, the Bank's only responsibility is to keep the inflation rate within the target range of 3 to 6 percent. To gain credibility, the Bank was not allowed (by law) to engage in contractionary or expansionary monetary policy in order to either dampen or stimulate the economy. This change in the policy stance of the Reserve Bank implies that it began to lessen its monetary accommodation ($\gamma \approx 0 < 1$), to counter any adverse effects on employment that technology shocks may trigger. On the basis of Equation (4.31), conditional on a demand shock, the negative correlation[163] between employment and labour productivity for the sub-sample $1994q2 - 2006q4$ may be due to the presence of decreasing short-run returns to labour ($\varphi < 1$).[164]

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[162] Further investigation needs to be conducted to determine if $(\gamma > 1)$ or $\gamma \in [0, \frac{1}{2})$ and $(\varphi > 2)$.

[163] Once again it is statistically insignificant and thus bootstrapping may be required to obtain an accurate standard error for the correlaton coefficient.

[164] Hall (1988) argues that the $\varphi-$ parameter may include the markup firms impose on its products.

We now use the multivariate model to analyze the impact of a technology shock on a set of macroeconomic variables using South African data.

4.5 A Multivariate Model: Impulse Response Analysis

4.5.1 Methodology

These set of macroeconomic variables we consider using the South African data are chosen as specified by the theoretical model. They are the *growth rates* of labour productivity (Δx), employment (Δn), real money balances $(\Delta m - \Delta p)$, inflation rate $(\Delta^2 p)$ and real interest rate $(\Delta r - \Delta^2 p)$ for the period $1971q1 - 2006q4$. Real interest rates are included as the monetary authority may affect the economy either by affecting the money supply directly or indirectly via the nominal interest rate. The stock of money is measured by M3 money balances, inflation by CPIX and we use the repo rate as a measure of interest rates to analyze the response of policy to technology shocks.

We analyze the effect of technology shocks on these macroeconomic variables by using an extension of the VAR decomposition described by Equation 4.1. An

The question the arises: What exactly is φ measuring? Does it measure "returns to labour" only? Given the study conducted on markups in the SA manufacturing sector, Fedderke Kularatne and Mariotti (2006) and Aghion and Fedderke (2007) find that the markup is twice that of the US. This implies that the $\varphi-$ parameter includes not only a measure of returns to labour but also the markup in the SA manufacturing sector. It also implies that, given the results of Tables 4.4, the markup does affect the response of output, employment and labour productivity to demand and technology shocks through its affect on the $\varphi-$ parameter.

extension of the moving average model depicted by Equation 4.1. is of the form:

$$\Delta q_t = \begin{bmatrix} \Delta x_t \\ \Delta n_t \\ \Delta m - \Delta p \\ \Delta r - \Delta^2 p \\ \Delta^2 p \end{bmatrix}_t = \mathbf{C}(L)\boldsymbol{\varepsilon}_t \tag{4.36}$$

where estimates of the $\mathbf{C}(L)$ 5×5 matrix is obtained from a reduced-form VAR representation of $[\Delta x, \Delta n, \Delta m - \Delta p, \Delta r - \Delta^2 p, \Delta^2 p]'$ and $\boldsymbol{\varepsilon}_t = [\varepsilon_t^z, \varepsilon_t^{m_1}, \varepsilon_t^{m_2}, \varepsilon_t^{m_3}, \varepsilon_t^{m_4}]'$.

Once again, in order to identify the technology shock $\{\varepsilon_t^z\}$ we assume that technology shocks are orthogonal to demand shocks $\{\varepsilon_t^{m_1}, \varepsilon_t^{m_2}, \varepsilon_t^{m_3}, \varepsilon_t^{m_4}\}$ and have a permanent effect on labour productivity, i.e., $E\varepsilon_t^z, \varepsilon_t^{m_j} = 0$ and $C^{1j}(1) = 0$ for $j = 2, 3, 4, 5$.[165]

This analysis requires the *level* of labour productivity, employment, real money balances and the inflation rate to be integrated of order 1 ($I \sim (1)$). Table 4.5 confirms this to be true for the South African data for the period $1971q1 - 2006q4$. Thus $[\Delta x, \Delta n, \Delta m - \Delta p, \Delta r - \Delta^2 p, \Delta^2 p]$ are stationary at the 5% significance level.[166]

Furthermore, we use a VAR with 4 lags to obtain estimates of the $C(L)$ matrix. This VAR model provides a more comprehensive description of the economy vis-à-vis the simple bivariate decomposition discussed in Section 4.2.

[165] Gali (1999) cautions one from identifying the possible demand shocks since it would require one to impose contoversial restrictions on the model. Therefore in this study we do not attempt to identify the various demand shocks.

[166] Note that its is the change in the inflation rate ($\Delta^2 p$) and the change in the real interest rate ($\Delta r - \Delta^2 p$). This result implies that the real interest rate is nonstationary implying that the Fischer Equation does not hold for South Africa. Fedderke and Pillay (2007) argue that Fisher Equation only holds for South Africa once we account for risk.

Variable	$\sim \mathbf{I(0)}$	$\sim \mathbf{I(1)}$
n	-2.12	-3.48^{*}
x	1.48	-5.14^{*}
$m-p$	0.96	-3.20^{*}
$r-\Delta p$	-2.14924	-5.59^{*}
Δp	-1.83	-7.18^{*}

* denotes rejections of the null of a unit root at the 95% critical value

Table 4.5: Augmented Dickey-Fuller Test Statistics

4.5.2 Results

The simulation of the response of employment, output, labour productivity, real money balances, real interest rate and the inflation rate to a technology shock are constructed using Model [4.36]. The behaviour of the these variables to a technology shock will be analyzed with respect to hypotheses suggested in Table 4.4. Given the fact the bivariate analysis in Section 4.2.3 illustrates the fact the response of employment and labour productivity differs between the subsamples, we examine the response of the five variables for the different sub-samples as well.

Figure 4.5 illustrates the impulse response to a positive one standard deviation technology shock. Estimating over the entire sample period, a positive technology shock leads to an immediate increase in labour productivity of 0.56 percent that is not matched by a proportional change in output (the latter's response building up more slowly over time) of approximately 0.5 percent and a transitory decline in employment of 0.1 percent. The gap between the initial increase in labour productivity and the (smaller) increase in output is reflected in a short-lived decline in employment. This results in the overall negative conditional correlation between employment and

labour productivity due to a technology shock. Moreover, in response to the technology shock, labour productivity stabilizes at 1.12 percent higher while output rises by 1.20 percent after 12 quarters. This is reflected by a marginal rise in employment rises of 0.025 percent 3 years after the shock.

Recapping the economic reasoning for this phenomenon:[167] With a technology shock, labour productivity increases, marginal cost declines and prices fall resulting in falling inflation, with a lag due to sticky prices. Falling prices results in a rise on real money holdings which increases demand. This increases output and employment and prices begin to rise once again. The gradual rise in real money holding is due to an initial decline in the price level and moderate money growth due to rising demand. Furthermore, the rise in the gap between real money holdings and real output $(m - p - y)$ indicates a rising velocity of circulation of money which is consistent with the observed decline in the nominal interest rate. In the long run, the real interest rate is higher, consistent with the higher marginal productivity of capital due to the technological shock.

Figure 4.6, depicts the impulse response for the sample $1971q1 - 1994q1$. The response of to a technology shock is a marginal increase in employment. The argument for this is that a highly accommodative monetary policy stance during this period was followed by the monetary authority. This is reflected in a rise in the inflation rate even though a technology shock occurred. This can only occur if $\gamma > 1$ from

[167] The economic reasoning is as described in Section 4.3.2.

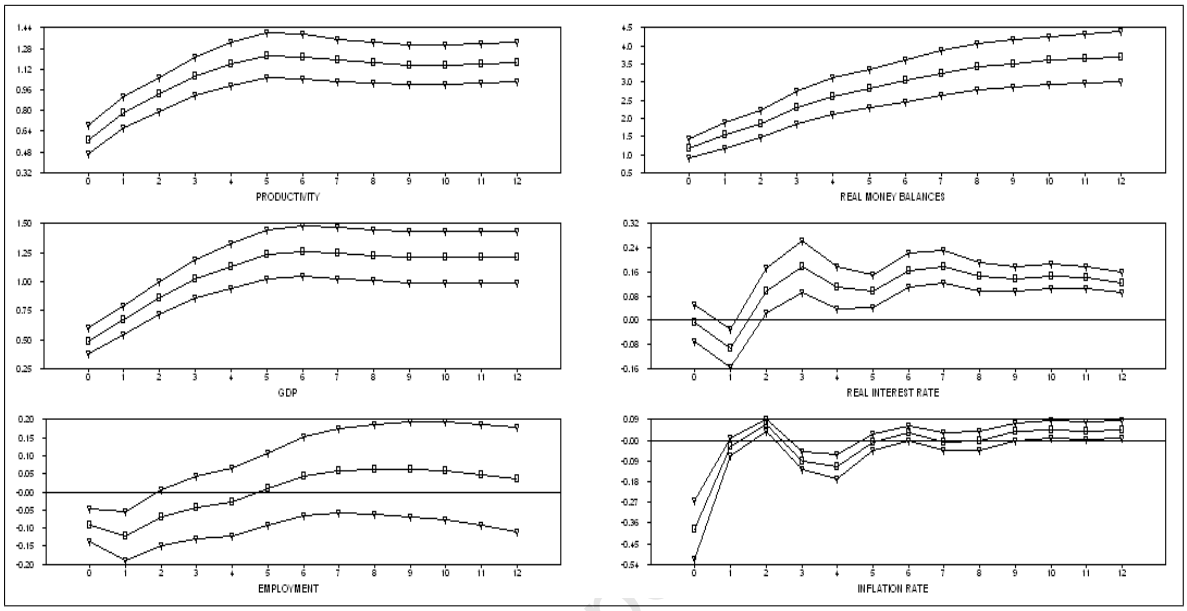

Figure 4.5: Multivariate Model - Impulse response (1971q1-2006q4)

(4.24).[168] However, monetary authority face a trade off between increased employment and increased price volatility and with the magnitude of unanticipated output change being more erratic. Moreover, Table 4.4 states that overshooting of output in response to a technology shock occurs when $\gamma > 1 \; \forall \; \varphi \in (0, \infty)$.

The results for the period $1994q2 - 2006q4$ (Figure 4.7) are similar to the impulse response observed for the entire sample (Figure 4.5). There are some differences vis-à-vis the impulse response for the entire sample. Firstly, Figure 4.7 illustrates that for the post-1994q2 sub-sample the long-run effect of a positive one standard deviation shock in technology is a less than one percent increase in both labour

[168] Note this also explains the positive conditional correlation between employment and labour productivity for the pre-1994q2 sample as depicted in Table 4.3.

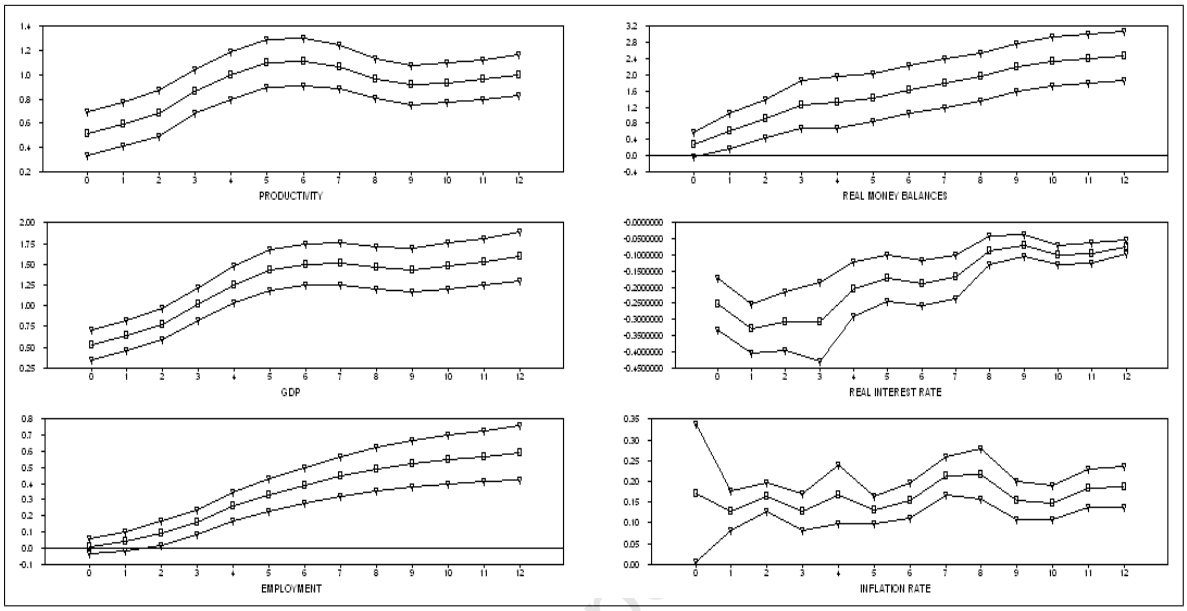

Figure 4.6: Multivariate Model - Impulse response (1971q1-1994q1)

productivity and output. This implies that in the post-1994q2 sub-sample, technology shocks have less of an impact on output and employment when compared to the entire sample period. Secondly, although, as predicted by the model, a technology shock results in an initial decrease in the inflation rate, the inflation rate reached in the post-1994q2 is higher. This is because nominal interest rates appear react more slowly to rising prices when demand picks up. However, the growth in real money balances are less pronounced for the sample $1994q2 - 2006q4$.

The impulse response analysis confirms the predictions of the model for a given set of parameter values. The crucial parameters that determine the behaviour of the economy to a technology shock (or demand shock) are:

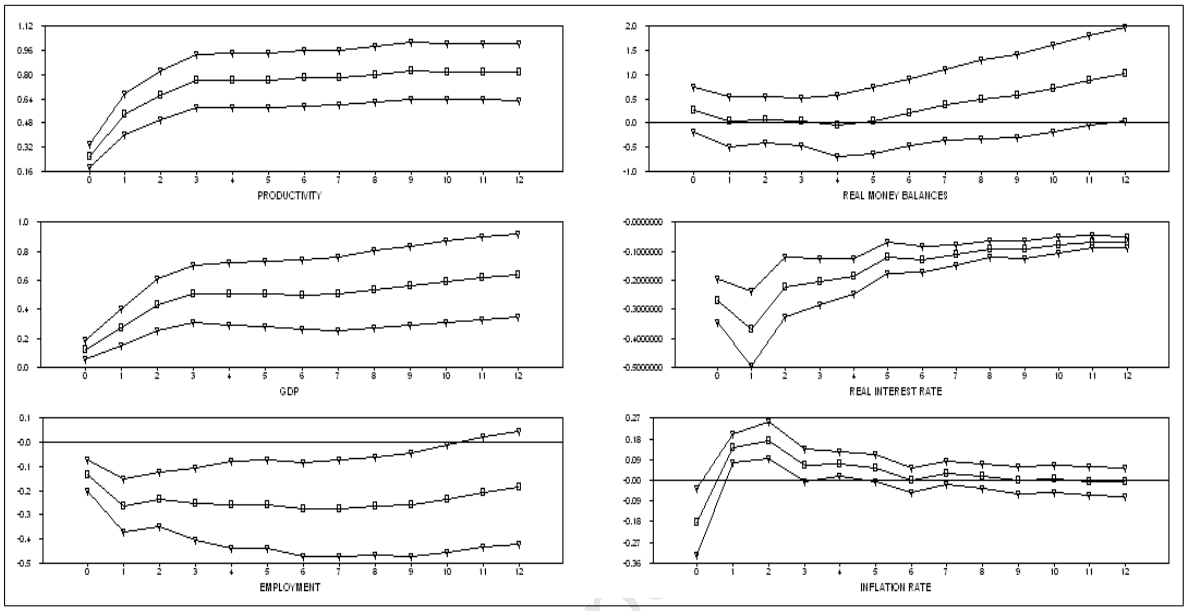

Figure 4.7: Multivariate Model - Impulse response (1994q2-2006q4)

- degree of monetary accommodation (γ); and
- returns to labour (φ).[169]

The South African economy's competitive structure has transformed per- to post 1994. Aghion and Fedderke (2006) allude to the possibility of increased competition in the post-1994 period, has resulted in a decrease in mark-ups in South African industry. This is supported by Aaron and Muellbauer (2007) in which they refer to the increased openness of the South African economy, fostering greater competition and therefore lower mark-ups post 1994. This has implications for the model

[169] Note that the returns to labour (φ) are a function of: the productivity of effort (θ); the elasticity of effort's marginal disutility relative to that of employment (i.e., σ_u vis-à-vis σ_n); and the elasticity of output with respect to effective labour input (α).

parameters.Specifically, the markup firms place on price of the product is affected..A change in a firm's markup affects the wage rate and therefore employment and labour productivity via Equation (4.19) and (4.20).

In an environment of sticky prices, given the above, the behaviour of the economy when technology shocks occur is indeterminate unless we are aware of the values of the above parameters. The dynamics of the business cycle faced by a transition economy will therefore vary widely from country to country.

4.6 Conclusion

We find a negative correlation between employment and labour productivity for the post-1994$q1$ data for South Africa. This finding is at odds with real business cycle theory. Given this evidence, we analyze the impact of technology and non-technology shocks on employment and labour productivity for South Africa

Given the evidence of imperfect competition reflected by high markups for the South African manufacturing sector, we adopt a model with imperfect competition, sticky prices, and variable effort . In this model, the combination of price rigidities and demand constraints leads firms to contract employment in the face of an exogenous increase in total factor productivity, wherein the presence of variable effort explains why measured labour productivity may rise with employment in response to an demand expansion. Thus the verdict is clear: the fluctuations in employment and output attributed to technology shocks are negatively correlated. The exact re-

sponse of labour productivity and employment is affected by the degree of monetary accommodation and returns to labour.

The implication of this finding is that since transition economies may have a higher degree of monopolistic competition which entails sticky prices and high markups, the behaviour of employment and labour productivity to shocks may differ from developed countries. Moreover, with varying returns to labour and varying degree of monetary accommodation, the behaviour of these economies may be unlike that of developed economies. In particular, standard business cycle theory will be unable to explain macroeconomic fluctuations in prices, output and real interest rates under these conditions.

A possible extension of this study is to account for regime switching by employing Markov-Switching models. This will enable one to analyse when the monetary policy regime switches and its implication for the behaviour of output and employment to technology shocks.

Chapter 5
Exchange rate volatility and Macroeconomic Fundamentals

5.1 Introduction

While cyclical behaviour of GDP growth does not veer the economy off its long run growth path, exchange rate volatility may have adverse consequences on the long-term growth prospects of an economy. Exchange rate volatility is an indication of the degree of uncertainty prevalent within an economy. Greater volatility of a country's currency implies that agents are unable to adequately plan ahead.[170] Moreover, increased uncertainty increases the threshold at which investment will occur.[171] Two examples of this are: Firstly, insufficient savings in transition economies lead to borrowing from international markets for investment and consumption. Excessive movements in their exchange rate may not only affect the ability of these economies to repay their debt, but may also affect their ability to plan adequately consequently creating an unfavourable investment climate. Secondly, uncertainty created by exchange rate volatility also generates volatile terms of trade and conse-

[170] See for example statement by the New Zealand Reserve Bank Governor Alan Bollard of March 11, 2004 and a press statement by the Minister of Finance Trevor Manuel of December, 21, 2001.

[171] See Fedderke (2004) and Bleaney and Greenaway (2001).

quently increased uncertainty for exporters and importers. This reduces investment and consequently depresses international trade.[172]

We begin by providing some observations on the behaviour of exchange rate volatility in transition economies in the recent past. Although previous studies analyze the behaviour of exchange rate volatility in developing, transition and developed economies using varying econometric techniques, to our knowledge, the literature does not specifically test whether the underlying structure of the performance of exchange rate volatility in transition economies is consistent across theses economies when faced with similar changes to their macroeconomic fundamentals. The Chapter concludes by providing some scenarios on possible exchange rate volatility in these economies in response to changes to a set of macroeconomic fundamentals and external shocks.

We conduct an empirical investigation as to the determinants of exchange rate volatility in transition economies by identifying not only possible shocks but also macroeconomic fundamentals that may account for the persistence of exchange rate volatility in these economies.[173] In the abscence of a generally accepted model of exchange rates,[174] we draw on the empirical literature on exchange rate volatility literature to select possible explanatory variables.[175]

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172 See Sauer and Bohara (2001), Dell'Ariccia (1999) and Chowdhury (1993).

173 See Devereux (1997) discussing the lack of a clear theoretical framework in the literature to analyse exchange rate volatility.

174 See Sarno and Taylor (2002).

175 See Devereux and Lane (2003), Hviding, Nowak, and Ricci (2004), and Hausmann et al (2006).

The possibility of endogeneity present in these empirical models on currency volatility is discussed by Devereux (1997) and Devereux and Lane (2003).[176] The issue of endogeneity in exchange rate models is common in the literature due to technical limitations in the econometric estimation techniques that fail to account for endogeneity issues for such models. Therefore, the study emphasizes that the coefficients obtained using this econometric technique portrays the strength of the relationship between the various explanatory variables and currency volatility. Thus the the estimated coefficients should be interpreted as correlations.

We consider a panel of transition economies to determine the macroeconomic fundamentals and external variables that drive real exchange rate volatility in these economies. Some of the macroeconomic fundamentals investigated are:import cover, budget balance to GDP and debt to GDP ratios, GDP growth rate, openness of the economy, uncertainty, the current account balance, financial deepening and the inflation rate. In addition, we consider oil price volatility, dollar-euro volatility and capital flows.

The novelty of this analysis emanates from the explicitly testing of the existence of long run homogeneity of the coefficients across the countries. That is, if the set of transition economies are sufficiently similar with respect to the long run coefficients attached to the explanatory variables used to determine real exchange rate volatility, confirming that these countries may be used together in a panel. The inclu-

[176] Devereux (1997) states the lack of suitable instruments for the macroeconomic variables.such as the current account deficit and budget deficit.

sion of explanatory variables depends on if they meet this condition. The statistical test we use is the Hausman test statistic. This statistic is obtained from estimating real exchange rate volatility using Pool Mean Group Estimator. Another advantage of this approach is that the dynamics are explicitly modelled.

This Chapter proceeds as follows: Section 5.2 provides some data on exchange rate behaviour in transition economies; Section 5.3 discusses some of the variables that may affect currency volatility; Section 5.4 discusses the econometric methodology employed; Section 5.5 discusses the econometric specification of the model; Section 5.6 provides an analysis of the data; Section 5.7 discusses the results; Section 5.8 investigates possible scenarios; and lastly Section 5.9 concludes.

5.2 Behaviour of Exchange Rate Volatility in Transition Economies

The "tequilla crisis"[177] of 1995 through to the Asian/Russian/Brazilian financial crises of 1997-98 adversely affected exchange rates in transition economies more than developed or developing countries. This is perhaps because these financial crises emanated in transition economies. However, these crises also highlighted the sensitivity of exchange rates in these economies to shocks.

The question that arises is: Does excessive exchange rate volatility occur in transition economies only during periods of crises?

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[177] This is the financial crisis that adversely affected transition economies following the December 1994 devaluation of the Mexican peso.

From a set of 51 developing, developed and transition economies, Figure 5.1 illustrates that exchange rates were, on average, most volatile[178] in transition economies from 1980−2000 and not only in the crisis years.[179]

The higher volatility in the exchange rate is associated with three stylized facts. Firstly, transition economies are increasingly drawn into the integrated world economy with respect to both their trade in goods and services and in financial assets.[180] Moreover, the bulk of their international commerce and finance is in terms of monies of major industrial countries, usually the US dollar. Thus private capital inflows have come to play a dominant role in transition economies' financing and adjustment. The downside is the increased exposure of these economies to abrupt reversals in capital flows and exposure to exchange rate risk. The instability associated with short-term capital flows is reflected in the countries' exchange rate gyrations. These fluctuations in the exchange rate are accelerated if the country has debt denominated in terms of monies of major industrial countries[181] Secondly, most of these economies have moved towards manufactured exports from primary commodity exports. This move has made their terms of trade more stable while making them more sensitive to exchange rate movements.[182] Lastly, transition economies are subject to large nominal

178 We discuss in detail in Section 5.6 the calculation of real exchange rate volatility.

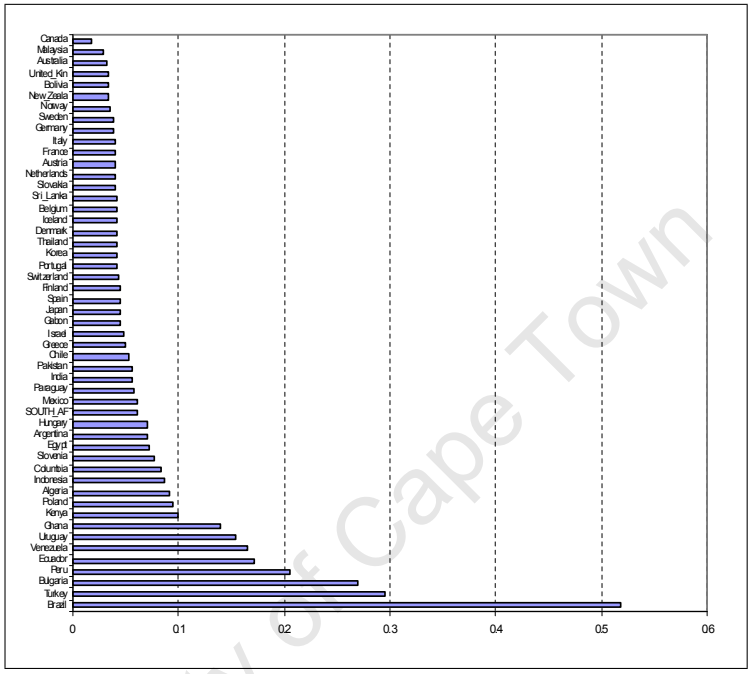
179 Hausmann et al (2006) finds a similar result for a set of 74 developed, developing and emerging economies over the 1980-2000 period.

180 Ricci et al (2008) state that the share of world trade for emerging countries rose by 27 percent in 1990 to 37 percent in 2004.

181 Examples of such crises are the "tequila crisis" of 1995 through to the Asian/Russian/Brazillian crises of 1997-98. The "tequila crisis" is the financial crisis that followed the December 1994 devaluation of the Mexican peso.

182 See Mussa et al (2000).

shocks because they have non-credible monetary institutions and weak fiscal position.[183] These nominal shocks are reflected in excessive exchange rate variability.



Sample: 1980-2000

Figure 5.1: Average Real Exchange Rate Volatility against US Dollar

Analyzing the worst performing currencies for the first half of 2006,[184] Figure 5.2 confirms that eight of the ten worst performing currencies for this period belong to transition economies. In the first half of 2006, the South African Rand recorded the biggest depreciation (14,8 percent) against the dollar. Figure 5.2 also highlights that, except for Chile, all of these countries experienced acute current account deficits for the first half of 2006. One of the factors behind rand depreciation was concern

183 See, for example, Hausmann et al (2006).

184 The data was obtained from International Financial Statistics of the International Monetary Fund.

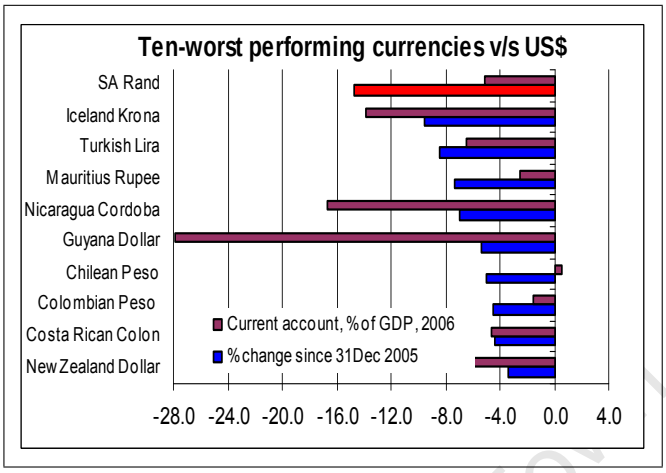


Figure 5.2: Ten worst-performing currencies in the first-half of 2006

about the widening current account deficit (1,2 percent of GDP in 2005 and 6,1 per cent in the first half of 2006).

Current account deficits indicate the inability of savings, both private and public, to meet private and public investment needs. Insufficient savings are indicative of budget deficits and/or high debt to GDP ratios. Thus the current account deficits are a symptom of macroeconomic imbalances. This finding supports the argument that macroeconomic fundamentals do affect exchange rate behaviour.[185] Moreover, these imbalances not only affect the trend in the real exchange rate but also its volatility.[186] This corroborates the finding of Hausmann et al (2006) that the substantial persistent difference in long term real exchange rate volatilities between developed and

[185] MacDonald (1999) claims that macroeconomic fundamentals have role to play in explaining exchange rate volatility. The paper argues for the use of error correction models in determining exchange rates in the long run. Stockman (1988, 1995) also advocate the use of macroeconomic fundamentals in determining real exchange rate variability.

[186] Canales-Kriljenko and Harbermeier (2004) state that variables that determine the level of the exchange rate affect exchange rate volatility as well.

transition economies indicate that there exist differences in the underlying economic fundamentals between these two sets of countries.

5.3 Variables that affect Currency Volatility

We earlier alluded to the possibility that current account imbalances adversely affect exchange rate volatility. Moreover, given that exchange rate volatility has adverse consequences on economies, understanding the drivers of exchange rate volatility is therefore crucial for economies.

Therefore considering empirical models of exchange rate volatility, Hausmann et al (2006) test for the impact and significance of shocks on exchange rate volatility for a group of developed, developing and transition economies. The shocks they consider are terms of trade shocks, output shocks and nominal shocks. They find terms of trade shocks are positively and significantly correlated with variability in the real exchange rate such that a positive terms of trade shocks should lead to an appreciation of the real exchange. However, Hausmann et al (2006) does discover that terms of trade shocks do have a smaller effect on exchange rate volatility during periods of high GDP growth. An output shock, as measured by the GDP growth, is found to have a positive and statistically significant effect on exchange rate volatility indicating that rising GDP growth may adversely affect exchange rate volatility. This result is amplified for rapidly growing transition economies catching up with the developed world. With rising growth rates and nominal rigidity present in these

economies, exchange rate volatility is the outcome. The paper also finds nominal shocks, as measured by a change in the inflation rate, while having an insignificant effect on exchange rate volatility,[187] is able only to account for a small, statistically significant, difference in exchange rate volatility between developed and transition economies.

Given the persistence of exchange rate variations and the inability of shocks to adequately explain away the difference between volatility between developed and transition economies,[188] Engel, Mark, and West (2007) assert that real exchange rate behavior at medium to long horizons can be at least partly explained by fundamentals.

To this end, a number of empirical studies have analyzed the link between exchange rate volatility and a set of variables (including macroeconomic fundamentals) for developing, developed and transition economies using a variety of econometric techniques. The impact of policy on exchange rate volatility through its effect on macroeconomic fundamentals have also been studied by a number of papers. For example, Chan and Ngiam (1998), on Singapore's experience during the Asian financial crisis of 1997, state the following: "The Singapore dollar has withstood the currency storm lashing the region because of its extremely strong economic fundamentals...(including) low foreign debt, huge foreign exchange reserves, large current account surpluses, substantial budget surpluses, high savings rates, strong inflow of

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187 Note that with the inclusion of the change in the inflation rate results in a loss of a significant number of observations. Therefore, Hausmann et al (2006) states that this result may not be robust.

188 Stockman (1995) and Hausmann et al (2006).

foreign direct investment, a sound financial system and prudent government policies". This highlights the importance of sound macroeconomic fundamentals in affecting real exchange rate variability.

For much of the empirical literature on exchange rate volatility influenced by macroeconomic fundamentals, a frequent point of departure has been the Mundell (1961) model for assessing the Optimal Currency Area (OCA) hypothesis. Specifically, Bayoumi and Eichengreen (1998) examine the empirical determinants of bilateral exchange rate volatility for a group of industrial countries, focusing on two OCA variables - namely, trade interdependence and the degree of commonality in economic shocks.[189] They show that the proxies for asymmetric shocks and trade linkages go some way toward explaining variations across countries in exchange market pressure. They claim that asymmetric shocks increase exchange rate volatility by intensifying exchange market pressure. Moreover, even if there is limited intervention by policy makers in response to asymmetric shocks, the real exchange rate remains a major conduit for the capturing this asymmetry since it reflects the price distortions emanating from the asymmetric shock.

Bangaké (2008) closely follow the Bayoumi and Eichengreen (1998) specification for a set of 21 African countries for the period 1990-2003. His results support the findings of Bayoumi and Eichengreen (1998) that greater bilateral trade reduces exchange rate volatility.

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189 See Alesina and Barro (2002) for a discussion on the effects of asymmetric shocks.

A robust theoretical prediction emphasized by Hau (2002a, 2002b) and Obstfeld and Rogoff (2000) is that more open economies exhibit less volatile real exchange rates. The argument is as follows. As an economy opens, the increase in the volume of imported goods provides a channel for a quick adjustment of the domestic aggregate price level. This decreases any short-run effect of monetary or real shocks on real household money balances and therefore reduces the scope of such a shock to develop real effects on either domestic consumption or the real exchange rate. Therefore, relatively closed economies,due to a lower import share, are deprived of aggregate price level flexibility transmitted through the exchange rate. These economies, in response to shocks, produce more pronounced effects on consumption and the real exchange rate, ceteris paribus.[190] Trade restrictions influence the level of the real exchange rate through its affect on domestic prices. Rising trade restrictions may lead to rising domestic prices and an appreciation of the currency. Devereux and Lane (2003) also find this result for developing and developed economies.[191] Hau (2002b) cautions us to the existence of reverse causality from real exchange volatility to openness such that exchange rate risk is an impediment to trade. Thus highly volatile exchange rates may result in countries opting for restrictive trade practices.

The movements in capital flows is reflected in exchange rate movements. More variable are capital flows to and from a country, greater the likelihood of increased

[190] Incomplete exchange rate pass-through in the short run does not change the nature of the argument, but may just imply that the structural link between real exchange rate volatility and openness is more difficult to detect over short measurement periods.

[191] See also Edwards and Ostry (1990) and Goldfajn and Valdes (1999) and MacDonald and Ricci (2003).

volatility in the real and nominal exchange rate. Capital flows are influenced by the country-specific internal socioeconomic position and the external environment in which the country operates.[192]

However, capital flows are also a function of information. That is, capital migrates according to beliefs held and information available on a particular country's internal socioeconomic position and the dictates of the external environment. Calvo, Leiderman and Reinhart (1993) state that rising volatility of capital flows is associated with asymmetric information. They depict a scenario where, in an environment characterized by asymmetric information, a sudden capital outflow may indicate to financial markets and lenders alike that the country has suffered a negative shock, even when no shock has occurred. This sudden capital flight may become self-perpetuating. This outflow of capital may have negative consequences for reserves, signalling possible existence of macroeconomic imbalances in the economy. Consequently, the expectations that gave rise to these detrimental capital outflows may become rational. All of these changes have adverse consequences for both the level and the variability of the real exchange rate. Policy makers can only counteract these irrational negative capital shocks by reducing the prevalence of asymmetric information. Policy makers can also increase the confidence in a country's economic position by eliminating restrictions on capital flows. Glick and Hutchinson (2005)

[192] Calvo, Leiderman and Reinhart (1993) argue that the renewal of capital flows to Latin America results from external factors and can be considered an external shock common to the region. The theory that economic reforms in some countries give rise to expectations of future reforms in others is discussed in Ghosh and Ostry (1992).

argue that reducing capital flow restrictions may reduce the likelihood of currencies being prone to speculative attacks and currency crises by reducing foreign exchange market distortions.

Cady and Gonzalez-Garcia (2007) hypothesize that increasing transparency and providing markets with more complete information permits market participants to better assess a country's macroeconomic prospects. Providing up to date, complete information on a country's fiscal position reduces the level of uncertainty with regards to a country's prospects. Rising uncertainty increases the riskiness associated with a particular country. This is reflected in, among other things, a volatile exchange rate.

Macroeconomic fundamentals acts as a signalling device to markets on the economic position of an economy.[193] An example of a signalling device is a country's reserve level. A low stock of reserves may reflect a history of populist monetary policy. While a high level of reserves reduces the likelihood of a currency crisis and lowers the external borrowing cost either through improved confidence in an economy and/or indirectly through improved credit ratings on foreign currency debt. That is, a country's default risk on debt is perceived to diminish with higher reserves.[194] All this translates to into improved market sentiment with rising reserve ratios reducing

[193] Cady and Gonzalez-Garcia (2007) contend a country's foreign currency liquidity position acts as a signalling device for agents.

[194] See Mulder, Perrelli, and Rocha (2002) and Jonsson (2001).

the uncertainty surrounding the country's fundamentals and its ability to withstand adverse shocks.

Hviding, Nowak and Ricci (2004) show that after controlling for macroeconomic conditions, increasing the level of reserves (relative to short-term debt) reduces the volatility of the real effective exchange rate. They argue that although theoretically freely-floating exchange rates do not require large reserve holdings, in practice the level of reserves may be an important signal for outside investors. Hviding et al (2004) also find non-linear relationship between real exchange rate volatility and reserves due to 'decreasing returns to reserves'.

A second signalling device is the government fiscal stance as measure by either the debt to GDP or budget balance to GDP ratios. The finding of Cady and Gonzalez-Garcia (2007) reveals that rising debt to GDP ratios may have adverse consequences on exchange rate volatility. Rising debt ratios signal to the market a decline in credibility and sustainability of the macroeconomic policy. They signal the inability of the government to meet its requirements through its revenue generating processes due to inept policies. Changes in the budget balance have two countervailing effects on the level of the real exchange rate.[195] On the one hand, an improvement in the budget balance will lead to an increase in private savings such that total spending falls and price of nontradables would fall, resulting in a depreciation of the real exchange rate.[196]

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195 See for instance Ostry (1994), and De Gregorio, Giovannini and Wolf (1994).

196 Note that overall savings would rise and total domestic demand fall in response to an improvement in the fiscal balance if Ricardian Equivalence does not hold perhaps due to uncertainty surrounding the duration of the improvement of the fiscal position.

On the other hand, the current account surplus generated by the initial real depreciation[197] would have to be wiped out in the long run by a real appreciation to ensure a trade deficit to offset the net inflow of foreign capital.

Devereux and Lane (2003) include determinants measuring financial linkages between countries for a group of developing and developed economies.[198] The two sets of financial series they consider measure the degree of internal and external finance. The former captures the degree of financial depth within a country while the latter represents bilateral portfolio debt liabilities between countries. Devereux and Lane (2003) observe that both increased financial deepening and external financial linkages reduce nominal exchange rate volatility in developing countries. An increase in a country's financial depth provides more efficient financial markets by improving an economies ability to absorb shocks by facilitating intertemporal smoothing by households and firms or adding liquidity to financial markets (including the foreign exchange market).[199] This helps stabilize the exchange rate. The argument for a decline in exchange rate volatility with rising external financial linkages has to do with policy - developing countries will attempt to reduce exchange rate fluctuations, the greater the reliance on external finance.

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197 The real depreciation of the currency originates from a decline in the domestic price level due to a fall in demand.

198 Fernandez-Arias et al (2001) and Poirson (2001) also consider financial factors (specifically, the ability to issue international debt in domestic currency)in a model of multivariate exchange rate volatility for a set of countries.

199 See Kularatne (2002) and Levine (1997).

Attempts at controlling the fluctuations in the nominal exchange rate has consequences for domestic prices. Therefore, increasing reliance on external finance and attempts by countries to control changes to the nominal exchange rate due to this reliance affects domestic prices and consequently, leads to increased variation of the real exchange rate. However, since Devereux and Lane (2003) only consider nominal exchange rate volatility, they fail to factor in price movements.

5.4 Econometric Methodology

5.4.1 Dynamic Heterogenous Panel Model

The natural advantage of using a panel data set and panel estimation is that the number of data points available becomes sufficiently large to draw meaningful results. Mark et al (2001) find evidence that with the increased efficiency from panel estimation, with the focus on longer horizons, implies that the macroeconomic models consistently provide forecasts of exchange rates that are superior to the "no change" forecast from the random walk model. Further, using dynamic heterogenous panel models, we allow for heterogeneity to exist in the short-run dynamics and test for homogeneity in the long-run, across the set of countries. This builds on the previous literature on exchange rate volatility amongst transition economies by testing the long-run homogeneity of currency volatility in response to macroeconomic fundamentals and external shocks across the set of transition economies. However, in the

current econometric literature, there does not exist a dynamic panel estimator that allows for multiple cointegrating vectors.[200]

Following Pesaran, Shin and Smith (1999), we base our panel analysis on the unrestricted error correction Autoregressive Distributed Lag (ARDL) (p,q) representation:

$$\triangle y_{it} = \phi_i y_{i,t-1} + \beta_i' x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \triangle y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}' \triangle x_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5.1)$$

$i = 1, 2, ..N$, stand for the cross-section units (the countries that compose the middle-income countries) and $t = 1, 2, ...T$ denote time periods. Here y_t is a scalar dependent variable, x_{it} $(k \times 1)$ is the vector of (weakly exogenous) regressors for group i, μ_i represents the fixed effects, ϕ_i is a scalar coefficient on the lagged dependent variable, β_i's is the $k \times 1$ vector of coefficients on explanatory variables, λ_{ij}'s are scalar coefficients on lagged first-differences of dependent variables, and δ_{ij}'s are $k \times 1$ coefficient vectors on first-difference of explanatory variables, and their lagged values. We assume that the disturbances ε_{it}'s are independently distributed across i and t, with zero means and variances $\sigma_i^2 > 0$.

We also make the assumption that $\phi_i < 0$ for all i. This implies that there exists a long run relationship between y_{it} and x_{it}:

$$y_{it} = \theta_i' x_{it} + \eta_{it}, \qquad i = 1, 2, ..., N, \; t = 1, 2, ..., T \qquad (5.2)$$

[200] See Pesaran, Shin and Smith (1999).

where $\theta_i = -\beta_i'/\phi_i$ is the $k \times 1$ vector of the long-run coefficient, and η_{it}'s are stationary with possible non-zero means (including fixed effects). Then (5.1) can be written as

$$\triangle y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \triangle y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}' \triangle x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{5.3}$$

where $\eta_{i,t-1}$ is the error correction term given by (5.2) and thus ϕ_i is the error coefficient measuring the speed of adjustment towards the long-run equilibrium.

Using the general framework described above,we consider the following approach:

Pool Mean Group Estimator (PMGE) The PMGE, advanced by Pesaran, Shin and Smith (1999), allows the intercepts, the short-run coefficients and error variances to differ freely across groups but the long-run coefficients are constrained to be the same. That is,

$$\theta_i = \theta, \quad i = 1, 2, ...N \tag{5.4}$$

The common long-run coefficients and the group specific short-run coefficients and the group-specific short-run coefficients are computed by the pooled maximum likelihood (PML) estimation technique. These PML estimators are denoted by $\hat{\phi_i}$, $\hat{\boldsymbol{\beta}_i}$, $\hat{\lambda_{ij}}$ and $\hat{\boldsymbol{\delta}_{ij}}$and θ. We then obtain the PMGE as follows:

$$\begin{aligned}
\hat{\phi}_{PMG} &= \frac{\sum_{i=1}^{N}\hat{\phi}_i}{N}; \hat{\boldsymbol{\beta}}_{PMG} = \frac{\sum_{i=1}^{N}\hat{\boldsymbol{\beta}}_i}{N}; \\
\hat{\lambda}_{jPMG} &= \frac{\sum_{i=1}^{N}\hat{\lambda}_{ij}}{N}, j = 1, .., p-1; \hat{\boldsymbol{\delta}}_{jPMG} = \frac{\sum_{i=1}^{N}\hat{\boldsymbol{\delta}}_{ij}}{N}, j = 1, ..q-1 \qquad (5.5) \\
\hat{\boldsymbol{\theta}}_{PMG} &= \hat{\boldsymbol{\theta}}
\end{aligned}$$

This depicts the pooling implied by the homogeneity restriction on the long-run coefficients and the averaging across groups used to obtain means of the estimated error-correction coefficients and other short-run parameters. Under long-run slope homogeneity, the PMGE are consistent and efficient. The Hausman (1978) test will be applied to examine the extent of the panel heterogeneity.

5.4.2 Threshold Autoregressive Estimation

Using the above estimation technique we can also test the Hviding, Nowak and Ricci (2004) finding of nonlinearity of reserves by employing the Threshold Autoregressive (TAR) estimation technique.[201] We now include an indicator term, which we use when testing for the existence of a non-linearity. This technique suggests the estimation of:

$$y_t = \beta_0 + (\beta_{11} + \beta_{12} I(P_{t-1} - \bar{P}))P_t \qquad (5.6)$$

where y_t is a measure of currency volatility, P_t is the policy variable (reserve holdings) and $I(P_{t-1} - \bar{P})$ is an indicator variable.

[201] See Potter (1995) and Koop, Pesaran and Potter (1996). Since PMGE is essentially a vector error correction model for panel data, we are able to incorporate the TAR estimation technique into the PMGE framework.

The indicator variable is created by selecting a potential optimal level of the policy variable denoted by $\bar{P}$. $\bar{P}$ is then subtracted from the original data series denoted P_{t-1}. All values of the new series that are greater than zero are set equal to one and all values less than zero are set equal to zero such that $I(P_{t-1} - \bar{P})$ is a dummy variable with values of zero and one. In order to determine what the threshold level might be, we add the β_{11} and β_{12} coefficients.

Previous empirical and theoretical literature find reserves to have a negative effect on exchange rate volatility. This implies that $\beta_{11} < 0$. Thus the threshold level of reserves $\left(\bar{P} = P^*\right)$ after which any further increases in reserves will either have no effect on exchange rate volatility $(\beta_{11} + \beta_{12} = 0)$ or lead to an increase $(\beta_{11} + \beta_{12} > 0)$ in exchange rate volatility. We test if either of these cases occur.

5.5 Specification

Standard models of exchange rates, based on macroeconomic variables such as prices, interest rates and output, are thought by many researchers to have failed empirically. However, Mark et al (2001) provide evidence that exchange rates incorporate news about future macroeconomic fundamentals. These models examine the response of exchange rates to announcements of economic data. We assess the impact of a set of macroeconomic fundamentals on real exchange rate volatility for group of tran-

sition economies. However, in the empirical literature, there is no consensus in the literature on a generally accepted model of exchange rates.[202]

Therefore, we begin by extending the econometric framework of Canales-Kriljenko and Habermeier (2004) and Hviding, Nowak and Ricci (2004). Furthermore, since we are explicitly concerned with effect of changes to macroeconomic fundamentals on exchange rate volatility in transition economies, we shall test if the explanatory variables we include in this model display a homogenous long-run effect on exchange rate volatility for a set of transition economies. We also control for external factors that may account for exchange rate volatility in transition economies. We demonstrate that such models might well be able to account for observed real exchange rate volatility in transition economies.

The data set consists of an unbalanced panel of 12 macroeconomic indicators for 19 countries between 1981 and 2003.[203] The measure of real exchange rate volatility (REXVOL), measured as the log of the coefficient of variation for the real exchange rate vis-à-vis the US dollar. Given the international empirical literature discussed in Section 5.2, real exchange rate volatility is hypothesized to be related to the following variables: the fiscal stance, measured as the budget surplus to GDP ratio (DGBAL) or indebtedness (DBGDP), measured by the log of government debt to GDP ratio in US dollars PPP; reserve adequacy (RA), measured as the number

[202] See, for example, Sarno and Taylor (2002).

[203] The set of countries are: Argentina, Bolivia, Chile, Columbia, Ecuador, Hungary, India, Indonesia, South Africa , Sri Lanka, Mexico, Malaysia, Pakistan, Peru, Paraguay, Thailand, Turkey, Uruguay and Venezuela. This set of transition economies is chosen from the International Finance Corporation Global Index of August 2003.

of weeks of import cover; real GDP growth (DGDP), measured in US dollars PPP terms; the inflation rate (INF) and the change in the inflation rate (DINF), measured using the consumer price index (CPI); financial deepening, measured by the ratio of M3 to GDP (FINDEEP); net capital inflows to GDP ratio (CAPFLOW), measured in US dollars PPP terms; the current account balance to GDP ratio (CAB); a measure of the degree of openness of the economy (OPEN), measured as the log of the ratio of exports plus imports to GDP; and a measure uncertainty (INSTAB), measured by the log of the interest rate differential between the US and each country's interest rate as a proxy for uncertainty. The interest rate differential between South Africa and US to proxy uncertainty is highly correlated with the measure of political instability in South Africa constructed by Fedderke et al. (2001). Furthermore, the interest rate differential measuring uncertainty generates peaks and troughs that match historical developments in South Africa.[204]

Due to data constraints, it was not possible to construct a direct measure of the terms of trade volatility as this data is not available for all countries at a high frequency. Second best is to proxy this volatility. This analysis selects oil price volatility (OILV), measured by the volatility of the US dollar price for oil, as the measure best suited to proxy terms of trade volatility. This is because the oil price is an important part of either the import or export basket for almost all the countries in the sample. It is also argued that commodity price volatility is a good proxy for terms of trade

[204] See also MacDonald (1999) on the importance of the instability measure.

volatility.[205] Researchers also find that commodity prices are strongly cointegrated with the real exchange rate and may even be a better predictor of exchange rate fluctuations than terms of trade.[206] MacDonald and Ricci (2003) provide an explanation why this is the case. They assert that the relative accuracy of commodity price data as opposed to arbitrary, country-specific export and import deflators, together with the high frequency of commodity price data, allows for financial markets to anchor their decisions on exchange rate movements to the prices of these commodities.

Given the substantial literature on the link between commodity-exporting countries and the level of the exchange rate, so it would follow that volatility in commodity prices may also filter through to volatility in exchange rates. For example, for a commodity exporting country, a higher commodity price should appreciate the real exchange rate through income or wealth effects by inducing higher wages. This would induce higher domestic demand and increase the price of nontradables.[207] These effects should be captured in the country's terms of trade.[208] Figure 5.3 portrays commodity price volatility matches volatile periods in the world economy as well.

There is a strong argument that there are time-specific factors at play when considering exchange rate volatility. One example is the Asian crisis of 1997/8. Although the effects of the sudden devaluation of the Thai bhat during the 1997/8 Asian

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205 See Havemann (2005) for a detailed explanation of the linkage between commodity prices, terms of trade and the real exchange rate.

206 See, for example, Chen and Rogoff (2003), MacDonald and Ricci (2002), and Cashin, Cespedes and Sahay (2004).

207 See Cashin, Cespedes and Sahay (2004) and Diaz-Alejandro (1982).

208 Recall that a country's terms of trade is measured as the ratio of export prices to import prices.

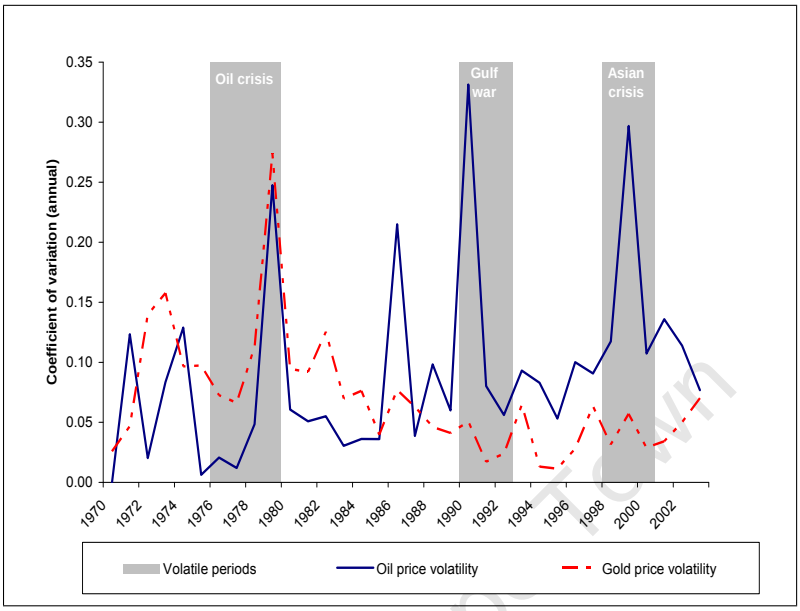

Figure 5.3: Oil and gold price volatility (1970-2002)

crisis were initially only felt in south-east Asia, financial contagion quickly spread throughout global financial markets. This is a good example of a case where the poor fundamentals of one country (in this case Thailand) led to exchange rate volatility in other (emerging) countries. There are a number of approaches that may be used to capture systemic volatility in the world economy. We use the volatility of the Dollar-Euro exchange rate (DEUROV) as proxy for world volatility.

Given the above, we estimate the following:

$$\Delta REXVOL_{it}=\phi_i REXVOL_{i,t-1}+\sum_{j=1}^{q-1}\lambda_{i,j}^{'}\Delta REXVOL_{i,t-j}+\sum_{j=1}^{p-1}\boldsymbol{\gamma}_{i,j}^{'m}\Delta\mathbf{X}_{i,t-j}^{m}+\sum_{j=1}^{p-1}\boldsymbol{\gamma}_{i,j}^{'TOT}\Delta\mathbf{X}_{i,t-j}^{TOT}+\sum_{j=1}^{p-1}\boldsymbol{\gamma}_{i,j}^{'W'}\Delta\mathbf{X}_{i,t-j}^{W}+\mu_{i,t} \quad (5.7)$$

where i and t are country and time indices, respectively. $\mathbf{X}_{i,t}^{m}$, $\mathbf{X}_{i,t}^{TOT}$ and $\mathbf{X}_{i,t}^{W}$ represent macroeconomic fundamentals, terms of trade volatility and world volatility, respectively. ϕ_i is the error correction coefficient.

The key coefficients of interest are the error correction term (ϕ), the long-run coefficients and the Hausmann test statistic.

5.6 Data

There are a number of measures of exchange rate volatility. We use the coefficient of variation (cv_t) of the currency to capture exchange rate volatility.[209] It is calculated based on the monthly real exchange rate for each country in the sample. The coefficient of variation is a normalized measure of dispersion. This is a more appropriate measure of volatility since the average real exchange rate for each country per year is significantly different from one another.[210] It is defined as the standard deviation (σ_t) divided by the mean (μ_t).

$$cv_t = \frac{\sigma_t}{\mu_t} \tag{5.8}$$

Note that the formula measuring the coefficient of variation (5.8) takes account of movements in the trend by dividing the standard deviation by the mean corresponding to each year.

[209] The data on exchange rate volatility including the other variables included in this study is obtained from the International Financial Statistics of the International Monetary Fund.

[210] I acknowledge that a measure of currency volatility using the effective real exchange rate contains more information such as trade flows. However, the data to construct the effective real exchange rate is not available for every country in this set of transition economies.

Most countries do not publish monthly real exchange series, so this for this analysis we create a real exchange rate series in the standard way, by deflating the nominal exchange rate relative to the United States using that country's consumer price index relative to the US consumer price index.

We focus on real exchange rate volatility vis-à-vis the US dollar because certain countries (like Argentina) followed fixed nominal exchange rates for a considerable duration of the sample period.[211] We may argue that some of these countries had less flexible exchange rate regimes and therefore less volatile exchange rates. It is important to realize that all countries experience real exchange rate volatility, regardless of the exchange rate regime. Clark et al (2004) find that less flexible exchange rate regimes do not necessarily guarantee reduced real exchange rate volatility. This is because the real exchange rate measures both internal prices and external prices (tradables and non-tradables). Thus even when the nominal exchange rate is fixed, the real exchange rate is still volatile.[212] Calvo and Reinhart (2002) show that all real exchange rates, pegged or floating, are characterized by currency volatility.

Furthermore, pegged currencies have a greater likelihood of becoming 'freely falling', as speculators may force the central bank to abandon a peg when reserves dry up.[213] Indeed, a flexible exchange rate may bring about real exchange rate stability, by reducing the likelihood of speculative attacks against the currency.[214]

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211 For example, Argentina had fixed exchange rate regime until the crisis of 1998.

212 See for instance Giovannini (1998), Engel (1993), Engel & Rogers (1997).

213 See, for example, Krugman (1996).

214 The role of exchange controls is also an area of debate. Canales-Kriljenko and Harbermeir (2004)

In addition, sticky prices result in real exchange rate volatility.[215] Given that the real exchange rate is frequently never equal to one, even in the long run, this indicates a failure of the Purchasing Power Parity (PPP) in the data. An explanation for this is that changes to the macroeconomic environment generate deviations from PPP as trend movements in relative prices lead to persistent deviations from PPP. Moreover, the fixing of the nominal exchange rate implies that prices reflect shocks in the economy. This leads to volatility in the real exchange rate.[216]

Increasing exchange rate volatility may be reflecting rising uncertainty surrounding the socioeconomic factors in a particular country. Figure 5.4 depicts SA Rand volatility from 1981 to 2003. In SA Rand volatility rose, simultaneously with rising risk levels. For example, increased political uncertainty in 1985 and 1994 when the Rubicon Speech and first democratic elections occurred, respectively, the real exchange rate was relatively more volatile.

Constructing this measure of exchange rate volatility for a set of transition economies for the period 1982-2004, Figure 5.5 shows the South African Rand to be the fourteenth most volatile currency with Turkey being the most volatile currency.[217] Dissecting this sample into decades and ranking the currencies from the most to least

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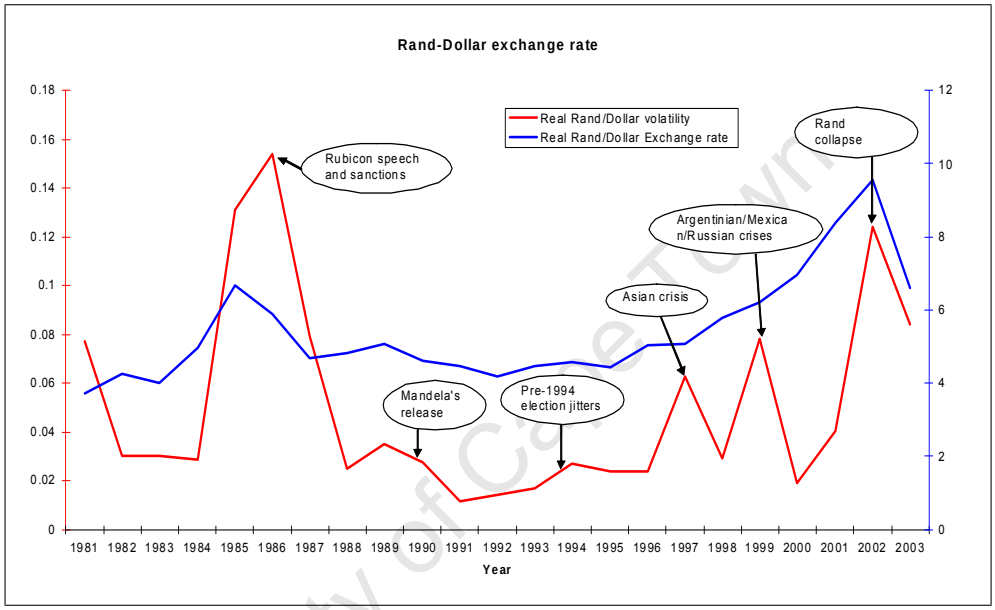
find that prudential limits on banks' foreign exchange position may reduce volatility by reducing speculative position taking. Such exchange controls may work to the detriment of the country if it creates an environment of over-regulation.

[215] See, once again, Giovannini (1998), Engel (1993), and Engel and Rogers (1997).

[216] It may be better to use a trade-weighted measure of real eachange rate volatility. We argue that for a significant number of countries in the sample most trade and foreign debt is denominated in US dollars, suggesting this not a particularly important problem.

[217] We started out with an original sample of 23 transition economies. For reasons which we highlight in Section 5.7, we reduce the sample to 19 countries.

volatile, Table 5.1 shows that Argentina and Turkey continue to have the most volatile currencies with the Bolivian pesos' volatility decreases and the South African Rand's volatility rising towards the 2000s.



Source: South African Reserve Bank

Figure 5.4: Rand-Dollar exchange rate from 1981-2003

5.7 Econometric Results and their Robustness

We now estimate Equation (5.7). We are unable to consider the full specification illustrated by Equation (5.7) due to limited time series data.[218] Therefore we estimate Equation (5.7) by considering the three groups of variables. The first group is the country's macroeconomic fundamentals, i.e. variables that carry specific information

[218] We use a lag of 2.

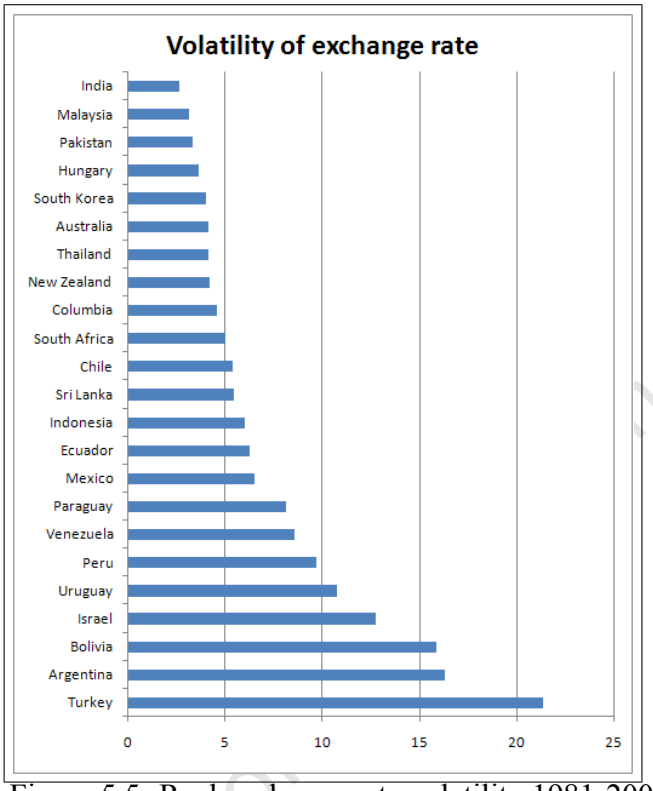


Figure 5.5: Real exchange rate volatility 1981-2004

about the country itself; the second group of variables – terms of trade volatility– captures the effect on real exchange rate volatility due to variability of a country's terms of trade; and the third group of variables - world volatility - reflects volatility of international markets.

Table 5.2 illustrates the estimations whose variables have a significant influence on real exchange rate volatility in the long-run.[219] Moreover, we check whether the Hausman test statistic reveals long-run homogeneity of currency volatility in response to macroeconomic fundamentals and external shocks across the set of tran-

[219] Most of the coefficients of the explanatory variables are significant except for GDP growth in Regression [3].

Country	1982-2004	80s	90s	2000s
Argentina	2	3	2	2
Australia	18	15	18	18
Bolivia	3	1	7	6
Chile	13	11	14	15
Columbia	15	17	15	11
Ecuador	10	10	19	5
Hungary	20	23	17	12
India	23	22	21	23
Indonesia	11	13	10	10
Israel	4	4	3	3
Malaysia	22	21	16	22
Mexico	9	8	12	14
New Zealand	16	14	20	16
Pakistan	21	19	23	17
Paraguay	8	7	8	9
Peru	6	5	5	13
South Africa	14	12	22	8
South Korea	19	18	13	19
Sri Lanka	12	16	9	20
Thailand	17	20	11	21
Turkey	1	2	1	1
Uruguay	5	6	4	4
Venezuela	7	9	6	7

Sample: 1982-2004

Table 5.1: Ranking of Real Exchange Rate Volatility against US Dollar

sition economies.[220] The results that are presented are shown to be robust to different specifications. From Table 5.3, we observe that the error correction term (ϕ) is between 0 and -1, indicating that a cointegrating relationship exists for all nine regressions.

[220] As indicated by Hau (2002b), there is an inherent endogeneity problem. Therefore, to correct for this, we instrument for the explanatory variables by lagging each variable by one period.

Using net capital flows and the measure of financial deepening the homogeneity test fails since the Hausmann test statistic is 1.31 (0.021) and 2.45 (0.015).[221] We therefore reject the null of homogeneity of the long-run coefficients. This implies that real exchange rate volatility does not have a similar response to net capital flows and financial deepening across the set of 19 countries in the long run.

The breakdown of homogeneity across the countries for the measure of financial deepening occurs because some countries have characteristics of developed-country financial markets while others have characteristics of developing-country financial markets.[222] Likewise, capital flows to these economies have a diverse effects on real exchange rate volatility across the countries because the type of capital flows that affect each economy are different. For example, some economies may have an inordinate amount of short-term or 'hot money' capital flows whilst other economies have capital flows that reflect long-term investment opportunities in a country.[223]

5.7.1 Macroeconomic variables ('fundamentals')

The results support the *a priori* expectation of the impact of changes to these macroeconomic fundamentals on real exchange rate volatility. Rising levels of reserves, an

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221 The p-values are in parentheses.

222 South Africa has highly developed financial markets similar to developed Anglo-Saxon economies. See Kularatne (2002).

223 A point to note is that we started the analysis with 23 transition economies and we present the analysis for a panel of 19 countries. The breakdown of the Hausman long-run homogeneity assumption for the entire panel is the reason for estimation across a smaller sample. The countries that we omitted are Australia, Israel, New Zealand and South Korea. We argue that the Hausman test fails because real exchange rate volatility in these countries are affected differently in the long run to the 19 countries in the subsample when changes occur to their macroeconomic fundamentals.

improved fiscal balance, rising GDP growth, increased openness, lower inflation and lower levels of risk or uncertainty reduces real exchange rate volatility. Detail results are given below.

1. Reserves

   From Regressions [1] – [4] and [7] in Table 5.2 reports that increasing the level of import cover, measured in number of weeks, reduces has a negative, significant impact on real exchange rate volatility. It is estimated that an increase in foreign reserves of 1 week reduces exchange rate volatility by between 2 to 4 percent. This result is robust across specifications. Using the methodology outlined in Section 5.4.2, the study tests for a nonlinear association between reserves and exchange rate volatility. We find that the optimal level of reserves is 4-and-half months of import cover, after which increasing the level of reserves has an insignificant impact on exchange rate volatility.[224] The result we find is similar to Hviding, Nowak and Ricci (2004).

2. Fiscal policy

   Improving the fiscal position decreases variability of the real exchange rate. Regressions [1] and [5] indicates a one percentage point improvement in the budget surplus to GDP ratio leads to a 0.8 percent or 1.3 percent decrease in real exchange rate volatility, respectively. Similarly a lower debt to GDP ratio is

[224] For example, at the end of 2005, South Africa had approximately 3 months of import cover. The implication of this finding is that SA could reduce Rand volatility by increasing reserves to the optimal four-and-half months.

associated with lower real exchange rate volatility. As indicated in Regressions [2] and [9], a one percentage point increase in the debt to GDP ratio leads to a 0.27 or 0.40 percent decrease in exchange rate volatility, respectively. These results confirm the finding of Cady and Gonzalez-Garcia (2007).

3. Current account balance

The research conducted found that the level of the current account balance did have a statistically significant effect on rand volatility.[225] A 1 percentage point improvement in the current account will lead to 4 percent decrease in rand volatility. In addition, improvements in the current account reduces rand volatility at an increasing rate, i.e., the more the current account improves, there are rising gains in terms of reduced rand volatility.

The level of reserves, a country's fiscal position and her current account balance are macroeconomic fundamentals that signal to the markets the credibility and sustainability of the macroeconomic policy. Imbalances in the economy will filter into low levels of reserves, a deteriorating fiscus and/or pressure on the current account. A deteriorating current account balance increases currency volatility as the country's dependence on capital inflows (which are relatively mobile) increases. Fluid capital flows will adversely affect real exchange rate volatility.[226]

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225 See Regression [7].

226 The deteriorating current account balance in some of the emerging-market economies has been mitigated by net equity portfolio inflows. For example, in South Africa's case, net non-resident equity portfolio inflows averaged US$ 0.7 billion per month in 2005, helping to fund an average monthly

4. GDP growth

GDP growth is only weakly significant and not robust to different specifications. One regression that did include this variable is reported – Regression [4]. It suggests that a one percentage point increase in growth leads to a 2.38 percent decrease in real exchange rate volatility. This finding is contrary to Hausmann et al (2006) finding of changes in output (measured by growth in GDP) having adverse consequences for growth. The implication is that rising growth rates in transition economies reduce currency volatility. Markets that observe growing economies are likely to have less uncertainty regarding the macroeconomic position of these economies resulting in reductions real exchange rate volatility. Moreover, a strongly growing economy may be at less risk of a currency crisis as it able to attract sufficient capital inflows.

5. Uncertainty

From Regressions [1] – [7] we observe that rising levels of uncertainty increases real exchange rate volatility between 0.10-0.12 percent for a one percent increase in uncertainty. This finding is not surprising as we discussed in Section 5.1 that real exchange rate volatility could be a proxy for uncertainty surrounding the socioeconomic position of a country.

current account deficit of US$ 0.8 billion. However, the dependence of South Africa on non-resident portfolio inflows has raised a potential dilemma: if equity inflows suddenly stop or are reversed, the loss of this rand stability anchor could put downward pressure on the rand and upward pressure on inflation via the exchange rate pass-through to prices.

6. Inflation rate

   From Regressions [8] and [9], rising inflation rates are found to increase real exchange rate volatility at a decreasing rate. Hausmann et al (2006) emphasize that large nominal shocks, like an increase in the inflation rate adversely affects currency volatility in transition economies more than developed economies because transition economies are more likely to have non-credible monetary institutions and weak fiscal position.

7. Openness

   A one percent increase in openness results in a 0.12 to 0.22 percent decrease in real exchange rate volatility from Regressions [6] and [5], respectively. This result helps to confirm the theoretical prior that relatively closed economies with little aggregate price flexibility due to a lower import share are deprived of this aggregate price level flexibility transmitted through the exchange rate and therefore produce (*ceteris paribus*) more pronounced effects on consumption and the real exchange rate. Thus, as purported by Hau (2002b), opening the economy reduces currency volatility.

5.7.2 Terms of trade shocks

As mentioned above, terms of trade volatility is proxied in this study by oil price volatility. Table 5.2 reports Regressions [1], [3], [5] and [8] which include oil price

volatility. All four regressions indicate rising oil price volatility has adverse consequences for real exchange rate volatility. In particular, one percent increase in oil price volatility leads to a 0.06 to 0.07 percent increase in the volatility of the exchange rate depending on the specification. This finding is in keeping with Hausmann (2005).

5.7.3 World volatility

Our proxy for world volatility, the real exchange rate volatility of the Dollar-Euro increases real exchange rate volatility in transition economies. A one percent increase in Dollar-Euro volatility leads to a 2.31 percent increase in a country's real exchange rate volatility. The argument that systemic impact of global volatility affects individual currency volatility in transition economies is supported by this result.

5.8 Scenarios

The effects of the various explanatory variables on real exchange rate volatility in terms of actual currency is discussed below. Table 5.3 provides scenarios[227] based on the regression coefficients illustrated in Table 5.2. The scenario is simulated on South African data.[228]

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227 Table 5.3 depicts standardised results.

228 As we failed to reject long-run homogeneity of the regressors across the set of countries, we claim that the impact is not statistically different across the set of transition economies in the long run. However, for each country, the exact impact of each explanatory variable on exchange rate volatility depends on the initial value of each explanatory variable and the exchange rate which may vary from country to country.

From Table 5.3 we observe that changes to the debt to GDP ratio and the current account balance has the highest impact on exchange rate volatility. Worsening current account deficits and debt to GDP ratios increase the standard deviation of the real exchange rate by 30 cents. In fact, the impact on real exchange rate volatility due to a deterioration of the fiscal and the current account balance is larger than the impact of oil price or Dollar-Euro volatility.

The results imply that government policy may have a larger impact on real exchange rate volatility than factors outside the domestic economy. These results once again reinforce the importance of macroeconomic performance of the country in reducing exchange rate volatility. The signalling effect of government macroeconomic policy is crucial for real exchange rate variability. Note that this study does not study the welfare implications of currency volatility. Therefore, one cannot claim that prudent macroeconomic policy, though it may reduce currency volatility, will positively affect welfare.[229]

Although the magnitude of the sensitivity of real exchange rate volatility to world volatility and oil price volatility is relatively low, the frequency of the change in these variables result in the daily movements in the exchange rate being affected primarily by these two variables. This is because information on the macroeconomic

[229] We emphasize that this study is a positive analysis and not a normative analysis since no welfare function is included.

performance of the country is rather infrequent[230] while information on the Dollar-Euro exchange rate and the oil price is available instantaneously.

5.9 Conclusion

This Chapter concentrates on the cross-country determinants of exchange rate volatility for a panel of transition economies. The results indicate that the behaviour of real exchange rate volatility to macroeconomic fundamentals and external factors, across a set of transition economies, is similar to one another in the long run. The study suggests that prudent macroeconomic policy - a combination of low inflation and a healthy budget balance - lowers exchange rate volatility.[231] Particularly, results in other studies underscore the role of reserves in reducing volatility, even if this is merely as a signal to market participants. The findings of an optimal level of import cover is significant in that provides a mechanism for anchoring the accumulation of reserves at some level.

Terms of trade volatility, proxied by oil price volatility, increases exchange rate volatility for the countries in the sample. This is not surprising as many of the countries are either significant importers or exporters of oil. Furthermore, the scenarios displayed in this analysis provides a more concrete understanding as to the impact of these variables on exchange rate volatility in Rands and cents.

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230 Usually only quarterly data is available on a country's macroeconomic performance.

231 See Hausmann (2008) report to the National Treasury of South Africa highlighting the importance of adhering to prudent macroeconomic policy objectives so as not to adversely affect currency volatility.

The governments of transition economies (if not all economies) should attempt to ensure good governance, efficient institutions and strive to create an enabling environment in order to influence the risk-adjusted return on investment in order to reduce the volatility of capital flows and in turn, reduce currency volatility.

A possible extension of this research, conditional on the availability of the data, is to analyse volatility of the effective real exchange rate for this panel of transition economies. A further extension is the inclusion of the welfare implications of currency volatility. By doing so, the research will be able to provide a normative discussion on the policy implications of policy action.

	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)	Regression (7)	Regression (8)	Regression (9)
Macroeconomic variables	Reserves, Budget surplus -to-GDP, uncertainty, oil volatility	Reserves, Debt-to-GDP, uncertainty	Reserves, GDP growth, uncertainty, oil volatility	Reserves, GDP growth, uncertainty dollar/euro volatility	Budget surplus -to-GDP, openness, uncertainty	Openness, uncertainty, oil volatility	Current account, change in current account, import cover, uncertainty	Inflation rate, change in the inflation rate, oil volatility	Debt-to-GDP, inflation rate, change in inflation rate
Import cover	-0.043** (-2.98)	-0.044** (-3.09)	-0.037** (-4.45)	-0.044** (-3.64)			-0.022** (-2.78)		
Budget surplus to GDP ratio	-0.008* (-1.89)				-0.013** (-2.36)				
Log debt-to GDP ratio		0.279** (2.90)							0.398** (4.04)
GDP growth			-0.574 (-1.50)	-2.378** (-4.33)					
Openness					-0.221* (-1.72)	-0.122** (-2.14)			
Inflation rate								0.178** (3.70)	0.32** (5.25)
Change in the inflation rate								-0.037** (2.77)	-0.032** (-1.99)
Log Uncertainty	0.103** (9.65)	0.100** (9.10)	0.117** (16.20)	0.132** (9.25)	0.105** (8.392)	0.096** (9.29)	0.100** (8.97)		
Terms of trade volatility									
Log Oil volatility	0.062** (2.44)		0.074** (3.94)			0.064** (2.79)		0.060** (2.20)	
Current account balance							-0.040** (-3.62)		
Change in current account balance							-0.068** (-3.95)		
World volatility									
Dollar/euro volatility				2.309** (2.82)					
Φ	-0.858** (-13.27)	-0.842** (-12.46)	-0.915** (-7.24)	-0.827 (-8.85)	-0.908** (-17.90)	-0.985** (-10.56)	-0.913** (-7.55)	-0.86** (12.90)	-0.79** (-12.87)
Joint Hausman test (p-value)	1.80 (0.77)	0.53 (0.91)	7.10 (0.13)	5.39 (0.25)	4.08 (0.25)	4.14 (0.25)	6.15 (0.10)	5.99 (0.11)	5.35 (0.15)

* denotes significance at the 10% level and ** denotes significance at the 5% level. Standard errors in parentheses.

Table 5.2: Estimation results

				Number of Rand cents above/below the average[1]		
Macroeconomic variables	**Current values**	**Scenario**	**Difference**	**First half of 2006**	**Scenario result**	**Difference[2]**
Import cover (months)	3*	2	1 month	29 cents	30 cents	1 cent
Budget surplus to GDP ratio (%)	-0.59*	-1.59	1 percentage point	29 cents	49 cents	20 cents
Debt-to GDP ratio (%)	35.8*	36.8	1 percentage point	29 cents	59 cents	30 cents
Uncertainty	Rise by 50 basis points			29 cents	31 cents	2 cents
Terms of trade						
Oil volatility	Standard deviation rises by US$ 1**			29 cents	30 cents	1 cent
Openness (%)	56	55	1 percentage point	29 cents	30 cents	1 cent
Current account balance	-4.10*	-5.1	1 percentage point	29 cents	59 cents	30 cents
World volatility						
Dollar/Euro volatility	Standard deviation rises by 1 US cent**			29 cents	34 cents	5 cents

1. Measures deviation of Rand-US$ exchange rate from its mean in Rand cents (standardized)

2. Measures increase in standard deviation of Rand US$ exchange rate (in cents)

* represents 2005 average; **average calculated for the first half of 2006

Table 5.3: Scenarios

Chapter 6
Final Discussion and Suggestions for Future Research

This thesis investigates the drivers of economic growth in transition economies with special emphasis on some of the institutional and macroeconomic challenges faced by these economies. The study develops theoretical and empirical models examine the redistribution of resources in a society, the impact of infrastructure development on growth, fluctuations in GDP, employment and labour productivity, and finally, the determinants of exchange rate volatility in transition economies.

The first issue we discuss is the possible tension between groups in society over the reallocation of resources. Chapter 2 begins with the development of a model of conflict in which two groups in society are engaged in strategic interaction. The two groups are the privileged and the disadvantaged. Each member of the privileged group has more of the resource than the disadvantaged group. The main assumption of the model is that redistribution to the disadvantaged from the privileged group can increase the productive capacity of society, but comes at the cost of rising political aspirations of the resource poor, which erodes the power of the resource rich. Results in this Chapter derives conditions under which the rich will redistribute to the point of equality with the poor; conditions under which the disadvantaged face genocide;

as well as the range of intermediate redistributive activity and associated levels of conflict likely to be employed by the privileged.

The model presented in Chapter 2 advances on the literature by showing the importance of the technology of production in societies in determining the possible political outcomes for society. In particular, the model argues that genocide of the disadvantaged group is more likely in agrarian societies as opposed to industrial societies. The model emphasizes the importance of the preference function, and the relative population size and initial resource allocations between the two groups in society in affecting the resource transfer between the two groups and the degree of conflict.

An extension to the model presented in Chapter 2 is to test the model on empirical data to determine if the models parameters are a good predictor of conflict. Moreover, the investigation of the dynamic interaction of these competing groups in society rather than only the steady-state solutions will provide a description of the behaviour of a society from conflict to peace and *vice versa*.

Once conflict is resolved, the infrastructure development is crucial for any economy. This is more so for rapidly growing transition economies experiencing capacity constraints due to limited physical infrastructure. Chapter 3 empirically investigates the impact of public infrastructure expenditure on economic growth in South Africa.

The model presented in Chapter 3 shows that public infrastructure expenditure has a positive effect on GDP directly and indirectly by increasing the marginal product of private investment. However, the empirical results find that both economic and social infrastructure investment adversely affects private investment. The countervailing finding is explained by the crowding out of private investment by public investment.

Moreover, the findings of the Chapter suggest that while expenditure on economic infrastructure has a marginal (indirect), positive effect on per capita output, social infrastructure expenditure has no net output effects in South Africa. Two possible reasons the Chapter proposes is that either social infrastructure expenditure is ineffective or that the crowding out of private investment by increases in social infrastructure investment negates any positive effect of such spending on GDP. Chapter 3 also finds positive effect of rising output and private investment on public infrastructure investment indicating that as the economy grows, individuals demand more and better roads, schools and hospitals.

Analyzing the efficiency of infrastructure by the quality of the services provided by the physical infrastructure stock is crucial in identifying the impact of infrastructure expenditure on growth. Thus one should explore how the quality and not only the quantity of infrastructure affects growth. It may indeed be the case that, in South Africa, the quality as well as quantity of infrastructure expenditure mat-

ters. However, the lack of data on the quality of infrastructure makes this analysis an arduous proposition.

Chapter 4 reveals that the short-run dynamics of labour productivity and employment in transition economies may not follow the standard real business cycle literature. In particular, the South African data displays a negative correlation between employment and labour productivity. An explanation of this behaviour is found in new-Keynesian business cycle models with monopolistic competition, sticky prices and variable labour effort. The model and empirical results confirm the importance of monetary accommodation, the degree of price stickiness in the product market, the magnitude of the markup and returns to labour in determining the behaviour of employment and labour productivity in response to technology shocks. The implication of this finding is that since transition economies may have a higher degree of monopolistic competition which entails sticky prices and high markups, the behaviour of employment and labour productivity to shocks may differ from developed countries.

Given the interaction between returns to labour and markups highlighted by Hall (1989), an extension to Chapter 4 is to estimate the exact returns to labour. Moreover, the difference in response of labour productivity and employment to a technology shock for the different sub-samples may indicate that the structure of the South African business cycle and/or, the policy responses to technology shocks may be changing. This indicates the possibility of regime shifts in the sample. Therefore, another extension to Chapter 4 is to allow for regime-switching. This may capture

changes to the monetary regime adhered to by the central bank and thus allow us to obtain a value for the degree of monetary accommodation in each regime.

In addition, Chapter 4 does not discuss possible imperfections in the South African labour market. Fedderke and Mariotti (2002) argue that the inflexibility of the labour market and the low skill level of the labour force are far more probable as a cause of sluggish employment growth resulting in the inability of real wages to appropriately adjust to labour productivity. Asymmetric information in the labour market may also affect the dynamics of employment and labour productivity. This too should be explored.

Chapter 5 considers the cross-country determinants of exchange rate volatility for a set of transition economies. Overall, the Chapter finds volatility is increased by increased uncertainty, terms of trade volatility, and loose fiscal policy while an improved current account balance and increased openness of the economy reduces currency volatility. Reserves are found to reduce real exchange rate volatility at a decreasing rate with the optimal level of reserves being $4\ \frac{1}{2}$ months.

From a policy perspective, whilst it is clear that prudent macroeconomic policy is the best course of action to reduce exchange rate volatility, the influence of external volatility on the exchange rate (over which the authorities have no control) should not be underestimated. Since the real exchange rate represents the relative price of tradables to non-tradables goods, a volatile real exchange rate may buffer the economy from external shocks therefore reflect the optimal response of agents to these shocks.

This may be the possible reason for the literature on the relationship between trade and exchange rate volatility providing mixed results.

Furthermore, exchange rate volatility is affected by unobservable variables such as market sentiment and expectations. These variables are, however, relatively more difficult to measure. This implies that models of exchange rate volatility that do not account for these variables, may miss the true picture. Thus, obtaining measurable proxy variables of market sentiment and expectations will provide a better gauge of currency volatility. This however is an arduous task.

The economic issues affecting transition economies investigated in this thesis indicate the complex nature of the macroeconomic challenges facing these economies. This thesis has examined some of the macroeconomic issues affecting transition economies. More research on some of these issues will provide a more complete account of the economic challenges faced by these economies.

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Appendix A
An Index of Economic Infrastructure

In the literature, two basic approaches have been suggested for measuring infrastructure stock. The first is to measure expenditure on infrastructure. Second, is to use physical measures by taking inventory of the quantity of the pertinent structures and facilities. Observing times series data on actual physical infrastructure available in SA will provide one with a non-monetary indication of the infrastructure capital stock in the country.

The indicator of productive infrastructures employed has been calculated aggregating through the Principal Components Analysis. The indicator is constructed as follows:[232]

$$\begin{aligned} I &= \sum_{i=1}^{n} \frac{1}{n} b_{ij} \sum_{j=1}^{n} x_j \\ &= \frac{1}{n} \left[\begin{array}{c} (b_{11} + b_{21} + ... + b_{n1})\, x_1 + ... \\ (b_{12} + b_{22} + ... + b_{n2})\, x_2 + ... + (b_{1n} + b_{2n} + ... + b_{nn})\, x_n \end{array} \right] \end{aligned} \quad \text{(A.1)}$$

where x_j represents the different measures of physical infrastructure,[233] b_{ij} are calculated by applying the varimax rotation on the principal eigenvectors obtained from the data set of the measures of physical infrastructure. A varimax rotation is a change of coordinates used in the principal component analysis that maximizes the sum of the variance.

[232] See Anderson (1984) for a full description of the methodology followed.

[233] x_j is observation value after elimination of scale bias, i.e., $x_j = (X_j - \bar{X})/\sigma$, where X_j is the original observation, $\bar{X}$ is the mean of the series and σ its standard deviation.