Macquarie University

Doctoral Thesis

External Shocks and Macroeconomic Variability in a Small Developing Economy.

Author:

Kagiso Mangadi

Supervisors:

Prof. Jeffrey Sheen

Dr. Natalia Ponomareva

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

in the

Faculty of Business and Economics

Department of Economics

July 2017

Declaration of Authorship

I, Kagiso MANGADI, declare that this thesis titled, 'External Shocks and Macroeconomic Variability in a Small Developing Economy' and the work presented in it are my own. I confirm that:

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- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
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Date: ________________________

"Approach life like a voyage on a schooner- enjoy the view, explore the vessel, make friends with the captain, fish a little and then get off when you get home."

Max Lucado

Abstract

External Shocks and Macroeconomic Variability in a Small Developing Country

by Kagiso Mangadi

The main aim of this thesis is to examine external shocks faced by small developing countries and the impact of these shocks on the economy, using Botswana as a case study. We present three papers which explore the external shocks within a variety of macroeconometric frameworks, and make policy recommendations based on our findings. In the first instance, we utilize a sign restricted vector autoregressive (VAR) approach to identify four generalized terms of trade shocks relevant for small commodity exporting countries. The findings of this paper show that the impact of shocks to Botswana's terms of trade is mainly determined by the global context in which the shocks occur. The response of macroeconomic policy therefore differs depending on the underlying determinants of each shock. Secondly, we employ a principal component analysis (PCA) to consider the common factors driving variations in a panel of Botswana's bilateral exchange rates. Here we find that the unobservable component most responsible for variations in these bilaterals is not a Botswana factor, but rather a risk-related factor that responds to conditions in the US and South African economies. Further, models incorporating this latent component improve predictive accuracy at high frequencies for some of the exchange rates. In the last paper, we examine the incidence of the resource curse and utilize a structural VAR framework to explore the response of key sectors in the Botswana economy to positive natural resource shocks. We find that while Botswana has successfully avoided the political dimensions of the resource curse, it cannot be said with certainty that the country escaped the economic dimensions of the phenomenon. Our results show that the economy exhibits some mild Dutch disease effects, however, these are minimized and brief due to successful policy efforts to maintain a competitive exchange rate.

Acknowledgements

This journey has been without a doubt grueling, emotional and challenging, even then, it has also been exciting and fun and the very best thing I've ever done. I am thankful for the many lessons I've learnt, and the growth, both personally and academically, that I have experienced. I walk away with so much more to share with the world and for that, I am so very grateful.

There are a lot of people who have walked this journey with me and I'm blessed to have had so much support and guidance.

It goes without saying that my most heartfelt gratitude goes to my principal supervisor, Professor Jeffrey Sheen for his excellent supervision and support throughout the course of my candidature. Thank you for your guidance and for providing invaluable input that has helped to shape this thesis greatly. Thanks too for your patience and encouragement, and for challenging me to produce research that I can be so very proud of.

I am also thankful to my associate supervisor, Dr. Natalia Ponomareva for her exceptional guidance and support. Thank you for your advice and the time you took to review the many drafts of this work. I would also like to extend my sincere gratitude to my friend and mentor, Dr. Ben Wang for his advice and encouragement. Thank you for your patience and the time you sacrificed to guide and assist me during the course of this journey.

I wish to thank the members of staff of the Department of Economics and the Faculty of Business and Economics at Macquarie University, and the members of staff at the University of Botswana, for their support and assistance. Thank you for making my candidature such a wonderful experience.

I have also benefited from comments by the participants of the 49th Money, Macro and Finance conference in Cardiff, Wales, as well as the 29th Annual PhD Conference on Business and Economics in Perth, Australia.

I am also very grateful to the many friends who were very much a part of this journey with me. A special thank you to the dear ones who shared in the tears and the victories, and made Sydney such a home for me. I am so very thankful for the memorable years and for all the time we spent together, I wish you all well in your future endeavors.

Lastly, my deepest appreciation and love to my family. Your prayers, love, support and encouragement made this journey possible. Thank you for understanding that I couldn't always be there for you while I pursued this dream. Above all, glory to God.

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Abbreviations

AIC	**A**kaike **I**nformation **C**riterion
ADF	**A**ugmented **D**ickey-**F**uller
BIC	**B**ayesian **I**formation **C**riterion
BEER	**B**ehavioral **E**quilibrium **E**xchange **R**ate
BoB	**B**ank **o**f **B**otswana
BoBCs	**B**ank **o**f **B**otswana **C**ertificates
CGE	**C**omputable **G**eneral **E**quilibrium
CPI	**C**onsumer **P**rice **I**ndex
DTC	**D**e Beers Diamond **T**rading **C**ompany
DCEC	**D**irectorate of **C**orruption and **E**conomic **C**rime
DSGE	**D**ynamic **S**tochastic **G**eneral **E**quilibrium
FRED	**F**ederal **R**eserve **E**conomic **E**quilibrium
FDI	**F**oreign **D**irect **I**nvestment
GFC	**G**lobal **F**inancial **C**risis
GDP	**G**ross **D**omestic **P**roduct
IMF	**I**nternational **M**onetary **F**und
KPSS	**K**wiatkowski **P**hillips **S**Shmidt **S**hin
MFDP	**M**inistry of **F**inance and **D**evelopment **P**lanning
MSPE	**M**ean **S**quare **P**rediction **E**rror
NDPs	**N**ational **D**evelopment **P**lans
NEER	**N**ominal **E**ffective **E**xchange **R**ate
OLS	**O**rdinary **L**east **S**quares
PCA	**P**rincipal **C**omponent **A**nalysis
RMA	**R**and **M**onetary **A**rea

SIC	**S**chwarz **I**nformation **C**riterion
SARB	**S**outh **A**frican **R**eserve **B**ank
SWF	**S**overeign **W**ealth **F**und
SDR	**S**pecial **D**rawing **R**ights
SSA	**S**ub-**S**aharan **A**frica
SVAR	**S**tructural **V**ector **A**utoregression
REER	**R**eer **E**ffective **E**xchange **R**ate
VAT	**V**alue **A**dded **T**ax

This one's to the memory of my beloved mum, Evelyn Mangadi. I miss you everyday.

Chapter 1

Introduction

This thesis utilizes novel approaches to investigate some of the challenges pertinent to small developing countries, using Botswana as a case study. To this end, we employ a variety of macroeconometric techniques, to examine the external shocks faced by commodity exporting developing countries such as Botswana, their macroeconomic effects and make appropriate policy recommendations based on our findings. In this way, we contribute to the scant literature on Botswana by employing innovative methodologies not previously used in the country's context, and focus on providing country-specific analyses that take into account some of the unique features of the Botswana economy.

Developing economies, particularly those in sub-Saharan Africa, have been found to be generally more susceptible to external shocks than their more developed counterparts. This is mainly due to institutional and political factors as well as the structure of the economies. Commodity exports tend to dominate domestic output and fiscal revenues in these countries, and they usually have little influence over the prices of the commodities they export, which also tend to be volatile. Consequently, government balances follow the booms and busts of commodity price cycles, and this has important implications for sovereign and external debt positions, and thus domestic stability (Frankel, 2010). In addition to this, weak institutions and poor governance in these countries often undermine sound macroeconomic policy formulation and implementation, which exacerbates the effects of external volatility and adversely affects economic growth and performance (Robinson et al., 2003).

External shocks to developing countries therefore tend to have persistent real effects and thus increase macroeconomic variability. Such shocks contribute to business cycle uncertainty and can significantly impact domestic economic performance through factors such as the perceived level of risk, inward foreign direct investment (FDI) and the stability of macroeconomic fundamentals, as discussed in Broda (2004) and Loayza and Raddatz (2007). It is therefore crucial to understand these shocks in order to determine the best policy action for dealing with them.

The forward-looking nature of macroeconomic policy requires that policy makers have adequate information about the behavior of key economic indicators. The exchange rate is one such indicator. This variable is one of the most important prices for small commodity exporters as economic growth tends to hinge on the external sector in these economies. The ability to adequately forecast exchange rates has important implications for economic policy and performance. This is because economic forecasts make it possible to assess the potential consequences of policy action, as well as highlight the transmission channels of these actions (Wieland et al., 2013). Recent work on exchange rates emphasizes the role of latent factors in explaining exchange rate variability; for example, Berg and Mark (2015) and Engel et al. (2015) find that third-country effects, and US and Euro factors are important unobservable components driving bilateral exchange rates for a panel of countries. Failure to consider these unobservable components can significantly impact the management of the exchange rate, which is a crucial determining factor for export performance, the trade balance, fiscal spending and overall economic activity.

This thesis therefore aims to identify some of the external shocks mentioned above, and determine their effects on a small developing economy, using Botswana as a case study. Understanding the impact of terms of trade shocks, as well as the main determinants of exchange rate variations and the effects of natural resource shocks to a country such as Botswana, may provide important insights which can contribute to our understanding of macroeconomic volatility in small developing commodity exporters. Botswana is a useful reference economy because of its history of strong institutions and good governance, political stability, well-managed natural resource revenues and sound macroeconomic policies, while being susceptible to external shocks. This makes the country an excellent benchmark for analysis.

There are three main empirical papers, forming Chapters 2 through 4 of this thesis. Each of these chapters answers a question regarding these external shocks. These three questions form the titles for each paper and are:

1. Botswana's terms of trade shocks: what are they?
2. What is driving Botswana's bilateral exchange rates?
3. Did Botswana really escape the resource curse?

In Chapter 2, which comprises the first paper,[1] we estimate a sign restricted structural vector autoregression (SVAR) model with a penalty function, as in Uhlig (2005), in order to identify four generalized terms of trade shocks. In this paper, we identify four shocks to the terms of trade under a variety of global economic conditions. The first three shocks are a global demand shock, a globalizing shock and a sector-specific shock. We also identify a global supply shock, which is a contemporary shock capturing the effects of world excess supply of oil typically influenced by the global business cycle. This shock is included to recreate the conditions that prevailed in the aftermath of the global financial crisis which saw a decline in oil prices accompanied by a slow down in world economic activity.

These four shocks are crucial for small commodity-dependent exporters as they are generally more vulnerable to the persistent and volatile effects of the terms of trade. Furthermore, since external shocks occur within a variety of international contexts, disentangling the shocks in this manner allows us to recreate these differing global conditions as well as to adequately capture the endogeneity of the terms of trade

[1] The work discussed in chapter 2 forms part of Mangadi and Sheen (2017). Versions of this paper were presented at the 49th Money, Macro and Finance Conference in September 2015 in Cardiff, Wales, and at the 29th PhD Conference on Business and Economics in November 2016 in Perth, Australia.

in world markets, as suggested in Kilian (2009). Our main contribution in this paper is that we apply novel techniques to identifying Botswana's terms of trade shocks, which has not been done before. We also introduce a new contemporary shock to the terms of trade and examine the resultant response of the Botswana economy.

Our results for this paper are in support of the empirical argument that the consequences of external shocks on domestic economies are largely dictated by the underlying determinants and sources of the said shocks. This is in line with past empirical work such as Jääskelä and Smith (2013), Melolinna (2012), Peersman and Van Robays (2009) and Kilian (2009) among others. For instance we find that while the global demand shock and the globalization shock both stimulate domestic output growth, the former is inflationary while the latter is not. It is for this reason that we argue that the policy responses for dealing with each shock are likely to differ as they take into account the different effects of these shocks on the economy.

In Chapter 3 we depart from past empirical research on Botswana's exchange rates by utilizing a principal component analysis (PCA) in order to determine the common factors driving ten of the country's bilateral exchange rates. This approach, as explained in Jolliffe (2002), makes it possible to extract unobservable factors from a data series with a minimal loss of information. A principal component analysis thus enables us to determine the potential role of latent factors in explaining the evolution of Botswana's bilateral exchange rates. We further employ a renowned statistical shrinkage technique, the Least Absolute Shrinkage and Selection Operator, or the *Lasso*, introduced by Tibshirani (1996) to determine the economic meaning of the largest identified unobservable component. Lastly, we employ rolling regressions to examine the usefulness of this first principal component in forecasting the bilateral exchange rate returns at various frequencies. The main contribution of this paper is that it departs from past empirical studies on Botswana by once again utilizing robust methodologies to determine the unobservable factor most responsible for variations in Botswana's bilateral exchange rates. This has previously not been done in the literature for Botswana. In addition to this, by using Botswana as a case study and a benchmark economy, the results of our findings can contribute to our overall understanding of exchange rate volatility in other small resource exporting developing countries.

We show that the largest principal component explains up to 66 percent of variations in ten of the country's bilateral exchange rate returns. This factor is found to be mostly related to conditions in the US and South African economies. Furthermore, the model incorporating our first principal component outperforms the benchmark model, that is the driftless random walk, in forecasting a majority of daily bilateral exchange rates. The main policy implication of our results highlights the importance of incorporating bilateral panels of Botswana's most important trading partner currencies in the management of the domestic currency.

The last empirical paper in Chapter 4 revisits a very important topic in development economics, namely the resource curse and the Dutch disease phenomena. In this work we investigate the incidence of the resource curse in the Botswana economy, with particular emphasis on the whether the country *really* escaped the Dutch disease as purported in literature. Our approach departs from past empirical work in Botswana in that we estimate a structural vector autoregressive (SVAR) model in order to explore the dynamic interactions of sectoral output across the economy following a resource boom. Our model incorporates key variables in the Dutch disease literature, we also include a proxy for a sovereign wealth fund to determine the success of sterilization efforts of the resource windfall by the central bank. This important variable also captures the extent to which external competitiveness is maintained following the influx of foreign exchange into the domestic economy. Here, the resource boom is modeled as a positive shock to global output, diamond prices and also to exports. As far as the literature that has been reviewed on the resource curse and Dutch disease goes, no other study has attempted to model the Dutch disease in Botswana within an SVAR framework, and this present study is the first to include a proxy for a natural resource fund.

Our findings show that Botswana escaped the resource curse in terms of the *political and social* dimensions of the phenomenon. However, Botswana did not really escape all of the *economic* aspects of the curse. We find evidence of mild Dutch disease effects as evidenced by the brief exchange rate appreciation and the eventual non-booming traded sector GDP contraction. This effect however is temporary, mainly due to the accumulation of foreign exchange reserves by the central bank. This policy action appears to successfully sterilize mineral revenues while promoting a competitive exchange rate. We note however that at times, non-mining tradable sector output remains below baseline levels even when the exchange rate is competitive, which points to the fact that there are other factors inhibiting growth that are not necessarily due to the resource boom. Our results also highlight the importance of harmonizing economic policy to ensure the positive effects of a policy stance are not being offset by other policy decisions elsewhere in the economy. For instance, we find that following a natural resource shock, the positive effects of accumulating foreign exchange reserves are eroded by a monetary tightening which follows due strong output growth.

The remainder of this thesis is structured as follows: Chapters 2 to 4 comprise the three empirical papers dedicated to answering each of the questions outlined above. Chapter 5 summarizes the main discussions in the thesis, highlights the policy implications for the most important results and discusses the recommendations for further research. There are also two appendices included in the thesis.

Chapter 2

Botswana's Terms of Trade Shocks: What are They?

The terms of trade play a prominent role in the macroeconomic performance of many economies, and is one of the most important relative prices for small open economies (Cashin et al., 2004), especially developing economies. Many shocks to the terms of trade occur, but they are not all the same since they arise in a variety of global contexts. Our contributions in this paper are to identify the impacts of these various shocks on a developing country, using a sign restrictions approach with a penalty function for impulse responses, and to consider the appropriate policy responses.

Terms of trade shocks tend to have persistent and volatile effects on macroeconomic variables such as output growth, exchange rates, inflation, real income and savings,(see Andrews et al., 2009; Broda, 2004; Cashin et al., 2004; Kose and Riezman, 2001; Mendoza, 1995). Such variability not only causes business cycle uncertainties, but can also have important implications for economic performance and growth (Loayza and Raddatz, 2007). The identification of the context of these terms of trade shocks, and hence their effects on macroeconomic variability, is necessary to inform the appropriate policy response. Since these shocks can have different macroeconomic implications, the necessary policy responses are also bound to differ.

The global context in which an international relative price shock occurs must be distinguished. It is argued in the literature that the response of macroeconomic variables to external shocks will largely depend on the characteristics and circumstances of the underlying shock. For example, Melolinna (2012), Peersman and Van Robays (2009) and Kilian (2009) showed that the consequences of oil shocks on the US and Euro economies were dependent on the features of the shocks. Kilian (2009) argued that there is a fundamental flaw in an approach that analyzes the response of macroeconomic variables to variations in the price of oil alone, while holding all other external variables constant. The same argument can be extended to the analysis of terms of trade shocks. It would be incorrect to analyze the consequences of terms of trade shocks on an economy by allowing only the terms of trade to change while holding all other variables constant. This is because, though the terms of trade may be exogenous to a small domestic economy, it is endogenous in the world economy. Failure to recognize this endogeneity between world variables and the terms of trade can lead to confusion, false conclusions and inappropriate policy responses. Export and import prices are typically influenced by different external shocks, each of which may affect the domestic economy differently depending on what happens to world demand (Karagedikli and Price, 2012). Therefore, to be able to understand the effect of terms of trade shocks on the domestic economy, it is crucial to determine the external drivers of the actual export and import price shocks.

The effects of terms of trade shocks tend to be more pronounced in developing countries than in the developed world. This is because most developing countries depend heavily on commodity exports. The structure of their economies is such that exports tend to be concentrated in one or just a few primary commodities and account for a sizeable proportion of GDP and government revenues (Hove et al., 2015; Kose and Riezman, 2001) while imports typically comprise mainly intermediate inputs, food items, oil and manufactures. In addition, developing countries have little influence over the prices of their exports, which are also usually characterized by high volatility. In this way, developing countries are highly vulnerable to terms of trade shocks. Because of this vulnerability, the appropriate policy response to the identified shock will likely depend critically on the global context. While there is an extensive literature on the effects of terms of trade shocks on developing economies (for example see Cashin et al., 2004; Cashin and Pattillo, 2006; Hove et al., 2015; Kose and Riezman, 2001), none of this literature, to our knowledge, has disentangled the global context of terms of trade shocks. Thus this paper considers a significant problem faced by most developing countries, which has not yet been properly addressed.

We estimate a sign-restricted structural vector autoregression (SVAR) model with a penalty function to identify the underlying determinants of a set of likely terms of trade shocks that have impacted Botswana in the last fifty years. Botswana is chosen because it is a quintessential small commodity-dependent developing country that has a history of sound macroeconomic policies and well-managed resource revenues while being vulnerable to terms of trade shocks. This makes it a good benchmark case for many other developing countries in understanding the implications of external shocks, because we can investigate the effects of external shocks without being concerned about the distortions created by the pitfalls associated with a large natural resource endowment leading to huge infusions of foreign exchange into the domestic economy. We use annual data for the period 1960 to 2012, and investigate the effects of the likely set of external shocks on the country's key macroeconomic variables.

Four generalized external shocks are identified in the model from the data using sign restrictions on impulse responses. The first is a positive global demand shock that is assumed to raise both export and import prices as well as global output. The second is a positive globalizing shock representing the experience of emerging economies into the global economy–especially China–that is assumed to raise export prices, reduce import prices, and improve global GDP. The third is a positive sector-specific shock, representing a booming commodity sector that could give rise to the Dutch disease. In this case, the export price alone is assumed to surge, and is not associated with a boom in the global economy. Finally, the fourth shock allows for a positive global supply shock, such as in energy markets, which is assumed to reduce import prices and is accompanied by a decline in global output.

The first three shocks identified in this study are in line with the work of Jääskelä and Smith (2013) and Karagedikli and Price (2012), who identify similar shocks for Australia and New Zealand respectively. Our study introduces a fourth global supply-side shock to the model, which was not included in the aforementioned studies. This shock likely represents what essentially happened in the immediate aftermath of the financial crisis of 2008, and is thus a significantly relevant addition to this earlier work. In addition, our work focuses on a developing economy with unique features such as Botswana, while they focused on developed economies. Since the structure of the Botswana economy is significantly different from that of the Australian and New Zealand economies, the results of the present analysis are better suited for informing appropriate policy in commodity exporting developing countries. Another point of difference is that our analysis is extended to include a penalty function in the identification process—a vital difference since it has been shown that the alternative use of the median response from multiple models is likely to be flawed (for example, see Uhlig, 2005).

We find that our results support the argument that the direction and magnitude of the response of macroeconomic variables to external shocks largely depend on the characteristics of the underlying shock. The identified world demand shock is found to be expansionary and inflationary, while the globalization shock is expansionary but drives inflation down as a result of falling import prices. A positive commodity market specific shock has opposite effects to the globalization shock. Unlike the globalization shock, the positive specific commodity market shock marginally dampens real GDP growth, and is instead inflationary due to rising import prices. The real effective exchange rate strengthens temporarily, causing other sectors to decline and counteracting the output effect of the booming sector. This is weakly consistent with a Dutch disease effect. Lastly, an identified global supply shock is found to suppress both output growth and inflation. All four shocks are actually 'positive' terms of trade shocks that lead to a decline in the market (lending) interest rate, which may be indicative of a declining credit risk premium. The appropriate monetary policy responses qualitatively differ for the first shock, and will quantitatively differ for all four shocks.

The remainder of this paper is structured as follows. Section 2.1 gives a brief overview of the Botswana economy, section 2.2 is a review of both the empirical and theoretical literature on the topic, with particular emphasis placed on existing literature pertaining to Africa and the developing world, as well as on the identification of external shocks. Section 2.3 provides a discussion of the methodology, including an outline of the SVAR model with sign restrictions adopted for the study, while sections 2.4 and 2.5 discuss the results and provide concluding remarks.

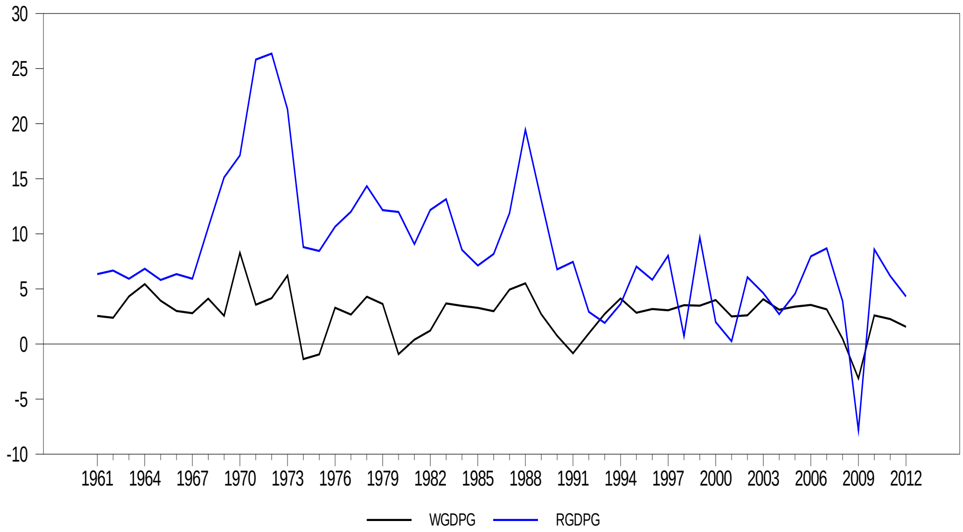
2.1 Brief Overview of the Botswana Economy

Botswana gained independence in September 1966. At the time, the country was poor and had very little prospects for development. The discovery and subsequent exploitation of minerals led to the transformation of Botswana from being one of the poorest economies in the world into a middle income economy in just under 30 years. During this period, growth rates of per capita income average 9 percent (Pegg, 2010). The structure of the economy also changed over time. At independence, the agricultural sector accounted for nearly 39 percent of GDP, however, it accounted for only 3 percent in 2012. On the other hand, the mining sector which contributed only 2 percent at independence accounted for over 40 percent of GDP by the mid-2000s. Much of Botswana's economic success has been attributed to the exploitation of mineral wealth within the context of sound macroeconomic policies, good governance, and political and social stability (Bank of Botswana, 2006).

Figure 2.1 shows the evolution of domestic output growth (blue line) and foreign output growth (black line) from 1960 to 2012.[1]

[1] Foreign output here is measured as the trade weighted average growth rate of Botswana's major trading partner countries' output.

FIGURE 2.1: Domestic and Foreign Output Growth (1960-2012)



Growth rates in domestic output remained consistently high and above those of foreign output for the three decades between the early 1960s and the early 1990s. Domestic growth during this period was largely driven by the commencement of mining operations following the discovery and exploitation of mining deposits in the 1950s. The highest growth rate was recorded in 1973 while the lowest was in 2009 when growth rates plummeted as a result of the global recession, which caused a slump in the world demand for diamonds.

Commodity exports play a significant role in the Botswana economy. The country has a sizeable endowment of diamonds and is the world's largest producer of diamonds by output value. As such, exports are largely dominated by the mineral sector, particularly diamond mining. Minerals also account for large portions of domestic output, export revenue and government revenue.

Figure 2.2: Composition of Botswana's Exports (2012)

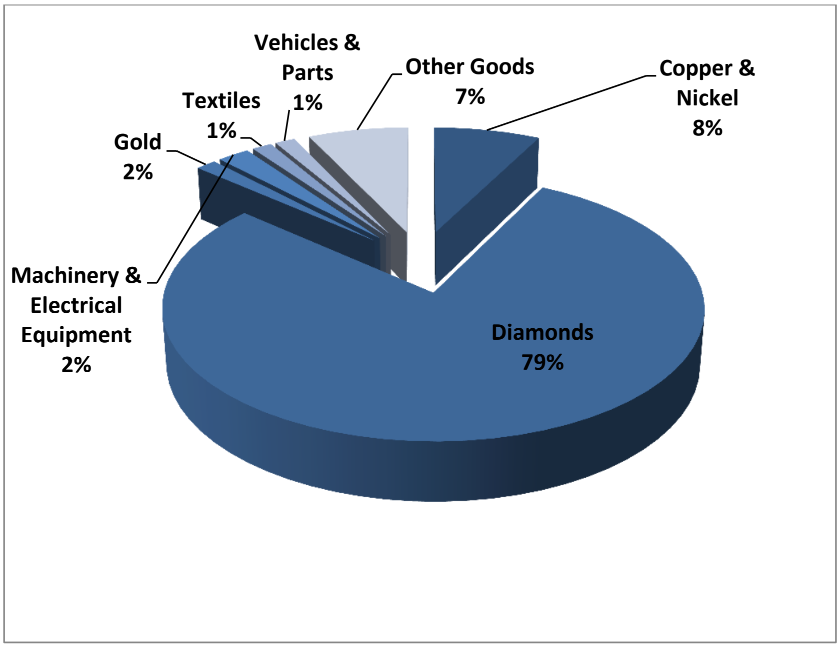


Figure 2.2 shows the composition of Botswana's exports in the year 2012. At the time, minerals accounted for 87 percent of total exports, with diamonds alone contributing 79 percent. The mineral sector, that is all mining including diamonds, copper-nickel, soda-ash and gold also contributed 29 percent to government revenue and 20 percent to domestic output in 2012 (Bank of Botswana, 2013). While these figures are still substantive, they are a lot lower than those recorded before the global financial crisis. This is because the mining sector was hardest hit as a result of the crisis, which caused a slump in the global demand for diamonds. Consequently, diamond production in Botswana declined by about 50 percent in 2009, which significantly affected export earnings, government earnings and GDP.

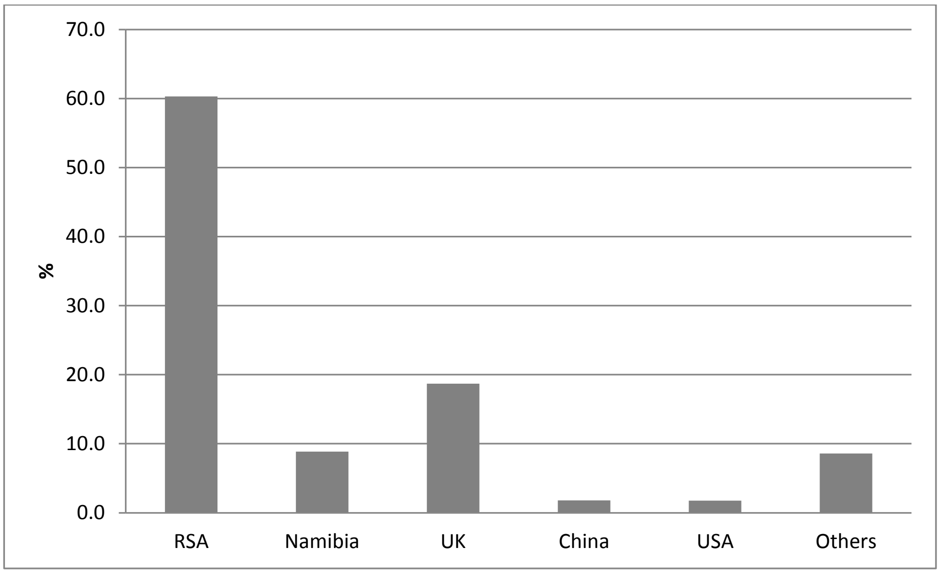
It is clear that the export sector in Botswana is highly undiversified with one dominant sector, namely mining. This is evidenced by the negligible contributions of sectors such as agriculture and manufacturing to domestic output, when compared to the mining sector. For instance, in the year 2012, manufacturing and agricultural sectors accounted for 5.9 and 2.7 percent of GDP respectively (Bank of Botswana, 2012).

A number of reasons have been cited for Botswana's inability to diversify so far.

These include the country's geographic location in terms of being landlocked which raises transport costs considerably, the close proximity to industrializing South Africa as well as the small size of the domestic market.[2] This provides stiff competition in attracting foreign direct investment (FDI) since South Africa has superior infrastructure and a much larger domestic market. In addition, agricultural production is severely hampered by poor soils, semi-arid climatic conditions and frequent and prolonged droughts. As a result, Botswana depends heavily on imports, particularly of foodstuffs, fuel and other petroleum products as well as manufactures which further increases the economy's vulnerability to external shocks.

In recent years, Botswana's trade balance as well as its direction of trade have been altered significantly as a result of the relocation of De Beers Diamond Trading Company (DTC) from London to Gaborone, the capital city of Botswana, in July 2012. This move meant that local production of rough diamonds was to be combined with output from other mines owned by De Beers for more downstream processing of the minerals before re-exporting to other countries. Figures 2.3 and 2.4 below shows the origin of imports as well as the destination of Botswana's exports in the year 2012.

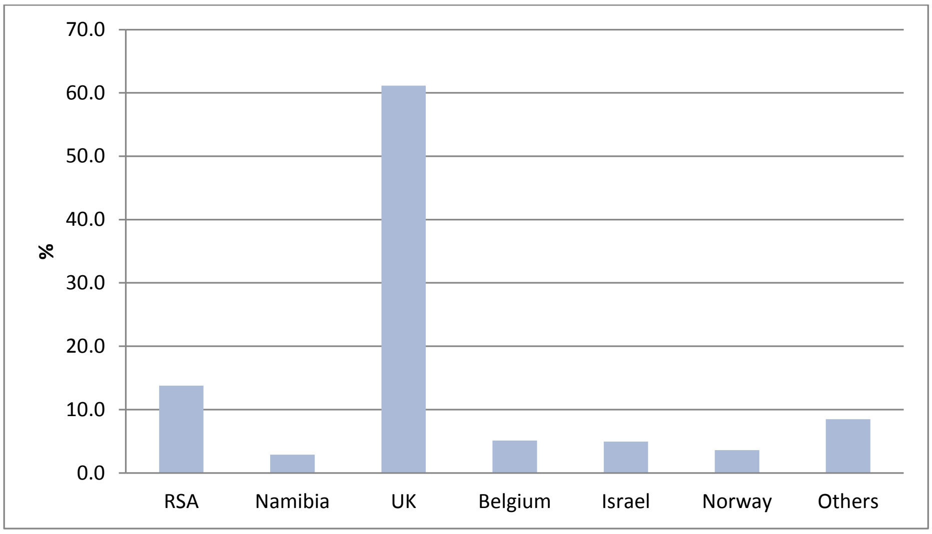
FIGURE 2.3: Origin of Botswana's Imports (2012)



[2]The population of Botswana is only 2,024,904.

South Africa remains an important source of imports and accounted for 60 percent of total imports in 2012. Imports from South Africa mainly comprise fuel and food. The United Kingdom, Namibia and Belgium have become important sources of diamonds imports, each contributing 19 percent and 9 percent and 1.3 percent to total imports in 2012 respectively.

Figure 2.4: Destination of Botswana's Exports (2012)



The majority of Botswana's diamonds are destined for the UK, Belgium and Israel, each of which in 2012 accounted for 61 percent and 5 percent respectively. Exports destined for South Africa contributed 14 percent to total exports and these were mainly diamonds and copper nickel, while Namibia was the recipient of vehicle exports, accounting for 3 percent of total exports. Other important destinations of Botswana's exports, particularly diamond re-exports included China, Hong Kong, the United Arab Emirates, India and the United States (Bank of Botswana, 2013).

2.1.1 Macroeconomic Policy in Botswana

Macroeconomic policy in Botswana seeks to attain the goals of monetary stability, maintaining the efficiency of the payment mechanism and ensuring public confidence in the national currency, among others. These goals contribute to the achievement of the broader national goals of economic diversification, growth, employment creation and poverty reduction.

To these ends, the exchange rate policy in Botswana seeks to maintain a stable Real Effective Exchange Rate (REER) of the domestic currency, the pula, against a basket of currencies of its major trading partners. A stable REER is important for maintaining the international competitiveness of domestic producers of tradable goods and services. REER stability in Botswana is achieved through a gradual and continuous adjustment of the Nominal Effective Exchange Rate (NEER) within a crawling band exchange rate framework (Bank of Botswana, 2012). This regime negates the need for large discrete adjustments to the exchange rate. The pula basket of currencies is made up of the South African rand (ZAR) and the Special Drawing Rights (SDR) of the International Monetary Fund (IMF).[3] Prior to January 2015, when the weights were changed, the weight of the South African rand was 55 percent, while that of the SDR was 45 percent. Since the change however, the weights have been equalized at 50 percent each. Furthermore, the rate of crawl of the Botswana basket, which was a downward crawl of 0.16 percent per annum, has been changed to zero. This may be as a reflection of recent trends in Botswana's inflation rates, and the fact that the inflation differential between Botswana and its major trading partners has narrowed considerably (Bank of Botswana, 2015).

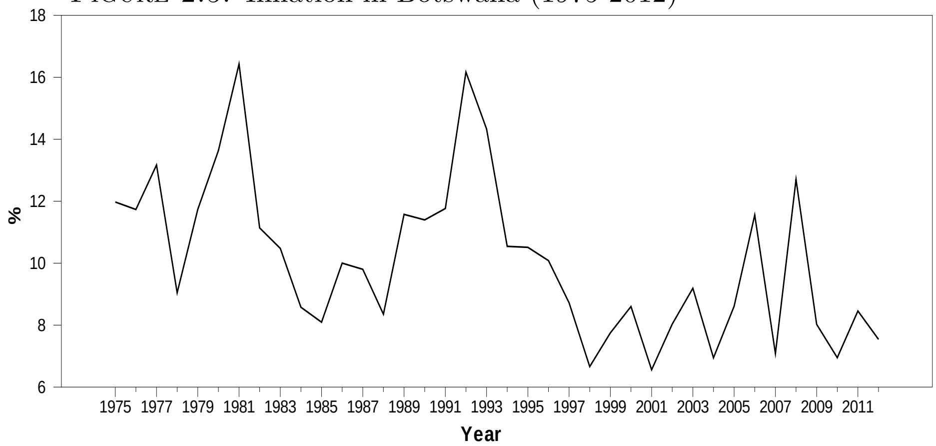
The central bank, Bank of Botswana (BoB), monitors the average forecast inflation of major trading partner countries, and makes adjustments to the NEER based on the difference between the BoB's inflation objective and the forecast inflation for South Africa and the SDR countries.

The BoB is also tasked with the design and conduct of monetary policy, with the aim of achieving a low, predictable and sustainable inflation rate. For the

[3] The currencies which make up the SDR are the US dollar, the euro, the Japanese yen and the British pound.

price stability objective to be realized, monetary authorities have set an inflation objective range of 3-6 percent, which is to be achieved in the medium term, a three-year rolling period. This period is considered to be long enough for policy actions to have an effect on the economy. The BoB monitors potential indicators of inflation and any deviations of the inflation forecasts from the set inflation objective act as a signal for policy response. The instruments of monetary policy in Botswana include open market operations through the sale and purchase of Bank of Botswana Certificates (BoBCs), the bank rate, and to a certain extent the primary reserve requirement (Bank of Botswana, 2012). The primary reserve requirement was reduced from 10 percent to 5 percent in April 2015.

FIGURE 2.5: Inflation in Botswana (1975-2012)



The figure above shows inflation rates in Botswana for the period 1975 to 2012. It is evident that while inflation rates in Botswana show a lot of variation, they have not reached exceedingly high levels that are common in most Sub-Saharan countries. Some notable periods of high inflation, such as 1992 when inflation rates were as high as 16 percent can be attributed to the successive devaluations of the Botswana pula in the mid-1980s and early 1990s. The pula was devalued by 15 percent in 1985, and by 5 percent in 1990 and again in 1991. The variation in inflation rates in the early 2000s was due to a number of factors, including the introduction of the Value Added Tax (VAT) in 2002, followed by a 12 percent devaluation of the currency in 2004 and again in 2005 by 7.5 percent, as well as escalating prices of food and fuel in commodity markets in 2007 and 2008.

One of the key tasks of the BoB is the management of foreign exchange reserves. These are mainly accumulated from historically sustained balance of payments surpluses as well as from returns on foreign currency investments. The foreign exchange reserves are not only important for meeting the demand for foreign currency and settling the import bill, they are also used for financing development, saving for future generations and more importantly for stabilizing the economy through the management of the crawling peg exchange rate (Bank of Botswana, 2012). Botswana's foreign exchange reserves are made up of a liquidity portfolio and a long-term investment component, the Pula Fund. The Liquidity Portfolio houses foreign currency that is required for regular international transactions of both public and private sectors in the short term. The Pula Fund component of the foreign exchange reserves is a sovereign wealth fund (SWF) that contains funds in excess of medium-term requirements. Botswana's foreign exchange reserves stood at USD8.7 billion in November 2014, which was equivalent to 16 and a half months of import cover (Bank of Botswana, 2015).

2.2 Review of the Literature

Shocks to the terms of trade and their effects on macroeconomic variables have been studied at length and using different methodologies. This section discusses some of the literature on the terms of trade, as well as on different techniques of disentangling shocks, which is a crucial part of our study.

2.2.1 Effects of Terms of Trade Shocks on Africa and Other Developing Economies

Developing economies, particularly in Sub-Saharan Africa (SSA), are characterized by a high level of volatility that tends to negatively impact economic performance and growth. Kose and Riezman (2001) argue that in order to ensure an improvement in the growth performance of SSA economies, it is important to find reasons for their high level of volatility. They constructed a dynamic stochastic model whose features reflected the structural characteristics of a typical African economy in order to determine the role of external shocks in explaining the sources of macroeconomic variability in Africa. Their study also examined the effect of fluctuations in world interest rates on economic performance of Sub-Saharan African economies. They found that in addition to explaining approximately half of output volatility in SSA countries, trade shocks are also responsible for prolonged recessions through their impact on aggregate investment.

A seminal paper on terms of trade shocks is Mendoza (1995), who examined the relationship between the terms of trade and economic fluctuations in small open economies. The study observed actual movements in the terms of trade and macroeconomic variables and then compared them with predictions from theory. Terms of trade shocks were found to be important in explaining the majority of fluctuations in GDP and exchange rates. In addition the response of macro aggregates to these shocks differed significantly from those induced by other shocks. This may be explained by their persistence and volatile nature, and the fact that they account for sizeable portions of variations in economic fundamentals . Further, developing countries macroeconomic aggregates were found to be more volatile than those of developed economies. An extension of this work by Kose (2002) found more or less similar results. This study extended Mendoza (1995)'s work by developing a model that better captured the features of developing economies.

Broda and Tille (2003) estimated a VAR model to investigate the effects of worsening terms of trade shocks on a developing country's real output, exchange rate and consumer prices. The analysis went further to test the theory that a country's ability to absorb terms of trade shocks is primarily determined by the exchange rate regime in place. This study was carried out for seventy-five developing countries in Africa, Asia, Eastern Europe and Latin America. Broda and Tille (2003) concluded that terms of trade fluctuations account for a large portion of output variations in developing countries.

Cashin et al. (2004) asserted that understanding the likely persistence of shocks to the terms of trade is crucial for formulating the appropriate policy response to these shocks. The study used annual data for forty-two SSA economies to characterize the duration of shocks to the terms of trade. The results of the study showed that terms of trade shocks tended to be relatively short-lived for about half of the countries in the sample.

2.2.2 Identification of Shocks in the Literature

Past empirical work on the impact of various shocks to the economy assert the importance of understanding the sources of the shocks in order to fully ascertain their effects on macroeconomic variables.

Kilian (2009) estimated a SVAR model to show that an assumption of exogenous oil prices is potentially misleading. The study disentangled oil price shocks into an aggregate demand shock, a precautionary demand shock and an oil supply shock. Peersman and Van Robays (2009) used a sign restrictions approach to examine the different types of oil shocks affecting the economy of the Euro area, distinguishing between three types of oil shocks. These were an oil supply shock, an oil-specific demand shock, which they identified as an oil shock that is not the result of an increase in world economic activity, and a global economic activity shock which they identified as one which increases world production of oil as well as the price of oil and global economic activity. In related work, Melolinna (2012) used a penalty function method to identify oil shocks and other macroeconomic shocks for the US economy.

Peersman (2005) estimated a four variable VAR of the US economy to examine the causes of the early millennium economic slowdown. The study compared the results from an identification scheme that utilizes traditional zero short run restrictions and long run restrictions with those of a sign restrictions approach. The shocks identified included an oil price shock, an aggregate supply shock, an aggregate demand shock and a monetary policy shock. Interestingly, Peersman (2005) found that the results were different depending on the identification technique used, and concluded that care should be taken when working with conventional zero restrictions methods since such techniques can influence the identified shocks considerably.

Liu and Theodoridis (2012) developed an SVAR model of the Australian economy to examine the effect of international shocks on the business cycle. The analysis involved estimating a dynamic stochastic general equilibrium (DSGE) model whose parameters were then used to determine the conditions for the sign restricted VAR analysis. He finds that the terms of trade contribute around a quarter of the variance of output forecast errors, which is consistent with the importance of commodities for Australia's exports.

Dungey and Fry (2009) proposed a new method for decomposing shocks which involved combining three different identification techniques, namely, the traditional short run restrictions, the sign restrictions methodology and using cointegrating relationships to identify monetary policy shocks, fiscal policy shocks and other economic shocks. They find that international shocks (including the terms of trade) have a somewhat greater effect on New Zealand output variations than fiscal policy shocks.

2.2.3 Disentangling Terms of Trade Shocks

A more recent paper by Karagedikli and Price (2012) on terms of trade shocks identified how the terms of trade propagated through the New Zealand economy. This study closely followed similar work by Jääskelä and Smith (2013) for the Australian economy. These papers applied a similar methodology by estimating sign restricted VARs with common variables, namely the growth of world GDP, import price inflation, export price inflation, the growth of domestic output, domestic CPI inflation, the interest rate and the exchange rate. The two studies differed in their measurement of variables and in the terms of trade shocks they sought to identify. Both studies identified a global demand shock. Karagedikli and Price (2012) also identified an import price shock, which they defined as a shock that leads to an increase in import prices and a decrease in world output. They also identified an export price shock, which was restricted to have a negative effect of world GDP and import prices. In addition to the global demand shock, Jääskelä and Smith (2013) also identified a commodity market specific shock that was constrained to have a positive effect on export prices, a negative impact on world GDP and no effect on import prices. This study concluded that while a rising terms of trade tends to be expansionary, it is not always inflationary with the effect largely dependent on the nature of the shock as well as the response of policy.

2.2.4 Policy Options for Dealing with Terms of Trade Shocks

There is much evidence showing the response of economies to macroeconomic shocks is influenced by the policy framework in place (see for example Aizenman et al., 2012; Aizenman and Riera-Crichton, 2008). The Friedman hypothesis recommends a flexible exchange rate as a buffer against real shocks. The argument is that, in the presence of price stickiness, the speed at which relative prices adjust is mainly determined by the exchange rate system. In this case, a flexible exchange rate is better since it allows for a more rapid adjustment of relative prices than a fixed exchange rate. Using a sample of seventy-five developing countries, Broda (2004) tested the Friedman hypothesis with respect to the responses of prices and quantities to real shocks under different exchange rate regimes. He could not reject the hypothesis. A similar paper by Chia and Alba (2006) examined the effects of terms of trade shocks on macroeconomic variables under alternative exchange rate regimes and found that the flexible exchange rate was better for absorbing the volatility of output in the short run. Similar results were also found by Broda and Tille (2003), who concluded that countries with a flexible exchange rate are better insulated against terms of trade shocks than those with a fixed exchange rate system.

The effectiveness of macroeconomic policies other than exchange rate policies, have also been evaluated. For instance, Andrews et al. (2009) found that along with a flexible exchange rate, well developed financial markets and a monetary policy that focuses on low inflation are also important for neutralizing the volatile effects of the terms of trade on an economy. Hove et al. (2015) sought to determine the optimal response of monetary policy to terms of trade shocks in commodity dependent emerging market economies, within a New Keynesian DSGE model of the South African economy. The study compared the performance of CPI inflation targeting with non-traded inflation targeting and exchange rate targeting in the face of terms of trade shocks. The findings were that CPI inflation targeting is a better policy option for economies that are more vulnerable to commodity terms of trade shocks—this policy response can also reduce macroeconomic fluctuations and welfare losses.

Two main conclusions emerge from the literature just reviewed. The first is that understanding external shocks, particularly those to the terms of trade in developing economies is crucial. The other is that the SVAR methodology is an important tool for disentangling shocks. However, the studies discussed above have not applied the sign restrictions methodology to understanding shocks to the terms of trade in a developing country context. Even though the current study closely follows Karagedikli and Price (2012) and Jääskelä and Smith (2013) in some aspects, these studies estimated sign-restricted SVARs to developed economies, whose features and structures are fundamentally different from developing country economies. By focusing on a developing economy with unique features such as that of Botswana, this study contributes to the literature on external shocks important to most developing economies.

2.3 Methodology

VAR models are often used for investigating interdependencies between variables. They yield impulse response functions, variance error decompositions and historical decompositions that contain important information for an atheoretical understanding of the dynamic interactions amongst relevant economic variables. However, to better integrate economic theory and inform policy, a structural vector autoregression (SVAR) model can be estimated. The structural error terms represent fundamental economic shocks, and it is through these that meaningful macroeconomic analysis can be carried out.

2.3.1 From a VAR to an SVAR

Consider the following VAR(1) model:

$$y_t = A_1 y_{t-1} + e_t \tag{2.1}$$

where y_t is an *nx1* vector of endogenous variables, A_1 is a matrix of coefficients and e_t are reduced form errors. The reduced form errors can be correlated, these residuals therefore have limited economic meaning.

The SVAR representation of equation (2.1) will be:

$$B_0 y_t = B_1 y_{t-1} + \varepsilon_t \tag{2.2}$$

The reduced form VAR and the SVAR can be distinguished by the following features: the matrix, B_0, which captures the contemporaneous relations between the variables; and the matrix B_1, which is an *nxn* matrix of coefficients capturing the model dynamics. B_1 is defined so that $A_1 = {B_0}^{-1} \times B_1$; finally, the reduced form errors are replaced by ε_t, which is an *nx1* vector of structural shocks with zero mean and variance-covariance matrix *V*. The fact that the covariances of ε_t are zero implies that each shock is independent and hence ε_t has a structural interpretation. These shocks are unobservable.

This implies the following relationship between the structural shocks and the reduced form disturbances:

$$\varepsilon_t = B_0 e_t \tag{2.3}$$

The goal of the SVAR methodology is to map the observed statistical relationships described by the reduced form innovations e_t, back into the economic relationships summarized by the structural shocks (ε_t). The statistical relationships are characterized by the estimated variance-covariance matrix, Σ.

From equation (2.3) above, let $P = B_0^{-1}$ so that, $e_t = P\varepsilon_t$. Then,

$$V = PE(\varepsilon\varepsilon\prime)P\prime \tag{2.4}$$

Since $\Sigma = E(\varepsilon\varepsilon\prime)$, then,

$$V = P\Sigma P\prime \tag{2.5}$$

Equation (2.5) is essentially the identification problem of the SVAR methodology. An $m \times m$ matrix P has to be selected such that equation (2.5) is true. However there are many such matrices that could satisfy equation (2.5), therefore certain assumptions have to be made regarding the form of P. These assumptions form the basis for imposing restrictions on the responses of the variables in the system.

2.3.2 Identifying Structural Shocks

Recall that the usefulness of SVAR models mainly depends on the identification of structural errors and that restrictions have to be imposed in order to identify these shocks. These restrictions can either be parametric and/or sign restrictions, with different conclusions drawn depending on the type of restrictions imposed.

Parametric restrictions involve constraining the parameters of the model. These solve the identification problem "by reducing the number of parameters to be estimated so that suitable instruments are made available for estimation" (Fry and Pagan, 2011).

There are different types of parametric restrictions. These include short run and long run restrictions. Short run restrictions are usually zero contemporaneous restrictions imposed on the short run parameters of the model. The Cholesky decomposition is a popular example of such restrictions. This technique identifies structural shocks by ordering the variables in the system such that the most exogenous variable appears first. They are short run restrictions because the response of variables is constrained in the period immediately following the shock.

Long run restrictions involve constraining the impulse responses in the long run to have values that are motivated by economic theory. Imposing long run restrictions recognizes that some shocks may have a permanent effect on the variables. Here, "the cumulative response of the variable over the entire period of analysis is zero" (Fry and Pagan, 2011).

The last class of parametric restrictions involves using a combination of short run and long run restrictions.

The identification methods outlined above however, are not without flaws. Zero short-run restrictions have been criticized for being too stringent, as well as for the fact that they are typically not based on economic theory. Even though long-run restrictions are more consistent with economic theory, they have been found to have considerable distortions due to small sample biases and measurement errors (Peersman, 2005).

The sign restrictions methodology is an alternative approach that may help to overcome some of the shortfalls of conventional identification techniques. This procedure requires no parametric constraints to be placed on the short run or the long run effects of a shock. Furthermore, the sign conditions are usually theoretically oriented in that they are based on models (such as a DSGE model). The sign restrictions approach involves "placing restrictions on the direction that variables will move over a given horizon, in response to different types of shocks" (Jääskelä and Smith, 2013). This technique assumes that all shocks are uncorrelated. Here, restrictions are placed on the signs of the accumulated impulse responses. This identification procedure is especially important in situations where variables are simultaneously determined, thus making it difficult to justify any parametric restrictions (Fry and Pagan, 2011). Before proceeding with the discussion on the sign restrictions methodology, it is crucial to note that this novel technique is often criticized for the multiple models problem, where impulse responses are generated from numerous models, instead of from a single model. It is for this reason that our analysis complements the sign restrictions approach with a penalty function such as in Uhlig (2005).

2.3.2.1 Sign Restrictions Approach to Shock Identification

This section extends the discussion in section 2.3.1 and follows Fry and Pagan (2011)'s discussion on generating candidate shocks using the sign restrictions approach.

Recall the VAR model and corresponding SVAR from section 3.1 as represented by equations (2.1) and (2.2).

Rewriting equation (2.1) as $(I - AL)y_t = e_t$, where L is the lag operator, leads to the moving average (MA) representation of the VAR model:

$$y_t = D_0 e_t + D_1 e_{t-1} + D_2 e_{t-2} + ... = D(L)e_t \tag{2.6}$$

where $D(L) = I_n + D_1 L + D_2 L^2 + ...$

D_j is the impulse response of y_{t+j} to a one unit change in e_t.

The corresponding MA representation of the corresponding SVAR is therefore:

$$y_t = C_0\varepsilon_t + C_1\varepsilon_{t-1} + C_2\varepsilon_{t-2} + ... = C(L)\varepsilon_t \tag{2.7}$$

where, $C(L) = C_0 + C_1L + C_2L^2 + ...$ with C_j being the j^{th} period impulse response of y_{t+j} to a one unit change in ε_t.

The estimated shocks from the VAR model are combined to produce orthogonal candidate structural shocks. We only retain combinations of the estimated shocks that yield impulse response functions for the corresponding structural innovations that carry the correct signs, otherwise they are discarded.

Suppose that after estimation we have:

$$\hat{e}_t = \hat{B}_0^{-1}\hat{\varepsilon} \tag{2.8}$$

The next step is to re-scale the structural shocks, by dividing each by its standard deviation. This ensures that they have unit variance.

Suppose that $\hat{S}$ is the matrix of estimated standard deviations of $\hat{\varepsilon}_t$ on the diagonal and zeros elsewhere. Then,

$$\hat{e}_t = \hat{B}_0^{-1}\hat{S}\hat{S}^{-1}\hat{\varepsilon}_t \tag{2.9}$$

If we let $\hat{S}^{-1}\hat{\varepsilon}_t = \hat{\eta}_t$ and $\hat{B}_0^{-1}\hat{S} = \hat{T}$, then $\hat{e}_t = \hat{T}\hat{\eta}_t$.

Here, $\hat{\eta}_t$ represents the new structural shocks with unit variances. Since these new standardized shocks are simply the new re-scaled version of $\hat{\varepsilon}_t$, they have the same characteristics. These shocks are also uncorrelated.

Next, an orthogonal square matrix, Q is introduced such that $Q'Q = QQ' = I_n$. The Q matrix is used to form combinations of $\hat{\eta}_t$ so that: $\hat{\eta}_t^* = Q\hat{\eta}_t$. These are the candidate structural shocks.

If this is the case, it means that:

$$\hat{e}_t = \hat{T}Q'Q\hat{\eta}_t = \hat{T}^*\hat{\eta}_t^* \tag{2.10}$$

The new set of structural shocks, $\hat{\eta}_t^*$ have the same covariance matrix as the standardized structural shocks, $\hat{\eta}_t$ however they will have a different impact $\hat{T}^*$ on e_t and hence on the variables y_t. In other words, the new shocks produce varying impulse responses, which is the basis for the sign restrictions methodology. In a nutshell, by restricting the signs of the impulse responses, we are selecting a matrix Q so that the structural shocks are identified.

2.3.3 Model Specification

A sign-restricted VAR is estimated using data for the Botswana economy. Botswana has a small open economy for which it is highly unlikely that domestic variables will have an impact on foreign variables. Therefore, a block recursive structure is imposed on the model, i.e. the model is partitioned into a domestic block of variables and a 'rest of the world' or foreign block. This allows for no feedback from variables in the domestic block to those in the world block. To achieve this, one has to ensure there are no contemporaneous or lagged domestic variables appearing in the set of equations for the world variables.

The following model is estimated:

$$\begin{bmatrix} w_t \\ d_t \end{bmatrix} = \alpha x_t + \sum_{i=1}^{p} A_i \begin{bmatrix} w_{t-i} \\ d_{t-i} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^w \\ \varepsilon_t^d \end{bmatrix} \tag{2.11}$$

where w_t and d_t are vectors of foreign and domestic variables respectively, x_t is a vector of exogenous variables, B is the matrix of contemporaneous impact of the vectors of mutually uncorrelated foreign and domestic innovations (ε_t^w and ε_t^d). To determine the optimal VAR order, p, we utilize the Akaike Information Criterion (AIC). This test is known to outperform the more popular Schwarz Information and Final Prediction Error Criteria in selecting the optimal order for small samples. The AIC selected an optimal lag length of 1, which was verified using the Bayesian Information Criterion.

To impose the small open economy assumption, the A_i matrix is defined to be lower triangular, ensuring that lags of the domestic variables have no influence on the world block.

The variables that appear in the foreign block are the growth of world output (Δy_t^w); export price inflation (π_t^x) and import price inflation (π_t^m).

$$w_t = (\Delta y_t^w, \pi_t^x, \pi_t^m)' \tag{2.12}$$

The domestic block contains key variables that describe conditions in the Botswana economy—these are domestic output growth (Δy_t^d), CPI inflation (π_t^d), the short term lending interest rate (i_t^d) and the change in the real effective exchange rate (Δq_t).

$$d_t = (\Delta y_t^d, \pi_t^d, i_t^d, \Delta q_t)' \tag{2.13}$$

2.3.4 Identification

The sign restrictions methodology is used to identify the shocks of interest. This is in line with past studies where sign restrictions were used to identify monetary policy shocks, fiscal policy shocks, technology shocks, oil shocks and so on (see Karagedikli and Price, 2012; Liu, 2008; Peersman and Van Robays, 2009; Uhlig, 2005).

Table 2.1 below shows the restrictions imposed on the world variables in order to identify the shocks of interest. A positive sign (+) means that the impulse response of the variable is constrained to be positive, while a negative sign (-) implies that the impulse response of the variable is restricted to be negative. A 'u' means that no restrictions are imposed on the variable in question.

TABLE 2.1: SVAR Sign Restrictions

	Export Prices	Import Prices	World GDP	Domestic Variables
Global Demand Shock	+	+	+	u
Globalization Shock	+	-	+	u
Commodity Market Specific Shock	+	u	-	u
Global Supply Shock	u	-	-	u

Four types of terms of trade shocks are identified by restricting the impulse responses of the variables in the foreign block. Since we are interested in the response of domestic variables to these external shocks, the variables in the domestic block are left unrestricted.

A global demand shock is essentially a shock to incomes. A positive global demand shock is one that stimulates overall global economic activity and increases the prices of all products, i.e. both import and export products. The global demand shock is identified by restricting the responses of world output, export prices and import prices to be positive. This is because a global economic boom is expected to increase world GDP as well as the prices of all products, whether exported or imported.

Recall that a positive globalization shock is one that captures the increasing participation and importance of emerging economies such as China and India in world markets. It should increase export prices due to the increase in global demand for raw materials, and at the same time, import prices should fall as a result of the decline in the price of manufactured goods coming out of these emerging economies. This shock is thus one that is restricted to an increase in global economic activity and export prices, but a reduction in import prices.

Like Jääskelä and Smith (2013), we define a positive commodity-market specific shock as a shock that accounts for increases in export prices not caused by a rise in global economic activity—to be sure, a fall is the restriction applied. This shock is therefore identified by restricting the responses of export prices and world output to be positive and negative respectively, while the response of import prices is left unconstrained. This identification allows for a test of the Dutch disease phenomenon, whereby a booming export sector crowds out other sectors.

The final terms of trade shock occurs through a fall in import prices accompanied by a decline in global activity. This is essentially a global supply-side shock, which can be thought of as a fall in price of energy inputs. This is a contemporary shock driven by global excess supply of oil, which is influenced by the global business cycle. Introducing this shock is justified in that falls in oil prices since the financial crisis of 2008 were driven by global excess supply in oil markets. This terms of trade shock is identified by restricting the responses of import prices and world GDP to both be negative.

Based on table 2.1 above and the discussion in the preceding section, the following equation shows the sign-restricted identifications for the shocks:

$$\begin{bmatrix} e_t^{\pi x} \\ e_t^{\pi m} \\ e_t^{yw} \\ e_t^{yd} \\ e_t^{\pi d} \\ e_t^{\Delta q} \\ e_t^{i} \end{bmatrix} = \begin{bmatrix} + & + & + & u & 0 & 0 & 0 \\ + & - & u & - & 0 & 0 & 0 \\ + & + & - & - & 0 & 0 & 0 \\ u & u & u & u & u & u & u \\ u & u & u & u & u & u & u \\ u & u & u & u & u & u & u \\ u & u & u & u & u & u & u \end{bmatrix} \times \begin{bmatrix} \varepsilon^{demand} \\ \varepsilon^{global} \\ \varepsilon^{comm.mkt} \\ \varepsilon^{supply} \\ \varepsilon^{\pi} \\ \varepsilon^{q} \\ \varepsilon^{i} \end{bmatrix} \tag{2.14}$$

A positive sign (+) means that the impulse response of the variable is constrained to be positive, a negative sign (-) is the reverse, while a 'u' means that no restrictions are imposed on the variable in question. The 3×4 upper left block represents the four identified external shocks of interest. For instance, the fourth column of the impact matrix in equation (2.14) above shows that the global supply shock is identified by constraining the responses of import prices and global output to be negative, while leaving export prices unrestricted. Since we are not identifying any domestic shocks, the last three columns of the impact matrix contain a series of zeros and 'u's. The 3×3 upper right block illustrates the fact that, for a small open economy, shocks to domestic variables cannot influence any of the world variables.

2.3.5 Sign Restrictions with a Penalty Function Approach

Once the restrictions have been imposed, the model is estimated and repeatedly simulated. There will be many VAR representations that agree with the postulated signs—so we can consider all the impulse response functions that are feasible and report the median response at each horizon for each variable (Liu, 2008). The problem with this, however, is that the orthogonality condition may be violated since the median response is calculated with impulse responses from multiple models.

It is for this reason that sign restrictions have been criticized. They generate impulse responses from multiple models rather than from a single model, which means that there can be many impulse responses that are consistent with the sign constraints. This problem is exacerbated by the fact that many of the uses of the information, such as the construction of variance decompositions, require that impulse responses be uncorrelated. The pure sign restrictions method thus fails to address the multiple models problem, which can result in excess uncertainty about the model's estimates and consequently may lead to incorrect policy inference (Fry and Pagan, 2007; Liu and Theodoridis, 2012). One way of dealing with the problem discussed above is to complement the sign restrictions method with the penalty function approach. This approach has been used in the literature to find a unique solution from the set of impulse responses that produce the correct signs (see Melolinna, 2012; Mountford and Uhlig, 2009; Uhlig, 2005). The penalty function method produces a unique set of structural innovations by minimizing some criterion function. The shocks of interest are identified by finding the impulse response that comes as close as possible to satisfying the sign restrictions. This is achieved by minimizing a penalty for the impulse responses that violate the sign restrictions, and rewarding responses that satisfy the constraints. This helps to exactly identify the best impulse response out of all those that satisfy the sign conditions, thus reducing the uncertainty of the identification procedure (Liu and Theodoridis, 2012).

From Uhlig (2005), a penalty function can be defined as follows:

$$f(w) = \begin{cases} w & \text{if } w \leq 0 \\ 100 * w & \text{if } w \geq 0 \end{cases}$$

where w is the impulse response. The penalty function above is asymmetric in that when imposing sign restrictions, wrong responses are penalized more times than correct responses are rewarded.

Let $r_{j,a}(k)$ be the impulse response of variable j at horizon k to an impulse vector a, where $k = 0, ..., K$. Here K is the last period at which impulse responses are restricted. σ_j is the standard deviation of variable j, such that the impulse responses are re-scaled. This makes it possible to compare deviations across the various impulse responses. Let l_{s+} be the set of variables for which the impulse response is constrained to be positive, while l_{s-} represents the set of variables for shock identification for which the impulse responses are restricted to be negative (Mountford and Uhlig, 2009; Uhlig, 2005).

The criterion function to be minimized can thus be given by:

$$\Psi(a) = \sum_{j \epsilon l_{s_+}} \sum_{k=0}^{K} f(-\frac{r_{j,a}(k)}{\sigma_j}) + \sum_{j \epsilon l_{s_-}} \sum_{k=0}^{K} f(\frac{r_{j,a}(k)}{\sigma_j}) \tag{2.15}$$

In our case, a global demand shock impulse vector is one that minimizes the criterion function $\Psi(a)$ while penalizing negative impulse responses of world output, export and import prices. The globalization shock minimizes $\Psi(a)$, while penalizing negative impulse responses of world output and export prices, and positive responses of import prices. The commodity market specific shock minimizes the criterion function while penalizing positive responses of world GDP and negative responses of export prices. Finally the global supply-side shock impulse vector is one that minimizes the criterion function while penalizing positive responses of import prices and world output.

2.4 Data

The data set for this analysis comprises seven key variables for the Botswana economy—these are export price inflation, import price inflation, world output growth, domestic output growth, domestic inflation, the real effective exchange rate and the domestic interest rate. The choice of variables is guided by past empirical work in this area as well as their relevance to the Botswana economy. We use annual data for the period 1960 to 2012; the low frequency dictated by the availability of data.

Export and import price inflation are calculated using export and import price indices obtained from the Federal Reserve Economic Data (FRED), while all other data was obtained from the World Development Indicators of the World Bank. World output growth is calculated as the trade-weighted real GDP of Botswana's major trading partner countries—Botswana's major trading partners include China, the European Union, Israel, Norway, South Africa, the United Kingdom and the United States.

Domestic output is Botswana's real GDP. The inflation rate is the headline inflation for Botswana, calculated from the consumer price index, while the interest rate used here is the prime lending rate, which is the lowest interest rate at which funds can be loaned out by commercial banks. It is thus a market-determined rate, which is largely influenced by credit risk premia as well as monetary policy decisions.

The real effective exchange rate (REER) is the trade-weighted average of Botswana's nominal bilateral exchange rates after accounting for the domestic consumer price index, CPI_t, and the trade-weighted average of consumer price indices of trading partner countries, CPI_t^*.

Table B.1 in Appendix B gives the descriptive statistics of the data series used.

2.5 Results

This section reports the results of the impulse response analysis undertaken after estimating the model. Taking into consideration the shortcomings of the sign restrictions methodology already discussed in the preceding section, we report the results of the sign restrictions approach with a penalty function. We then explain briefly what would happen without the penalty function.

2.5.1 Impulse Response Analysis: Sign Restrictions with a Penalty Function Approach

The sign restrictions with a penalty function methodology imposes more restrictions, along with the sign constraints, to resolve the identification problem that arises due to weak information, thus narrowing down the range of acceptable responses that carry the correct sign. In this way, the multiple models problem is avoided and a unique solution obtained. Furthermore, since it has become common practice to impose contemporaneous restrictions, as opposed to constraining longer lags, the sign restrictions are imposed for the first period only.

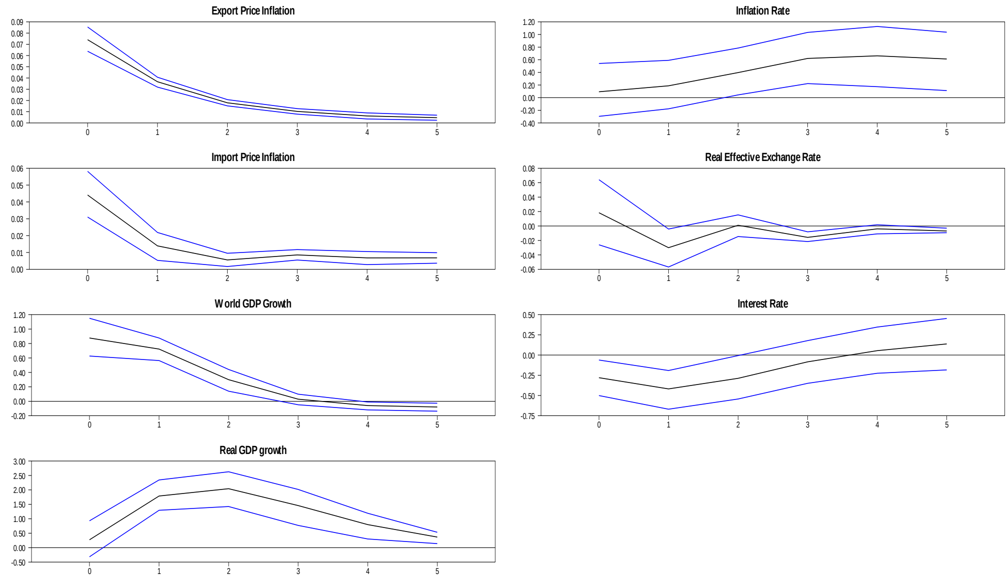
The analysis is based on 2000 successful draws from the posterior of the VAR and from the unit sphere.[4] From these, we extract the median target, 16th and 84th percentiles of the impulse responses. The results of the experiments are discussed in the following subsections.

2.5.1.1 Responses to a Global Demand Shock

Figure 2.6 below shows the responses of the variables of interest following a positive global demand shock. To reiterate, this type of shock is one that stimulates overall global economic activity and increases prices of all commodities. A positive global demand shock is therefore identified by restricting the impulse responses of world output, import prices and export prices to be positive.

[4]The analysis is based on 10000 draws.

Figure 2.6: Responses to a Positive Global Demand Shock



As expected, the positive shock leads to a positive contemporaneous response of world output that declines over time but appears to remain above trend growth for up to 3 periods before normalizing. Both import and export prices increase on impact, but with the rise in export prices being slightly higher than that of import prices, thus signifying an improvement in the terms of trade.

With the exception of the interest rate, the responses of the rest of the domestic variables are insignificant, however their median responses will still be discussed. The global demand shock results in a positive response of domestic output growth. The positive effect declines over time but appears to be long-lasting, which may be attributed to the positive growth of world output and the eventual real depreciation of the exchange rate. The contemporaneous response of the inflation rate strengthens over time and remains positive, reinforced by the high prices of imports. Interestingly, there is a negative effect on the interest rate, which may indicate that a decline in credit risk premia in the booming economy outweighs any possible counter-cyclical response by the central bank. That is, risk premia is more likely to fall due to favorable economic conditions following the positive shock, if the decline in risk premia is large enough to outweigh any monetary tightening by the central bank, there will be a negative response in the interest rate.

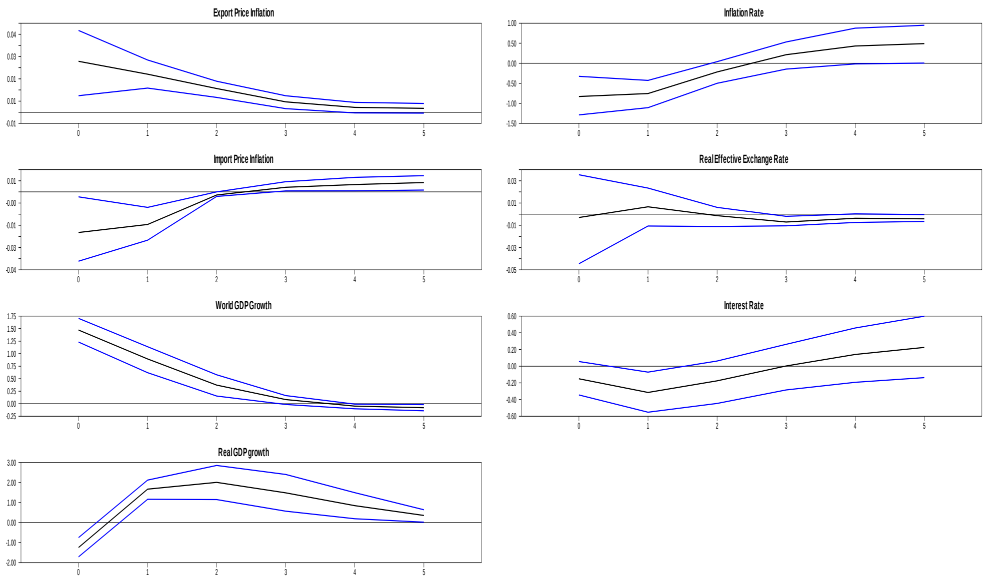
In summary, a positive global demand shock leads to an improvement in the terms of trade. The shock also stimulates domestic output and induces upward inflationary pressures on the economy. With interest rates lower, the central bank should be in a position to tighten monetary policy to moderate inflation.

2.5.1.2 Responses to a Globalization Shock

A globalization shock essentially captures the impact of the increasing dominance of emerging economies such as China and India into world product markets. This type of shock is expected to increase export prices as the global demand for raw materials rises, while at the same time import prices fall due to the influx of cheap manufactures coming out of these economies. A positive globalization shock is thus identified by restricting the responses of world GDP and exports prices to be positive, while the import prices are constrained to be negative.

The responses of the variables in the model to a globalization shock are shown in figure 2.7 below.

Figure 2.7: Responses to a Positive Globalization Shock



In keeping with *a priori* expectations, the shock contemporaneously increases both world output and export prices, while decreasing import prices, once again signalling an improvement in the terms of trade. The effect of the shock on export prices declines over time but remains positive for some time. The response of world output growth also declines and normalizes by the end of the third year.

Even though domestic real GDP is slightly negative on impact, the improvement in the terms of trade and the increase in the output of trading partner countries stimulate output growth, which quickly becomes positive and remains above trend growth for 5 years. The contemporaneous response of inflation is negative due to falling prices of imports. The positive shock also leads to a slight depreciation of the exchange rate that lasts for less than half a year. Once again, the negative effect on the interest rate may suggest that a beneficial credit risk premia effect outweighs any counter-cyclical monetary policy response by the central bank.

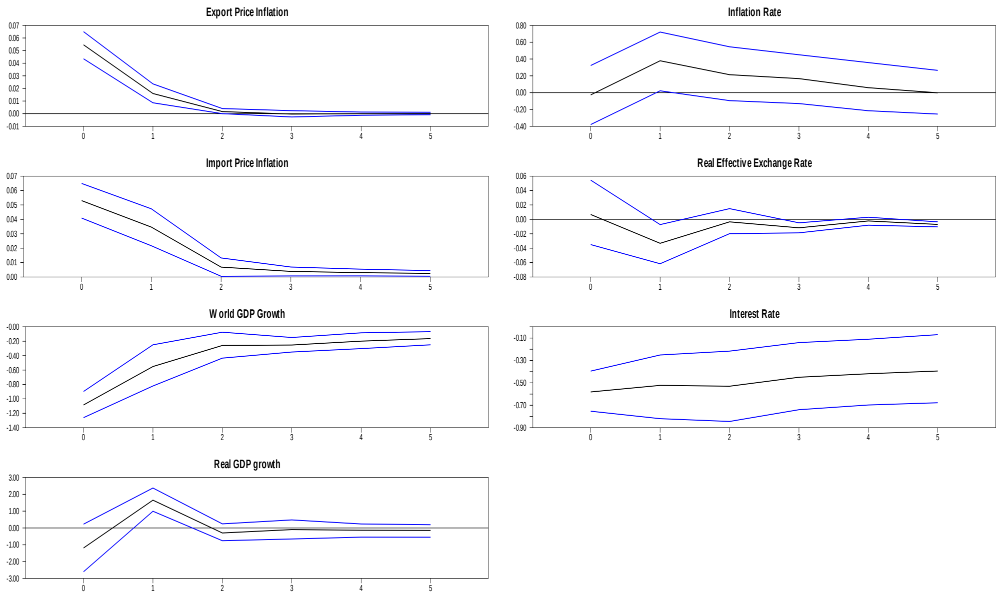
To summarize, a positive globalization shock is expansionary but not inflationary, in that not only does it stimulate the growth of domestic output over time, the fall in import prices exerts downward pressure on the inflation rate. With inflation abating more than the nominal interest rate, the real rate of interest will be higher, and the central bank may choose to lower the interest rate further. However it should take into account the booming GDP, and be aware that this positive terms of trade shock will correct itself over time.

2.5.1.3 Responses to a Commodity Market Specific Shock

A positive commodity market specific shock relevant to Botswana is one that accounts for an increase in export prices not caused by a rise in global economic activity. It is therefore identified by restricting the impulse responses of world output growth and export prices to be negative and positive respectively. Figure 2.8 below shows the response of both foreign and domestic variables to a positive commodity market specific shock.

The contemporaneous responses of world output and export prices are as expected. In identifying this shock, the response of import prices was left unrestricted, so the response reported here is the unrestricted response. From figure 2.8, the positive shock leads to a contemporaneous increase in import prices, this is in line with the result Jääskelä and Smith (2013) obtained for Australia. While both import and

Figure 2.8: Responses to a Positive Commodity Market Specific Shock



export prices increase, the increase in prices of exports is slightly higher, therefore this particular shock results in a small improvement of the terms of trade.

Though the responses of the domestic variables are relatively insignificant, except for the interest rate, their median patterns will still be discussed.

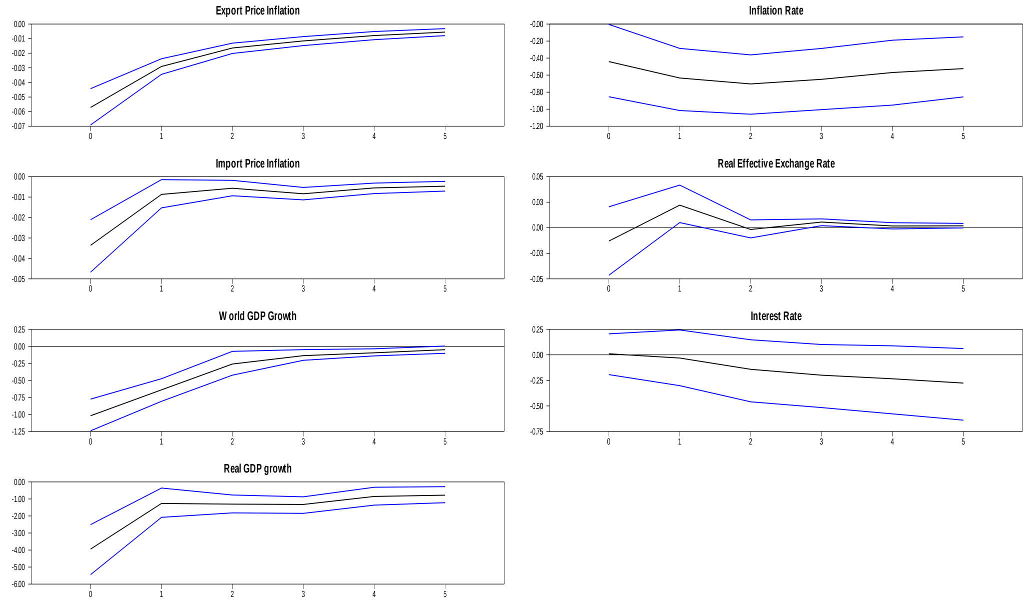
The growth of domestic output is negative on impact. This may be largely explained by the negative response of world GDP growth to the shock. The response of inflation is a little sluggish on impact, but quickly becomes positive within a year where it stays for up to 5 periods. The central bank responds to falling output levels by adopting an easy monetary policy stance for some time. The exchange rate appreciates briefly on impact, however a combination of high import prices and low interest rates contribute to a real depreciation of the exchange rate within a few months of the shock. As explained earlier, this result may be interpreted as (weak) evidence of a Dutch disease effect—a booming sector leading to a terms of trade increase strengthens the real exchange rate temporarily, and compromises the competitiveness of other sectors. Overall GDP growth may thus decline in the short term.

Overall, the commodity market specific shock may dampen the growth of output and initially appreciate the real exchange rate. The central bank may respond by lowering the interest rate further, which will moderate the real appreciation and ease the short term Dutch disease.

2.5.1.4 Responses to a Global Supply Shock

A global supply shock is one associated with a fall in import prices and a slowdown of global economic activity. This shock is therefore identified by restricting the responses of import prices and world output growth to be negative.

FIGURE 2.9: Responses to a Negative Global Supply Shock



The global supply shock in Figure 2.9 leads to a negative response of prices of all commodities (and particularly energy prices) and world GDP growth. Consequently, domestic output and inflation also respond negatively on impact, but with output growth recovering over time while the response of inflation is long lasting. The response of the nominal interest rate, while initially unaffected on impact, becomes stronger and negative, as the monetary authorities respond to stimulate output growth and to reduce the risk of deflation. Falling export prices, coupled with the low interest rate lead to a real appreciation of the exchange rate which lasts for up to 3 periods.

In summary, a positive global supply side shock suppresses both GDP growth and inflation, and raises the real interest rate. This suggests that the central bank ought to undertake a significant monetary expansion to stimulate output growth and guard against possible deflation.

2.5.2 Impulse Response Analysis: Comparison of Results with a Pure Sign Restrictions Approach

The model is run again using Uhlig (2005)'s pure sign restrictions approach (i.e. without the penalty function) and the results obtained are largely insignificant, with the exception of the responses of the variables in the foreign block for which restrictions are imposed. This may be explained by the multiple shocks and multiple models problems, where other shocks can be identified with the same set of restrictions and assumptions imposed, and also because there are many impulse responses that agree with the set restrictions, obtained from many models. It is for this reason that the analysis is paired with a penalty function that successfully reduces the responses obtained by focusing on a single model that is closest to the median response in each period.

However, even though the responses are insignificant, it is worth noting that for the most part, they appear to follow similar patterns as the responses under the penalty function approach. These responses can be viewed in Appendix A.3.

2.6 Conclusions

This study sought to identify the underlying external determinants of terms of trade shocks within a particular developing country context, as well as to determine the effects of these shocks on developing country macroeconomic variables. The study focused on the small developing economy of Botswana using data for the period 1960 to 2012.

To this end, a sign restricted VAR with a penalty function was estimated to identify four types of terms of trade shocks, namely a global demand shock, a globalization shock, a commodity-market specific shock and an oil price shock, and an analysis was carried out to determine how these different shocks affect domestic output growth, domestic inflation, the real exchange rate and the nominal interest rate.

We find that the response of macroeconomic variables to external shocks do depend on the features of the underlying shock. While the global demand shock and globalization shock both stimulate domestic output growth, they each have a different effect on inflation. The global demand shock is found to be inflationary while the globalization shock drives inflation down as a result of falling import prices. A positive commodity market specific shock appears to have an effect opposite to that of the globalization shock. Unlike the globalization shock, the commodity market specific shock dampens real GDP growth, it is however inflationary due to rising import prices, and is weakly consistent with a Dutch disease effect. Lastly, the positive global supply shock is found to suppress both output growth and inflation, leading to a monetary expansion over time.

The results of the penalty function approach were compared with those of a pure sign restrictions approach, and even though the results of the latter approach were found to be mostly insignificant, most of the domestic variables seemed to follow similar patterns in both approaches.

Based on our findings of the response of macroeconomic fundamentals following the shocks, it is evident that the monetary policy implications of the results will depend on the type of shock. In the case of a positive global demand shock, the central bank has room to employ a contractionary monetary policy in order to curb rising inflationary pressures. This can be achieved without counteracting the full effect of the positive shock on real GDP. This is because the rising global output growth, together with a real depreciation of the exchange rate and the improvement in the terms of trade may still act to stimulate domestic GDP growth.

The central bank's policy option in response to the effects of the globalization shock is to decrease the nominal interest rate further. This would encourage investment spending, increasing domestic output growth even more. The low interest rate, along with high foreign output and the exchange rate depreciation further amplify the positive effect of the globalization shock on real output growth.

The commodity market specific shock suppresses domestic output growth due to a potentially weak form of the Dutch disease. While Dutch disease effects are more complex to address, the central bank could lower interest rates, simultaneously addressing the exchange rate misalignment and stimulating overall domestic output growth.

In dealing with the effects of a global supply shock, the central bank can decrease interest rates even further. This has the potential to improve investment spending, increase net exports and thus domestic output growth.

All of the contextual shocks identified were in effect positive terms of trade shocks. However our results and discussions indicate that the appropriate policy response differs qualitatively for the first shock. That is, the results imply a monetary tightening for dealing with the effects of the global demand shock, whereas the appropriate action for the last three shocks would be an expansionary monetary policy. For all four shocks, the quantitative policy responses will likely differ and should be informed by an appropriate empirical analysis.

These conclusions are based on an SVAR model with sign restrictions to identify the key terms of trade shocks. As a next step in this research line, it would be informative to develop and estimate a structural DSGE model for a better and theoretically deeper understanding of the effects of these shocks on a developing country's economy.

Chapter 3

What is Driving Botswana's Bilateral Exchange Rates?

3.1 Introduction

The exchange rate is a key macroeconomic indicator for any economy, but more so for small commodity-exporting countries, such as Botswana, whose growth prospects are closely tied to the performance of the external sector. This important fundamental forms a vital foundation for the flow of goods and services, capital flows, as well as for key economic variables such as inflation and the trade balance (Yagci, 2001). Sound exchange rate management is important for ensuring international competitiveness, economic growth and macroeconomic stability. Further, a mismanaged exchange rate can breed a myriad of problems, including increased uncertainty, higher transaction costs and inflation. It can also discourage trade and foreign direct investment (FDI). Therefore, ensuring a well-managed and stable exchange rate remains an important task for monetary authorities especially in primary commodity-exporting economies.

Recent empirical work on exchange rates emphasizes the role of unobservable factors in explaining exchange rate variations. The argument here is that exchange rate changes are not necessarily a result of observable macroeconomic fundamentals only, but rather that some *unobservable* factors also contribute significantly to these fluctuations. Another issue in line with this debate is the failure of structural models to adequately forecast exchange rates. The influential study by Meese and Rogoff (1983b) highlights the poor predictive ability of structural models when compared to the driftless random walk model. This study shows that observable macroeconomic fundamentals have limited forecasting ability of exchange rates in the short run and the medium run. This failure has often been attributed to the fact that exchange rates follow a random walk. Engel and West (2005) however counter-argue that this is not necessarily the case, in that it is the latent factors driving exchange rates that themselves could be approximated as following a random walk. Another explanation for this poor predictive performance is what has been termed the 'scapegoat' effect. In explaining this effect, Bacchetta and van Wincoop (2004) and Bacchetta and Van Wincoop (2013) argue that structural parameters can be explained by macroeconomic fundamentals such as exchange rates, however these parameters are also driven by shocks to latent factors. At times, exchange rates may fluctuate as a result of shocks to these unobservable factors, causing market participants to wrongly assign blame to observable macroeconomic indicator(s), giving them undue weight. In this way, the macroeconomic variable(s) become 'scapegoats.'

If this is indeed the case, then it is crucial to isolate these unobservable components in order to improve our understanding of exchange rate variations. One approach to this is to extract these latent principal factors from a panel of bilateral rates and use those as complementary factors in explaining exchange rate movements.

We therefore employ a principal component analysis (PCA) on ten bilateral exchange rates of the Botswana pula (BWP), the national currency, in order to determine the unobservable common factors responsible for the evolution of these bilaterals. The data set consists of monthly growth rates of nominal bilateral exchange rates of the pula against currencies of some of the country's most important trading partners, as well those contributing heavily to the determination of the pula value.[1] The sample period for the study runs from January 2001 to December 2015.

[1]That is, the South African rand (ZAR), British pound (GBP), US dollar (USD), Japanese yen (JPY), the Norwegian krone (NOK), the Israeli new shekel (ILS), the Hong Kong dollar (HKD), the Chinese yuan (CNY) and the Indian rupee (INR)

It is crucial to note that while literature on exchange rates is vast for developed economies, the same cannot be said for developing countries, especially those in the sub-Saharan Africa region. Data constraints on the region is one explanation for this lack of adequate research. In instances where research exists, it is usually as part of panel studies that do not necessarily take into consideration the unique features of individual economies. The current study therefore adds to the sparse literature on the Botswana pula exchange rate by providing a country specific analysis using novel econometric techniques. Our approach also departs from previous empirical work on Botswana by assessing the potential role of unobservable factors in explaining exchange rate movements of the pula.

We find that the first principal component accounts for 66 percent of variations in the bilateral pula exchange rates. In addition to this, this component is related to key macroeconomic and financial variables of the United States and South Africa. The factor responds to contemporaneous and lagged values of the VIX index, the federal funds rate and the bond spread between the South African 10 year government bond and its US counterpart. It is also influenced by Botswana's prevailing exchange rate regime, past values of the growth in US capacity utilization, the US yield slope as well as the South African policy rate. Our results also suggest that the full effect of variations in the South African rand on the Botswana pula is muted by the soft peg between the two currencies. In the absence of the crawling peg, we would observe a more volatile rand/pula exchange rate, while the other extreme of a hard peg would ensure no variation between the two currencies at all.

We then examine the usefulness of the estimated first principal component in forecasting the bilateral exchange rates. Our analysis involves comparing the performance of the principal component model against a popular benchmark, the driftless random walk. We find that the first principal component improves the accuracy of one week ahead forecasts of the rand/pula exchange rate, as well as one period ahead daily exchange rates of the British pound, the US dollar, the Japanese yen, the Israeli new shekel, the Hong Kong dollar, the Indian rupee and the Chinese yuan. In this way, our study asserts that bilateral exchange rate panels of the Botswana pula contain important information, which is otherwise not contained in observable fundamentals. Based on the forward-looking nature of macroeconomic policy in Botswana, we propose that the Bank of Botswana ought to include information contained in these bilateral panels in its management of the country's exchange rate. Our findings are noteworthy and reinforce the argument that latent variables can play a significant role in explaining exchange rate changes as suggested by Ponomareva et al. (2015), Greenaway-McGrevy et al. (2015) and Felício and Rossi Júnior (2014) among others.

The remainder of the paper is structured as follows: section 3.2 is a review of Botswana's exchange rate policy. A brief discussion of the chronology of key events in the management of the Botswana pula is provided, followed by an explanation of the current policy framework. Section 3.3 is a review of literature relevant for the study, while section 3.4 discusses the methodologies employed in the study including an outline of the PCA technique. Sections 3.5 and 3.6 focus on descriptions of the data and the major findings of the study, while section 3.7 concludes.

3.2 Exchange Rate Policy in Botswana

Before proceeding with the analysis, it is necessary to understand Botswana's exchange rate policy as well as important developments in the period since the national currency was introduced in 1976. This section starts with a brief discussion of exchange rate theory, followed by a chronology of some of the most important events regarding the pula exchange rate.

Macroeconomic policies in Botswana are guided by and entrenched in a national development strategy that aims to achieve rapid and sustainable economic growth, as well as ensuring a well diversified economy. As such, Botswana's exchange rate policy is largely geared towards guarding against a misaligned currency and ensuring stability of the real effective exchange rate (REER) in order to promote external competitiveness. Decisions regarding the exchange rate policy framework rest with the President of Botswana with advice from the Minister of Finance and Development Planning, and in consultation with the central bank, the Bank of Botswana (BoB). The central bank is also responsible for the implementation of exchange rate policy.

Exchange rates are generally classified as either fixed or floating/flexible. Between the two extremes, there is a range of intermediate exchange rate regimes. The advantage of these intermediate regimes is that they provide room for short-term flexibility by allowing for the adjustment of exchange rate margins and parity in the medium-term. The choice of an appropriate exchange rate regime is typically determined by the country's specific conditions. These include features such as the size of the economy, trade openness, structure of trade, the level of financial development as well as political conditions and the credibility of the authorities and institutions in place Yagci (2001). In addition to this, the exchange rate adopted for a currency may change over time as the country's structural characteristics also change.

Under a fixed exchange rate regime, the value of the domestic currency in terms of the foreign currency is held constant through intervention by policy makers in the foreign exchange market. The foreign currency to which it is pegged usually belongs to a major economy or an important trading partner, or as part of a monetary union. Some of the advantages of this regime include promoting stability and competitiveness, especially if the peg currency is stable. It also provides a nominal anchor for inflation in the case where the currency is fixed to a country with low inflation. Fixed exchange rates have often been justified for developing countries since they tend to have an under-developed financial sector which may lack the capacity to efficiently determine the market exchange rate (Bank of Botswana, 2007). This regime also bolsters confidence in the domestic currency, which may be crucial for the holding of domestic currency denominated assets.

A major disadvantage of a fixed exchange rate mechanism is that the system may fail if the country lacks the necessary foreign exchange reserves required to maintain the value of the currency, particularly in the event of large capital outflows. Further, Husain et al. (2003) caution that this regime, just like the floating exchange rate system, may accelerate economic variability in the event of real shocks and nominal rigidities. In addition to this, there is a higher chance of the currency coming under speculative attacks and increased possibilities of banking crises.

A floating exchange rate regime is one where the value of the domestic currency vis-á-vis the foreign currency is determined freely by market forces in the foreign exchange market. In this case, there is room for policy makers to still influence the exchange rate by adjusting domestic policy instruments such as interest rates. Floating exchange rates are advantageous in instances where large international reserves are a constraint since none are required to back the currency. This mechanism also fosters an environment where adverse shocks to the economy may be easily absorbed. Floating exchange rate regimes however, are criticized for the fact that they tend so exhibit high short term volatility, and can at times be inflationary.

3.2.1 History of the Botswana Pula and Evolution of the Exchange Rate Policy

This subsection provides a brief summary of the major events in the development of exchange rate policy in Botswana. Table 3.1 below presents a summary of some of the most important exchange rate policy events of the Botswana pula.[2]

In the first ten years after gaining independence in September 1966, Botswana remained a member of the Rand Monetary Area (RMA), which was a monetary union with membership also comprising Lesotho, Swaziland, South Africa and Namibia (then known as South West Africa). This membership was advantageous at the time since the country had very limited foreign exchange revenue, as well as underdeveloped institutional and administrative capabilities. Consequently, there was no need to introduce independent monetary and exchange rate policies because within the union, these were mostly dictated by the largest economy, South Africa.

However, with improvements in Botswana's financial position as well as economic growth and development, the country withdrew from the monetary union and sought to pursue independent policies. In August 1976, the Botswana pula was introduced, and was pegged to the US dollar at the rate BWP1:USD1.15, which still maintained parity with the South African rand. This allowed for a smooth transition and helped to alleviate some of the potential challenges arising from introducing a new currency (Bank of Botswana, 2007).

[2]The discussion is based on information obtained from various issues of BoB annual reports.

Table 3.1: Evolution of Botswana Pula Exchange Rate Events.

Date	**Event**	**Comments**
1966-1976	Member of the Rand Monetary Area (RMA)	No independent monetary and exchange rate policies.
August 1976	Withdrawal from the RMA and Botswana pula introduced	pula pegged to US Dollar.
April 1977	5% pula revaluation.	Anti-inflationary measure.
September 1979	Rand taken off US dollar peg.	Rapid appreciation of rand against US Dollar.
June 1980	Pula taken off the US dollar peg and new pula basket is introduced.	Stability measure to reduce volatility of the rand/pula exchange rate
November 1980	5% pula revaluation	Anti- inflationary measure.
January 1981	Steep drop in global gold prices.	Drastic depreciation of the rand.
May 1982	10% pula devaluation.	Stabilization measure.
February 1984	RSA foreign debt freeze and run on the rand.	Rapid depreciation of the pula against the US dollar.
July 1984	5% pula devaluation.	Competitive measure.
August 1984	Adjustment of rand weight in pula basket.	Measure to reduce pula drift from rand.
January 1985	15% pula devaluation.	Competitiveness measure.
January 1986	New pula basket introduced	A result of rapid rand appreciation against the US Dollar.
June 1989	5% pula revaluation.	Anti-inflationary measure.
August 1990	5% pula devaluation.	Competitiveness measure.
August 1991	5% pula devaluation.	Competitiveness measure
September 1991	Introduction of Zimbabwe dollar to pula basket.	Due to increase in trade with Zimbabwe.
June 1994	Technical adjustments and removal of Zimbabwe dollar from pula basket.	To capture new trade patterns and as a competitive measure.
February 2004	7.5% pula devaluation.	Competitiveness measure.
May 2005	12% pula devaluation.	Competitiveness measure.
May 2005	Exchange rate regime change	REER stability and to avoid discrete adjustments
February 2013	Disclosure of basket weights and rate of crawl	Transparency promotion
January 2015	Adjustment of pula basket weights and rate of crawl.	Reflection of recent inflation trends.
January 2016	Upward adjustment of pula basket rate of crawl.	Reflection of monetary development expectations.

Source: Bank of Botswana Annual Reports (Various issues).

Following concerns about imported inflation from neighboring South Africa, the pula was revalued by 5 percent in 1977. This was also a strategic move designed to showcase the strength of the pula, which by then was backed by increasing official international reserves accumulated from rising diamond revenues. In 1979, rand/pula equality expired when South Africa adopted a floating exchange rate regime and took the rand off the US dollar peg. This move, along with the rapid appreciation of the rand against the US dollar (and consequently, the depreciation of the pula against the rand), had important implications for the rand/pula relationship as well as for domestic inflation. As a result, an adjustable peg was introduced in June 1980. The pula was pegged to a basket of currencies comprising the rand and the special drawing rights (SDR) currencies.[3] The composition of the basket was dictated by patterns in international trade, as well as the requirement to include vehicle currencies used in international trade. The rand was assigned a greater weight in the basket to reflect the importance of rand denominated consumption and net revenue decisions of a majority of Botswana firms (Masalila and Motshidisi, 2003). The weights of the currencies in the pula basket were not publicly disclosed at the time, however this has since changed as the Bank of Botswana now publishes these weights.

In the period between 1980 and 1991, the exchange rate was occasionally adjusted, with special attention paid to the rand/pula exchange rate, in order to meet policy makers' objectives of price stability and external competitiveness. During this period, the pula was subjected to several devaluations and revaluations. The 10 percent devaluation in May 1982 was a stabilization measure to mitigate some of the effects to the balance of payment crises following the oil shock of 1981. The devaluations of the mid to late 1980s were mostly in response to the collapse of the rand brought about by the economic sanctions and disinvestments in protest against the apartheid regime. The 5 percent revaluation in 1989 was as an anti-inflation measure due to fears of rising inflation in South Africa emanating from a sharp depreciation of the rand against major currencies.

The management of the exchange rate has required discrete changes to the composition of the basket of currencies as well, usually in response to changes in the direction and pattern of trade. The dominant weight of the rand in the basket has ensured a relatively stable exchange rate of the pula vis-á-vis the rand, and an overall depreciation of the pula against major currencies over time (Bank of Botswana, 2007).

[3]The SDR currencies are Great British pound (GBP), the United States dollar (USD), the euro (EUR) and the Japanese yen (JPY)

Concerns about significant REER appreciation, resulting from an appreciation of the NEER coupled with accelerating domestic inflation, led to two successive major devaluations in the mid-2000s. The pula was devalued by 7.5 percent and again by 12 percent in February 2004 and May 2005 respectively. In addition to this, the fact that the positive effects of past devaluations were often quickly reversed by the accompanying inflationary pressures resulting from the currency realignment meant that it was time for an exchange rate regime change. It was determined that a framework that allowed for small continuous adjustments to the exchange rate in the context of an effective monetary policy could achieve the desired objectives of export competitiveness (through REER stability) and price stability without the resultant inflationary pressures (Bank of Botswana, 2007). This led to the subsequent introduction of the crawling peg mechanism, which is still the current framework in place. This will be discussed at length in the next subsection.

3.2.2 Current Framework: Crawling Band/Peg Mechanism

The current policy framework is a crawling band/peg exchange rate mechanism. This regime switch was meant to ensure exchange rate stability while alleviating the need for sizeable periodic adjustments. Once the framework is in place, it is important for policy makers to avoid discrete devaluations or revaluations as this action may undermine the credibility of the system and can also be viewed as a reflection of some policy failures (Bank of Botswana, 2007).

Under the crawling peg framework, the domestic currency is pegged to a basket of currencies (usually comprising the country's most important trading partners), with varying weights and at a predetermined rate of crawl. Small periodic adjustments are made to the exchange rate, in response to selected economic indicators. There are two approaches to the rate of crawl. The first is *backward-looking*, here the rate of crawl generates changes to the exchange rate based on past inflation adjustments. The second type is *forward-looking*, here changes to the exchange rate are made based on a fixed predetermined rate of crawl. Since it is possible for the predetermined rate to be misaligned with inflation differentials between the home country and trading partner countries, it is subject to regular revisions.

In the case of Botswana, the mechanism is implemented by allowing for continuous changes to be made to the trade-weighted NEER of the pula. The rate of crawl is determined through a forward-looking approach where it is computed by the difference between the domestic inflation objective of the Bank of Botswana and the forecast inflation for trading partners.[4] The pula is currently pegged to a basket comprised of the the South African rand and the SDR at varying weights. Before 2015, the rand had the largest weight at 55 percent, while the SDR accounted for the remaining 45 percent. In January 2015, the weights of the currencies in the pula basket were changed to 50 percent each and the crawl was changed from -0.16 percent (downward crawl) per year to zero. In January 2016, the Bank of Botswana maintained the weights, but changed the rate of crawl from zero to 0.38 (upward crawl).

The implementation of the crawling band exchange rate mechanism is found to have overall yielded the desired results when compared with previous regimes. REER stability has improved overall, with the NEER registering a 9.8 percent depreciation over the 32 months between May 2005 and December 2007. It has also been found to be successful in dampening domestic inflationary pressures.

3.3 Review of Literature

While exchange rates, their determinants and forecasts have been studied at great length, most research has been focused on the more developed economies. Recent studies have revolved around the "Meese-Rogoff" paradox and the apparent failure of economic fundamentals to adequately forecast exchange rates.

Recent empirical work on exchange rates highlights the role of latent variables in explaining variations, as well as in improving exchange rate forecasts. This research stems from the seminal work by Meese and Rogoff (1983b), who found that structural models of exchange rates performed poorly in out-of-sample forecasting of exchange rates, when compared with the random walk model. This study led to the conclusion that the driftless random walk model is an excellent approximation

[4] In Botswana, the inflation objective is currently set at 3-5 percent

of exchange rates, and has since been used as a benchmark for testing the predictive ability of models. Meese and Rogoff (1983a) attributed the breakdown of structural models to misspecified empirical models, volatility of risk premia, long run real exchange rates and inadequate inflation measures.

As noted earlier, Bacchetta and van Wincoop (2004) attribute this poor performance to the 'scapegoat' effect. Recall that this effect involves wrongly assigning blame to these observable variables for exchange rate movements caused by unobservable factors. This study developed a simplified monetary model characterized by rational expectations and investor heterogeneity to illustrate the scapegoat effect. Bacchetta and van Wincoop (2004) show the possibility of rational confusion where investors falsely assign blame to current macroeconomic indicators for fluctuations caused by latent factors. This paper forms the foundation for the more recent Bacchetta and Van Wincoop (2013), which highlights the role of *expectations* of structural parameters, as opposed to structural parameters themselves, in determining the relationship between exchange rates and macroeconomic aggregates. Their argument here is that the scapegoat story tends to exacerbate these effects.

Greenaway-McGrevy et al. (2015) employ statistical factor analysis to explain fluctuations across a panel of 27 monthly exchange rates. The study finds that these variations are dominated by two unobservable factors, a dollar factor and a euro factor which can be interpreted as risk-based. The study also find that the dollar-euro model outperforms the random walk in out-of-sample forecasting of exchange rates at longer horizons. Greenaway-McGrevy et al. (2015) therefore recommend that future research needs to consider the dominance of these dollar-euro factors in exchange rate modeling, and even go on to assert that understanding the determinants of these two factors will be crucial for explaining bilateral exchange rate movements for *any* currency.

Engel and West (2005) examine the puzzle that macroeconomic aggregates fail to predict exchange rates. They conclude that there is no evidence to support the notion that exchange rate variations are only due to observable macroeconomic variables. Engel et al. (2015) test the predictive ability of a myriad of models incorporating varying combinations of unobservable variables obtained from a panel of 17 bilateral US exchange rates and observable fundamentals. The latent factors are constructed from exchange rates and forecasting performance is determined by comparing the root mean squared prediction errors of four models against the random walk. Like Greenaway-McGrevy et al. (2015), the factor models are found to dominate the random walk at longer horizons.

Berg and Mark (2015) identify third country effects as latent factors responsible for bilateral exchange rate effects for a panel of countries. The study extracts components from macroeconomic fundamentals of a country beyond the two associated with the bilateral exchange rate, to test if these components contain any important information for the variations in the bilateral exchange rate. The study finds that these third country effects contribute significantly to variations in the bilateral exchange rate. Felício and Rossi Júnior (2014) utilize a PCA to extract unobservable factors in order to examine the usefulness of factor models in explaining the exchange rate dynamics of the Brazilian real. The latent variables are isolated from a panel of 18 currencies. The results of the study show that the estimated factors, which they interpreted as being related to shocks in international financial markets, contained viable information for forecasting and understanding exchange rate dynamics.

Given the necessity for isolating latent variables for use in the analysis of exchange rates, the PCA methodology is one candidate for the extraction of unobservable components from data panels.

Despite the heavy reliance of Botswana on the external sector, there is only a limited number of country-specific studies on its exchange rate dynamics. Panel studies that include Botswana tends to draw general conclusions that do not necessarily take the country's unique features into consideration.

One of the most influential country-specific studies regarding the Botswana pula is by Atta et al. (1999). This study investigates the relationship between the exchange rate and the determination of the price level in Botswana. The study utilizes cointegration methods and develops a dynamic error correction model to establish exchange rate-inflation dynamics in the economy. The results show a relation between the pula exchange rate and *South African* prices. This work builds on the study by Leith (1991) who examines exchange rate changes and foreign price pass-through to Botswana's domestic prices. The study finds evidence of complete pass-through from foreign price levels and exchange rate changes to the domestic price level. Leith (1991) goes on to establish that external competitiveness in Botswana came at the expense of imported inflation.

Iimi (2006b) applies the behavioral equilibrium exchange rate (BEER) approach to the pula to investigate its possible misalignment with economic fundamentals for the period between 1985 and 2004. This approach involves the estimation of an equilibrium behavioral equation of the pula exchange rate over the sample period. The findings of the study show evidence of an exchange rate undervaluation in the late 1980s and a 5 to 10 percent overvaluation in the years after. Iimi (2006b) thus recommends an exchange rate devaluation to correct the misalignment, and a more holistic approach and structural reforms to address some of the challenges of maintaining a crawling peg exchange rate in the presence of a tight fiscal position due to high health expenditures and high poverty and unemployment rates. Deléchat and Gaertner (2008) use a combination approach to investigate the exchange rate level of the pula. The study takes particular note of the possible implications which may arise as a result of the country's heavy reliance on diamonds exports. Their choice of methodologies includes a construction of balance of payments trends and some REER indices, as well as econometric estimations and examination of the current account based on the exhaustibility of diamond revenue. The study finds that while the pula REER was initially overvalued, it has since realigned with macroeconomic fundamentals. Motlaleng (2009) explores trends and volatility of the Botswana pula exchange rate for a period which covers both the pre and post regime change. The findings show that pula stability improved with the introduction of the crawling peg regime, and that overall, there is evidence of a continual depreciation of the exchange rate.

3.4 Methodology

This section outlines some of the key features of the PCA approach, which is essential for answering the set research questions. This technique is crucial for extracting the unobservable components common to Botswana's bilateral exchange rates since it seeks to reduce the dimensionality of a data set while maintaining a minimal loss of information.

3.4.1 Principal Component Analysis

The PCA method enables us to explain the covariance-variance structure between a given number of variables of interest. The technique aims to statistically extract common factors responsible for the evolution of a set of variables, while at the same time preserving as much of the variation in the original data set as possible. To achieve this, the data is transformed into a new set of uncorrelated variables, called 'principal components'. These new variables are ordered in such a way that the components that explain the most variation in the original data set appear first (Jolliffe, 2002).

Let $\mathbf{x}$ be a vector of p numeric variables. Total variability in the system will therefore depend on p components. However, it is possible to find a smaller set of derived variables, say k (where $k \ll p$), that accounts for almost the same amount of variation as the original p variables. That is, these derived k variables preserve most of the information contained by the variances, covariances and/or correlations from the p original variables. In this way, it becomes possible to replace the p original variables with the k principal components.

Consider a linear function comprised of elements of the vector $\mathbf{x}$ with a maximum variance, such that the following linear relationships hold:

$$\begin{aligned} PC_1 &= \mathbf{a_1'x} = a_{11}x_1 + a_{12}x_2 + ... + a_{1p}x_p \\ PC_2 &= \mathbf{a_2'x} = a_{21}x_1 + a_{22}x_2 + ... + a_{2p}x_p \\ &\vdots \\ PC_p &= \mathbf{a_p'x} = a_{p1}x_1 + a_{p1}x_2 + ... + a_{pp}x_p \end{aligned} \tag{3.1}$$

$PC_k = \mathbf{a}_k'\mathbf{x}$ is the k^{th} principal component derived from the original p variables. Each linear function, $a_k'x_k$ is uncorrelated with all the preceding ones, having maximum variance. For instance, the k^{th} principal component ($\mathbf{a}_k'\mathbf{x}$) has maximum variance subject to being uncorrelated with $PC_1, PC_2..., PC_{k-1}$.[5] It is possible to obtain up to p principal components, however the PCA technique enables us to have a smaller number of components (that is, k) which explain the majority of the variation found in $\mathbf{x}$.

Now, let $\mathbf{\Sigma}$ be the known covariance matrix of vector $\mathbf{x}$.[6] $\mathbf{a}_k$ is an eigenvector of the covariance matrix $\mathbf{\Sigma}$ with a corresponding eigenvalue equal to λ_k.[7]

While the PCA methodology does not ignore covariances, the main focus of the analysis is on variances. The variance of the k^{th} principal component is given by equation (3.2) below:

$$Var(PC_k) = \mathbf{a}'_k \mathbf{\Sigma} \mathbf{a}_k \tag{3.2}$$

From the equations above, it is possible to change $Var(PC_k)$ by varying $\mathbf{a}_k$. In order to ensure uniqueness therefore, a normalization constraint is imposed by choosing $\mathbf{a_k}$ such that it has unit length, that is $\mathbf{a'}_k\mathbf{a}_k = 1$. If this is the case then, $Var(PC_k) = \lambda_k$.

3.4.2 Computing Principal Components

This subsection extends the discussion in the preceding section and follows Jolliffe (2002)'s derivation of principal components.

Recall that the first principal component is given by $PC_1 = \mathbf{a}'_1\mathbf{x}$ and that $Var(PC_1) = \mathbf{a}'_1\mathbf{\Sigma}\mathbf{a}_1$, where the vector of constants $\mathbf{a}_1$ is constrained to have a unit length. According to Jolliffe (2002), choosing constraints where $\mathbf{a'}_k\mathbf{a}_k$ does not equal a constant results in an overly complicated optimization problem, and also yields variables which differ from the principal components.

[5] That is, $\mathbf{a}'_k\mathbf{x}$ is uncorrelated with $\mathbf{a}'_1\mathbf{x}, \mathbf{a}'_2\mathbf{x}, \ldots, \mathbf{a}'_{k-1}\mathbf{x}$.

[6] The *(i,j)*th element of $\mathbf{\Sigma}$ represents the known covariance of the i^{th} and j^{th} elements of our vector of numeric variables, $\mathbf{x}$ for $i \neq j$, and the variance of the j^{th} element when $i = j$ (Jolliffe, 2002).

[7] Note that, $\lambda_1 \geq \lambda_2 \geq ...\lambda_p \geq 0$.

To derive the form of the principal components therefore, we maximize $Var(PC_1) = \mathbf{a}_1'\mathbf{\Sigma}\mathbf{a}_1$ subject to $\mathbf{a}_1'\mathbf{a}_1 = 1$.

That is, we maximize:

$$\mathbf{a}_1'\mathbf{\Sigma}\mathbf{a}_1 - \lambda(\mathbf{a_1'a_1} - 1) \tag{3.3}$$

Imposing the first order condition for maximization, we differentiate equation (3.3) above with respect to $\mathbf{a}_1$ and set it to zero. The result is:

$$\mathbf{\Sigma}\mathbf{a}_1 - \lambda\mathbf{a}_1 = 0 \tag{3.4}$$

which simplifies to:

$$\mathbf{a}_1(\mathbf{\Sigma} - \lambda\mathbf{I}_p) = 0 \tag{3.5}$$

$\mathbf{I}_p$ is a $p \times p$ identity matrix, and as before, λ is an eigenvalue of the covariance matrix, $\mathbf{\Sigma}$ with a corresponding eigenvector, $\mathbf{a}_1$. As there are p eigenvectors in all, the next task is to determine which of these will give $\mathbf{a}_1'\mathbf{x}$ the largest variance. The equation below shows the quantity that is to be maximized to achieve this.

$$\mathbf{a}_1'\mathbf{\Sigma}\mathbf{a}_1 = \mathbf{a}_1'\lambda\mathbf{a}_1 = \lambda\mathbf{a}_1'\mathbf{a}_1 = \lambda \tag{3.6}$$

From equation (3.6) therefore,

$$Var(\mathbf{a}_1'\mathbf{x}) = \mathbf{a}_1'\mathbf{\Sigma}\mathbf{a}_1 = \lambda_1 \tag{3.7}$$

The eigenvector $\mathbf{a}_1$ is the one that corresponds with the largest eigenvalue of the matrix $\mathbf{\Sigma}$, given by λ_1.

In summary, the k^{th} principal component of the the vector $\mathbf{x}$ is $\mathbf{a}_k'\mathbf{x}$, with a variance $Var(\mathbf{a}_k'\mathbf{x}) = \lambda_k$. The variance of the principal component is equal to the k^{th} eigenvalue of $\mathbf{\Sigma}$ and has a corresponding eigenvector, $\mathbf{a}_k$.

3.4.3 Interpretation of PCA Results

The number of latent variables or components obtained from a PCA is determined by the number of observed variables in the original dataset. However, it is often the case that not all the obtained principal components are retained and interpreted as only a few may account for the most variation in the observed variables. There are various criteria for the selection of the number of components to be retained for further analysis. For our purposes however, only four of the most widely used rules in practice will be discussed. These are: the cumulative/percentage of variation explained, the scree plot or scree graph criterion, Kaiser's Rule or the eigenvalue-one method, and finally the comprehensibility/interpretability criterion.

The cumulative/ percentage of variation explained procedure suggests retaining a required number of principal components enough to satisfy some predetermined minimum cut-off value. The retained number of components is therefore the smallest number for which the chosen minimum threshold is exceeded. The choice of the minimum set value is mostly subjective and depends on a number of factors, providing that the set cutoff preserves the most amount of information in the original data. The acceptable cut-off range in practice is between 70 percent and 90 percent, however it is possible for the figure to be higher or lower depending on the data set (Jolliffe, 2002). The scree plot or scree graph method proposed by Cattell (1966) suggests that the number of principal components to be retained is determined by the point where the slope of the graph changes from 'steep' to 'shallow', that is, the position of the break or elbow of the scree graph. In this case, the principal components which appear before the break are said to be the ones containing the most meaningful information and should therefore be retained. The Eigenvalue-one method retains principal components with eigenvalues exceeding one, these are said to explain the most amount of variation. The comprehensibility criterion simply requires that there should be an appropriate number of variables which have significant loadings on each selected principal component, and that these variables should comply with theory (Felício and Rossi Júnior, 2014).

3.4.4 Regression Analysis

Once the principal components have been isolated, the next step is to interpret the unobservable variables to give them economic meaning. This can be achieved by carrying out a regression analysis as in Ponomareva et al. (2015). Therefore, the following model is estimated:

$$Y_t = c + \alpha Y_{t-1} + X_t \beta' + X_{t-i} \gamma' + \epsilon_t \tag{3.8}$$

Y_t is the estimated principal component, c is a constant, X_t and X_{t-i} contain current and lagged values of the explanatory variables.

Three model approaches to estimation are used. The first is an Ordinary Least Squares (OLS) regression of the first principal component against the entire set of current and lagged values of the explanatory variables.

However, OLS estimates have been criticized for, among others, their prediction inaccuracy when faced with a large set of explanatory variables or highly correlated regression coefficients. That is, even though OLS estimates are usually characterized by low bias, they may have a rather inflated variance. In addition to this, when faced with a large set of explanatory variables, it is often profitable to identify a smaller subset of the original predictors which most present the strongest effects (Hastie et al., 2011). This problem can be addressed in two ways, the first of which is through *subset selection*, and the other is by employing model shrinkage techniques known as *ridge regressions*.

Subset selection, which is our second estimation approach, is a discrete technique whereby explanatory variables are either retained or removed from the model, it encompasses methods such as best-subset selection, forward and backward-stepwise selection and forward-stagewise regression. While this method does improve the accuracy of estimates by yielding a lower prediction error than the full model, its discrete nature means that it is variable in model selection and will be highly influenced by small changes in the data.

Model shrinkage techniques are more continuous in nature and therefore tend to be superior in terms of prediction accuracy and stability. Ridge regression shrinks the model coefficients by imposing a size constraint on the residual sum of squares. This helps address the problem that arises when a large positive coefficient for one variable is canceled by a similarly large negative coefficient for another variable (Hastie et al., 2011).

Tibshirani (1996) proposed a statistical shrinkage technique known as the least absolute shrinkage and selection operator, or simply "lasso". This method is a hybrid of subset selection and ridge regression in that it carries out variable selection as well as model shrinkage. Here, the model coefficients are shrunk while others are set to be equal to zero. This shrinkage approach improves prediction accuracy and allows for a more parsimonious selection of variables in the model. This makes up our third approach.

It is worth noting though, that the shrinkage techniques, that is ridge regression and the lasso method, both reduce the variance of the predicted values. thus improving overall prediction accuracy, but at the expense of model bias. The two techniques sacrifice a little bias in order to reduce the variance of the model estimates. However, based on the discussion above, the lasso method is most suited for our estimation as it overcomes some of the shortcomings associated with OLS estimations while maximizing the benefits of both the subset selection and ridge regression methods. A brief overview of the lasso method is discussed in Appendix B.2.

3.5 Data

The empirical analysis focuses on ten of Botswana's bilateral exchange rates, namely the South African rand (ZAR), the British pound (GBP), the euro (EUR), the United States dollar (USD), the Japanese yen (JPY), the Norwegian krone (NOK), the Israeli new shekel (ILS), the Hong Kong dollar (HKD), the Indian rupee (INR) and the Chinese yuan (CNY). These currencies were selected based on their relevance to the Botswana economy as well as in terms of trade weights.

Data for the South African rand and the SDR currencies were obtained from the Bank of Botswana, while data for the Norwegian krone were obtained from the

Bloomberg database. Due to data availability constraints, cross currency exchange rates were calculated for the Israeli new shekel, the Hong Kong dollar, the Chinese yuan and the Indian rupee using their respective US dollar exchange rate data obtained from the Bloomberg database. Our analysis focuses on the monthly growth rates of the bilateral exchange rates.

In order to interpret the extracted principal components and to give them economic meaning, we consider selected Botswana, US and South African financial and macroeconomic variables in the regression analysis. Models consisting entirely of Botswana fundamentals, South African fundamentals, and combinations of both were eliminated from the analysis in pre-testing as the results were insignificant.

For our estimation therefore, we consider the Chicago Board of Options Exchange Volatility Index, called the VIX, also known as a market fear or market volatility risk index. This index is commonly used to represent global market volatility as conveyed by option prices on the S&P500 equity index (González-Hermosillo, 2008). The analysis also includes the growth of US capacity utilization and the federal funds rate, as well as the US yield slope, measured by the difference between the ten-year government bond and the three-month treasury bill rate. We also consider the policy rate of the South African Reserve Bank (SARB), known as the repo rate. Our model also includes the inflation rate for Botswana as a measure of economic activity, as well as diamond prices to capture Botswana's involvement in the global diamond market. We also consider a sovereign spread calculated as the difference between yields on the South African 10 year government bond and its US counterpart. Data for all variables in the model were obtained from the Federal Reserve Economic Data (FRED) database, with the exception of Polished Price Diamond Price index series which were obtained from the Bloomberg database.

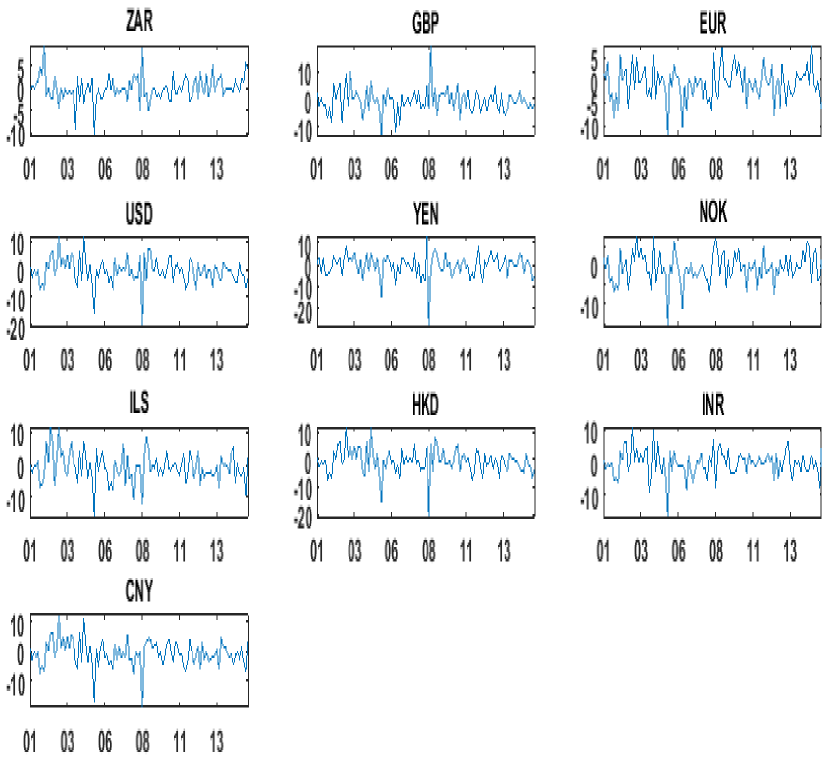
3.6 Empirical Results

This section discusses the results of the analyses undertaken in our study. It begins with a brief discussion of the preliminary analyses, followed by the results of the PCA exercise. As previously stated, in order to give the obtained principal components economic meaning, we employ a regression analysis of the most important factor against selected macroeconomic and financial variables. The analysis concludes with forecasting exercises to determine if models incorporating the principal component outperform the hailed random walk benchmark.

3.6.1 Preliminary Analysis and Descriptive Statistics

Figure 3.1 below shows the evolution of monthly growth rates of some of Botswana's nominal exchange rates for the sample period, January 2001 to December 2015. For our purposes, we define the pula exchange rate as units of foreign currency per domestic currency, therefore an *increase* in the exchange rate implies an appreciation, while a depreciation is signified by a *decrease* in the exchange rate.

FIGURE 3.1: Growth Rates of Currencies.



We observe two prominent depreciations of the pula over the sample period for most of the bilateral exchange rates. The first is observed in the mid-2000s and coincides with the back-to-back devaluations of the pula by 7.5 percent and 12 percent in February 2004 and May 2005 respectively.

The second sharp depreciation occurs around the onset of the Global Financial Crisis (GFC). With the exception of the South African rand, the pula weakened considerably against most major trading partner currencies at this time. We take particular note of the sharp depreciation against the US dollar and Japanese yen, which was a reflection of the more pessimistic sentiment of market participants in response to the crisis, and the consequent decline in risk tolerance. This behavior led to the so called 'flight to quality' or 'flight to safety' behavior, which is characterized by an increase in the demand for assets denominated in what is considered to be the more safe advanced economy currencies. Sharp depreciations are also observed against the yuan and the Hong Kong dollar, which is a reflection of the close ties between the two currencies and the US dollar. Overall, this period saw a total depreciation of the pula against the SDR currencies of nearly 18 percent. The 10 percent depreciation of the pula against the South African rand over this same period was mostly a consequence of the nearly 26 percent depreciation of the rand against the SDR (Bank of Botswana, 2008). Once again, this may be a reflection of investors' reduction in risk tolerance for assets denominated in emerging economy currencies, that is, the uncertainty that resulted from the GFC caused investors to move their investments from emerging markets such as South Africa to the more developed markets like the US, which is considered a safe haven in comparison to the riskier developing economies.

We see a reversal in the trend towards the end of the period, with the pula appreciating against most major currencies and depreciating against the rand. The strengthening of the rand at this time was mainly due to significant reductions in South Africa's current account deficit, coupled with escalating prices of gold, and platinum and a boost in financial inflows due to the 2010 Soccer World Cup, that was hosted by the country (Bank of Botswana, 2009).

Table 3.2 below is a summary of the descriptive statistics of the bilateral exchange rates over the sample period. The mean, standard deviation, minimum and maximum values are reported.

Table 3.2: Descriptive Statistics.

Series	**Mean**	**SD**	**Min**	**Max**
ZAR	-0.0001	0.0173	-0.0926	0.0834
GBP	-0.0037	0.0266	-0.1320	0.0665
EUR	-0.0045	0.0251	-0.1114	0.0544
USD	-0.0035	0.0279	-0.1476	0.0672
JPY	-0.0031	0.0331	-0.1742	0.0712
NOK	-0.0036	0.0260	-0.1101	0.0682
ILS	-0.0038	0.0290	-0.1262	0.0865
HKD	-0.0035	0.0279	-0.1492	0.0671
INR	-0.0015	0.0262	-0.1447	0.0689
CNY	-0.0049	0.0285	-0.1464	0.0672

The rand/pula bilateral exchange is the least volatile, which may be a reflection of the historic dominant rand weight in the pula basket, while the yen/pula exchange rate is the most volatile. In addition to this, we note that on average, the pula has been depreciating against trading partner currencies, which can be explained by the downward crawl adopted by the Bank of Botswana over the majority of the sample period.

Table 3.3 below shows the results of the Augmented Dickey-Fuller (ADF) test for stationarity as well as those of the Kwiatkowski-Phillips-Shmidt-Shin (KPSS) test.

Table 3.3: Tests for Unit Root.

Series	***ADF***	***pValue***	***KPSS***	***pValue***
ZAR	-2.8807	0.0045	0.1087	0.1000
GBP	-2.5500	0.0110	0.0767	0.1000
EUR	-2.9063	0.0043	0.0571	0.1000
USD	-2.6882	0.0077	0.0527	0.1000
JPY	-3.0927	0.0028	0.0818	0.1000
NOK	-3.1703	0.0022	0.0891	0.1000
ILS	-2.7837	0.0057	0.0861	0.1000
HKD	-2.6870	0.0078	0.0527	0.1000
INR	-2.6742	0.0080	0.0687	0.1000
CNY	-2.5425	0.0112	0.0707	0.1000

Note: The critical values for the ADF and KPSS tests at 5 percent significance level are -1.94 and 0.1460 respectively.

The results of the ADF test show that the null hypothesis of unit for all eight variables is rejected, we therefore conclude that the series are stationary. The results of the ADF are confirmed by those of the KPSS test, we fail to reject the null hypothesis of stationarity and conclude that the series contain no unit root.

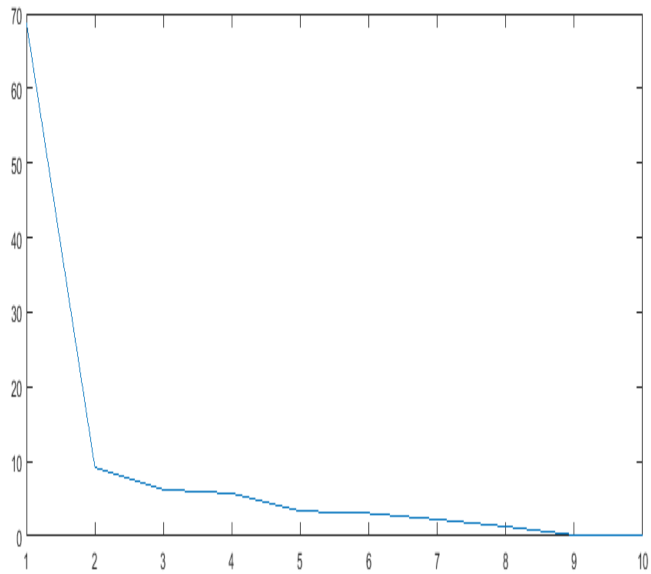
Correlation coefficients between the growth rates of the currencies were also obtained. These results are summarized in table B.1 in the appendix section. The growth of the South African rand is least and negatively correlated with all the growth rates of other currencies and records the lowest correlation coefficient of 23 percent with the Indian rupee. On the other hand, the growth rates between the US dollar and the Chinese yuan record the highest correlation at 99 percent, a reflection of the close link between the two economies.

3.6.2 PCA Results

The PCA methodology enables us to isolate latent components which can contribute to our understanding of variations in the bilateral exchange rates of the Botswana pula.

Figure 3.2 below is a scree plot of the eigenvalues obtained, starting with the largest component and arranged in descending order. The scree plot is a very useful aid in presenting PCA results. It is a plot of the size of eigenvalues versus their number, and it assists in the visual analysis of each component's contribution to the variability of the data.

FIGURE 3.2: Scree Plot of Eigenvalues



From the figure, we see that the first three components contribute just over 83 percent of fluctuations in the ten bilateral exchange rates, with the first principal component explaining the most amount of variation at 66.25 percent. The next three components together account for nearly 13 percent of total variation, while the contribution of the last four components, although small in comparison, is not negligible at 4.22 percent. This information is summarized in the table below.

TABLE 3.4: Contribution of the Principal Components to Variations in Bilateral Exchange Rates.

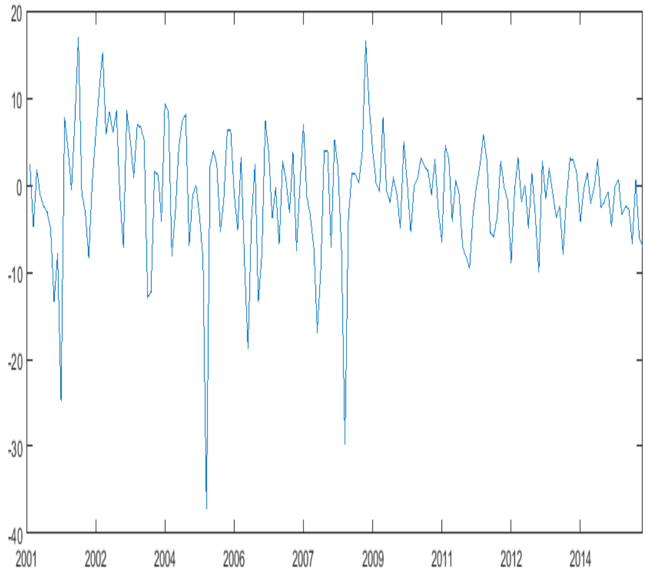
Principal Component	Explained Variation	Cumulative
PC1	66.2523	
PC2	9.7886	76.0409
PC3	6.9724	83.0133
PC4	6.0365	89.0498
PC5	3.4515	92.5013
PC6	3.2749	95.7762
PC7	2.4296	98.2058
PC8	1.5436	99.7494
PC9	0.2428	99.9922
PC10	0.0078	100

3.6.2.1 Interpretation of PCA Results

There are ten principal components. We use the scree plot criterion to determine the number of components to interpret. By retaining the first principal component for interpretation, this also satisfies the cumulative/proportion of variance explained methods as well, since the first component explains 66 percent of the variation in the bilateral exchange rates. This figure is considered substantial enough to inform our results.

The figure below is a plot of the first principal component for the period January 2001 to December 2015.

FIGURE 3.3: First Principal Component of Returns (2001-2015)



There are three notable sharp drops in the first principal component over the sample period. The first is observed in 2001 and coincides with the 9/11 attacks in the US. This however is immediately followed by a rather rapid rise within a year. A similar trend is observed during the acute phase of the GFC (the third drop), where the first principal component initially declines rather rapidly before spiking up within a few months.

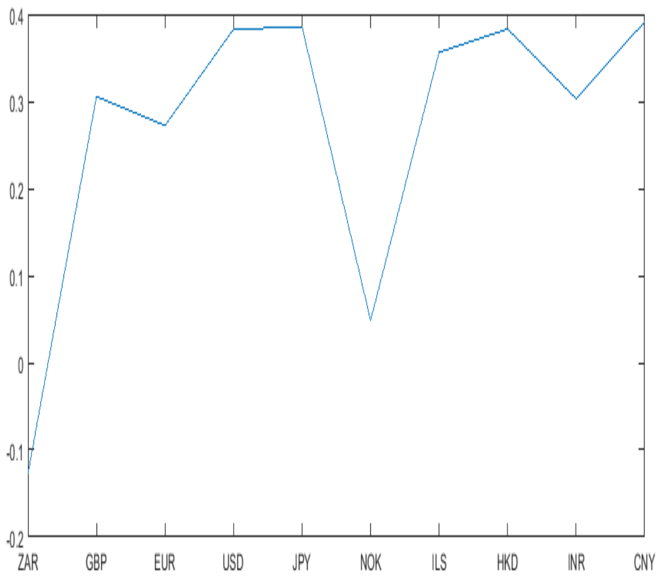
The second steep decline of the first principal component is the largest and occurs in the mid-2000s. This particular drop corresponds with policy actions and a regime change undertaken by the Bank of Botswana in efforts to ensure competitiveness and stability of the pula. Recall that there were two successive devaluations in February 2004 and May 2005 and the adoption of the crawling peg exchange rate regime in May 2005. We therefore conclude that this sharp decrease is attributable to these policy actions. This is the only sharp swing that we can attribute to domestic conditions.

The information above may suggest that, contrary to *apriori* expectations, the largest determinant of fluctuations in the pula exchange rate is not purely a domestic factor, but rather it is one related to shocks in global markets, and quite possibly the US economy.

Our hypothesis that variations in the pula exchange rate are mainly determined by activity in world markets and to a certain extent movements in the US dollar, is backed by two main reasons, the first one being the dominant role of the US dollar as a funding and foreign reserve currency. The second reason is the level of Botswana's involvement in US-dollar-based trading in the global diamond market. This hypothesis that the first principal component is related to foreign factors is in line with Berg and Mark (2015) and Felício and Rossi Júnior (2014) who identified third country effects and global markets factors as some of the latent variables explaining exchange rate dynamics. To test this hypothesis therefore, we first check the loadings for the first principal component as well as the correlation coefficients between the first three factors and the growth rates of the currencies.

Figure 3.4 below shows the factor loadings for the first principal component, and table B.1 in appendix B shows the correlation coefficients between the first three principal components and the bilateral exchange rates. The factor loadings essentially capture the degree to which each currency contributes to the meaning of the first component, which can assist in our interpretation of this latent variable.

FIGURE 3.4: First Principal Component Loadings



The results show that the first principal component has positive loadings for all the currencies except for the South African rand. Surprisingly, the component is not only negatively related to the rand/pula exchange rate, it is also least correlated to it. Furthermore, this component is mostly related to the the US dollar, the Chinese yuan, the Hong Kong dollar and the Japanese yen.

Past empirical work on common factors influencing exchange rate variations identifies the JPY/USD exchange rate as being one of these important factors. This is because of the yen's role in carry trade and it is one of the currencies that dominate the foreign exchange market (Greenaway-McGrevy et al., 2015). This could also be true for the yen/pula exchange rate in this study and explain the high correlation between Japanese yen and our largest principal component. The high correlation with the yuan and the Hong Kong dollar is largely explained by the two currencies' close ties with the US dollar.

The negative and low correlation between the extracted component and the rand may be viewed as being counter-intuitive due to the close economic ties between Botswana and South Africa. One would expect that the factors driving the largest variations in Botswana's fundamentals would be closely related to South African variables and therefore have a much high correlation. However, even though the correlation between the first principal component and the rand is low in comparison to the other currencies, it is not negligible at nearly 50 percent. In addition to this, the inverse relationship makes for an interesting result that is worth discussing further.

If indeed the first principal component is a risk-related factor influenced by shocks in global financial markets, the inverse relationship with the rand is not an unexpected result. For instance, a positive global shock will tend to increase investors' appetite or tolerance for risk, which consequently influences their choice between investing in developed economies versus in emerging markets. Conversely, periods of distress in global financial markets are characterized by suppressed appetite for risk (González-Hermosillo et al., 2003). Assets denominated in emerging economies currencies such as the South African rand tend to have higher returns than those belonging to the more mature economies. Therefore, the demand for emerging market assets will change depending on how much risk investors are prepared to accept. This risk-on risk-off behavior is largely determined by global economic activity. That is, investors' risk tolerance will increase when faced with a more optimistic global economic outlook. This will see them gravitating towards the more risky emerging economies assets, which consequently increases the demand for currencies such as the rand, leading to their appreciation against most major currencies.

In our case therefore, a positive global shock will lead to an increase in demand for the more risky South African assets. The rand appreciates due to the resultant increase in the demand for the currency, leading to a subsequent weakening of the pula. The increased global risk appetite favors South Africa more than Botswana as the former has a more established and diversified financial sector in comparison.[8] Since the pula is softly pegged to the rand, the full effect of the strengthening of the rand on the Botswana pula is muted by the soft peg. Our argument here is that in the presence of the soft peg, an increase in risk tolerance will reduce the demand for advanced economy assets, the SDR currencies weaken while the rand and other emerging market currencies strengthen. Therefore the pula depreciates against the rand, it will however strengthen against the SDR but by more than for the case with no peg. A hard peg with the rand would suggest no variation between the two currencies, and in this case the pula will strengthen against the SDR by a lot more with the rand. The other extreme of no peg however would amplify the effects of the increase in risk tolerance. Under this scenario, the rand will strengthen against the SDR (as the SDR currencies weaken against emerging market currencies), the pula strengthens against the SDR as well but weakens more against the rand.

3.6.3 What Determines the First Principal Component?

To further test our hypothesis in the preceding subsection, we regress the first principal component against several current and lagged values of Botswana, US and South African financial and macroeconomic fundamentals. To reiterate, the variables considered for the estimation include Botswana's inflation rate, diamond prices, the VIX index, US capacity utilization, the federal funds rate, the US yield slope, the South African repo rate, the bond spread between the South African 10 year government bond and its US counterpart. Lastly, we include a dummy variable to capture the exchange rate regime change in Botswana which takes the value of one in May 2005 and zero otherwise.

[8] For example, the Johannesburg Stock Exchange is the largest in Africa and the 19th largest in the world.

Table 3.5 below shows the results of the regression analysis. We report the estimates obtained for each of the three models as well as their statistical significance. To recap, the first model is a regression of the estimated component against the entire set of explanatory variables, the second model is a shrunk version of the first model where the first principal component is regressed against only the significant variables from model 1. Lastly, the lasso shrinkage technique is employed to obtain the third model, which represents a more parsimonious selection of the explanatory variables.

Table 3.5: OLS Regression Results.

Variable	Model 1	Model 2	Model 3
Constant	-0.52	0.00	-0.55
Y_{t-1}	0.16*	0.00	0.21**
Growth of VIX $Index_t$	-1.62**	-1.96***	-2.61***
US Growth of Capacity $Utilization_t$	-0.19	0.00	0.00
US Federal Funds $Rate_t$	20.98**	26.55***	0.00
US Yield $Slope_t$	-3.96*	0.00	0.00
SA REPO $Rate_{t-1}$	3.29	0.00	0.00
SA-US Bond $Spread_t$	-8.46***	-7.00***	0.00
Regime Change $Dummy_t$	-0.79*	-0.74*	-0.55
BW Inflation $Rate_t$	-1.87	0.00	0.00
Diamond $Prices_t$	1.58	0.00	0.00
Growth of VIX $Index_{t-1}$	-0.49	0.00	-0.78*
US Growth of Capacity $Utilization_{t-1}$	0.69	0.00	1.22**
US Federal Fund $Rate_{t-1}$	-27.58**	-26.48***	0.00
US Yield $Slope_{t-1}$	8.35**	5.09**	0.00
SA REPO $Rate_{t-1}$	-5.84	0.00	0.00
SA-US Bond $Spread_{t-1}$	10.62***	7.93***	0.00
Regime Change $Dummy_{t-1}$	-3.16***	-3.22***	-3.13
BW Inflation $Rate_{t-1}$	3.03	0.00	0.00
Diamond $Prices_{t-1}$	-1.24	0.00	-0.37
Growth of VIX $Index_{t-2}$	-0.20	0.00	0.00
US Growth of Capacity $Utilization_{t-2}$	0.12	0.00	0.00
US Federal Fund $Rate_{t-2}$	4.87	0.00	0.00
US Yield $Slope_{t-2}$	-5.43**	-4.72**	0.00
SA REPO $Rate_{t-2}$	5.49*	1.81**	1.19*
SA-US Bond $Spread_{t-2}$	-2.30	0.00	0.84*
Regime Change $Dummy_{t-2}$	0.52	0.00	0.78*
BW Inflation $Rate_{t-2}$	-2.03	0.00	0.00
Diamond $Prices_{t-2}$	-0.06	0.00	0.00
Adjusted-$\bar{R}^2$:	0.532	0.531	0.486
Correlation:	0.7914	0.7555	0.7216

Notes:*, ** and *** show significance level at 1, 5 and 10 percent.

There is a high correlation of nearly 80 percent between the actual and fitted values for the first model, which has an adjusted $\bar{R}^2$ of 0.532. Model 2, which contains only the most statistically significant variables from model 1 has a correlation coefficient of 75 percent and a slightly lower adjusted $\bar{R}^2$ of 0.531. The first and the second models are close and have nearly identical selections of significant variables. Model 2 drops the lag of the first principal component and the current value of the US yield slope from the selection.

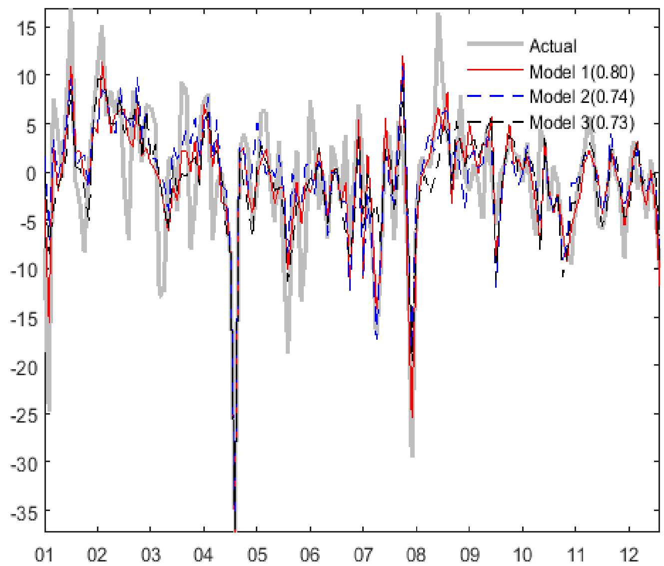
The lasso shrinkage model tests the selections made by the second model, and makes additions to the list of the variables already selected. The model has a correlation coefficient and associated $\bar{R}^2$ of 72 percent and 0.49 respectively. The lasso technique also additionally selects the lagged value of the first principal component, lagged values of the growth of the VIX index, US capacity utilization, the SA-US 10 year bond spread as well as the prevailing exchange rate regime, as being significant in explaining movements in the first principal component.

The results presented above further support our interpretation of the first principal component as being related to global shocks and perceptions about risk and market sentiment. We base our interpretation on the results of model 3 since it is the more parsimonious model. Based on these findings, the identified component is negatively related to contemporaneous and lagged values of the VIX index, implying that an increase in market fear lowers investors' appetite for risk and therefore their willingness to take on riskier emerging market assets. In the same way, it is positively related to two-month lagged values of the SA-US bond spread. This result is in line with *apriori* expectations. A wider bond spread in a previous period corresponds with relatively lower interest rates in the US. Investors therefore expected US interest rates to be higher in the current period, implying increased market sentiment and a higher risk appetite for South African assets. We see a persistent effect of the crawling peg coming through in the results, which is not surprising since the current regime allows for a continuous adjustment of the exchange rate as the Bank of Botswana sees fit. The estimated component is also positively related to lagged values of the growth of US capacity utilization. Economic theory states that capacity utilization is determined by the business cycle. Increases in capacity utilization tend to be inflationary, due to rising output, bond prices fall as a result and yields increase, leading to increased market sentiment and a high risk tolerance. Investors therefore are more likely to increase their demand for emerging economy assets. The first principal component is also positively but weakly related to the lagged South African policy rate, an increase in the repo rate may signal higher yields in the South African financial markets and therefore an increase in investors' risk tolerance for the country's assets.

Based on the preceding discussion therefore, we reiterate that the largest component driving Botswana's bilateral exchange rates is a risk related factor driven by global shocks and hence investors' willingness to take on risk by investing in emerging markets. The effects of this factor is transmitted to the Botswana economy indirectly through its impact on South Africa.

The figure below shows actual and fitted values of the first principal component and the three models discussed above, with the correlation coefficients shown in brackets for each model.

FIGURE 3.5: Actual and Fitted Values of the First Principal Component



All three models fit the actual values of the first principal component really well. The models also appear to successfully pick both the three largest turning points as well as a lot of the smaller turns which further assures the success of our estimations.

To summarize, current and lagged values of some key US and South African macroeconomic fundamentals explain nearly 50 percent of fluctuations in the most important factor determining Botswana's bilateral exchange rates.

3.6.4 Forecasting the Bilateral Exchange Rates

The next step of the analysis tests the predictive ability of the identified principal component model in forecasting Botswana's bilateral exchange rates. This enables us to determine if the information contained in Botswana's bilateral panels can be useful in forecasting the exchange rate. We expect the first principal component to have some forecasting ability of the bilateral exchange rates, particularly given the management of the pula exchange rate through a crawling peg. Our sample runs from January 2001 to December 2015. The forecasting procedure involves employing 18 months rolling regressions to obtain the unobservable components, which are more suited for the tests used to verify the forecasting results. In the next step, an AR(1) process is fitted to the first principal component, and we finally produce one-period ahead forecasts of the bilateral exchange rates.

Following convention as evidenced by Rossi (2013), we compare the forecasting performance of the principal component model with that obtained by the toughest benchmark to beat, the driftless random walk model. The random walk predicts that the nominal exchange rate will remain unchanged at its current level. The superiority of the model is showcased by a Mean Squared Prediction Error (MSPE) that is smaller than or equal to that of the competitor model.[9]

Table 3.6 below summarizes the results obtained for one month ahead forecasts. It shows the MSPE of the principal component forecasts denoted as PC1, as compared to those obtained the random walk model (RW) as well as the test statistics for the Diebold-Mariano (DM) test suggested by Diebold and Mariano (1995) and the Clark-West (CW) test by Clark and West (2006). The two tests of relative predictive ability are used to evaluate the statistical significance of the results obtained by comparing MSPEs of the competing models. Both tests minimize some loss function by comparing the MSPEs, however they differ in that the DM test focuses on whether the predictive ability of the competing model is equivalent to that of the benchmark model, while the CW test ascertains whether both models are the same in population.[10]

[9]The MSPE is simply the average of the squared prediction errors obtained from the model, over the out-of-sample period (Rossi, 2013).

[10]The CM test compares *models* while the DM test compares the *forecasts* from the benchmark model with those obtained from the competing model.

Larger models will typically have larger MSPEs when compared with their smaller counterparts. Rossi (2013) and Clark and West (2006) however caution that a smaller prediction error, does not necessarily mean the larger models are not superior, as the extra predictors could still be important for forecasting. Further, the DM statistic is also said to be negatively biased and to favour the random walk. We therefore complement our analysis with the CW test, which takes this into account by including a term that accounts for the estimation error in the DM test statistic. A detailed discussion of the CW and DM tests is provided in appendix B.

TABLE 3.6: Forecasting Performance: Monthly Exchange Rates.

Currency	RW	PC1	DM Test	CW Test
ZAR	7.35	7.34	0.03	1.16
GBP	17.67	16.16	0.87	1.00
EUR	13.04	13.54	-0.79	-0.30
USD	21.43	22.10	-1.05	0.57
JPY	28.65	33.03	-1.48	-1.73
NOK	14.62	15.01	-1.71	-1.43
ILS	19.47	20.69	-2.01	-0.55
HKD	21.38	22.06	-1.06	0.58
INR	15.97	16.86	-1.85	-0.72
CNY	20.20	21.77	-2.34	-1.03

The results of the forecasting experiment show that the first principal model MSPEs are higher than the random walk in all cases except for the South African rand and the British pound. However, the statistics from both the DM and CW tests are insignificant for all the currencies. We therefore conclude that the random walk model outperforms the principal component model for monthly forecasts of all the currencies.

We then perform the same experiments for high frequency models, that is, we obtain daily and weekly forecasts to determine if the results obtained above hold. Forecasts are obtained using 378 day and 78 week rolling windows, which are both equivalent to 18 months.

3.6.4.1 One-Day Ahead Forecasts

Table 3.7 below shows the predictive performance of the principal component model in comparison with the benchmark model for daily bilateral exchange rate forecasts.

Table 3.7: Forecasting Performance: Daily Exchange Rates.

Currency	RW	PC1	DM Test	CW Test
ZAR	0.25	0.26	-0.77	0.51
GBP	0.61	0.61	0.99	2.48***
EUR	0.56	0.56	-0.74	0.63
USD	0.74	0.74	1.26	2.72***
JPY	1.15	1.14	0.45	1.62*
NOK	1.07	1.08	-0.70	0.88
ILS	0.84	0.83	1.00	2.66***
HKD	0.74	0.73	1.30*	2.75***
INR	0.78	0.78	1.02	2.64***
CNY	0.76	0.76	0.21	1.71**

In the case of daily exchange rates, the principal component forecasts have identical or lower MSPEs than the random walk forecasts for all currencies except the Norwegian Krone and the South African Rand, for which the random walk has a lower MSPE. To further verify these results, we consider the DM and CW statistics.

The results of the DM test for all currencies except the Hong Kong dollar are insignificant, however, the CW returns significant results for the British pound, the US dollar, the Japanese yen, the Israeli new shekel, the Hong Kong dollar, the Indian rupee and the Chinese yuan. The principal component model therefore outperforms the random walk without drift model for these currencies. These results are accepted since the CW test is generally a more preferred test. It is important to note that a small MSPE does not always imply a better model for the population. The CW test can indicate that the PCA model outperforms the random walk model even when it has a lower MSPE, this is because the test corrects for sample bias.

3.6.4.2 One-Week Ahead Forecasts

Table 3.8 below shows the results of the one week ahead forecasting performance of the principal component model when compared with the random walk.

Table 3.8: Forecasting Performance: Weekly Exchange Rates

Currency	RW	PC1	DM Test	CW Test
ZAR	1.15	1.15	0.28	1.52*
GBP	2.84	2.84	-0.24	1.15
EUR	2.58	2.59	-0.35	0.82
USD	3.35	3.36	-0.26	0.97
JPY	5.33	5.37	-0.41	0.96
NOK	3.26	3.30	-2.19	-1.55
ILS	3.12	3.18	-2.25	-1.65
HKD	3.28	3.30	-0.35	0.87
INR	3.01	3.06	-1.48	-0.98
CNY	3.41	3.46	-1.24	-0.72

The random walk model consistently beats the principal component model for all currencies except the South African rand, implying that the identified first principal component contains important information for forecasting rand/pula weekly exchange rates.

In summary, even though the obtained results show lack of forecasting ability of the bilateral exchange rates for lower frequency models, the findings establish a strong predictive performance for daily exchange rates. A somewhat similar result was obtained by Ferraro et al. (2015) when examining the predictive ability of oil prices in forecasting exchange rates. This study showed evidence of a strong forecasting ability of daily exchange rates, which however broke down for monthly and quarterly exchange rates. Ferraro et al. (2015) therefore emphasized the importance of considering transitory effects of oil prices in driving exchange rates, which would otherwise not be apparent at longer frequencies. The same argument can be extended to our analysis, and highlights the importance of taking into account the short term effects of latent factors on Botswana's bilateral exchange rates. Therefore, further research in this area should consider the transitory effects of unobservable factors in explaining exchange rate movements to account for these short term effects.

3.6.5 Robustness Checks

As a result of data availability constraints, the ILS, HKD, INR and CNY exchange rates were calculated from their exchange rates vis-'a-vis the USD. Due to possible concerns that may arise from employing cross-currencies, we excluded these currencies and repeated the analyses to determine if our finding of a US related factor could have been influenced by the use of cross-currencies.

The fraction of variation for the experiment with just the growth rates of the ZAR, GBP, EUR, USD, JPY and NOK is presented in the table below. The smaller data set means that there will be a redistribution in the proportion of variance explained by each component, however, we note no major difference in the variation explained by the first principal component, which is still the factor of interest. The contribution of the first principal component falls from 66 percent to about 62 percent.

In terms of model fit, there is only a marginal improvement with the new data set. The correlation coefficients are identical for models 1 and 2, with the model 3

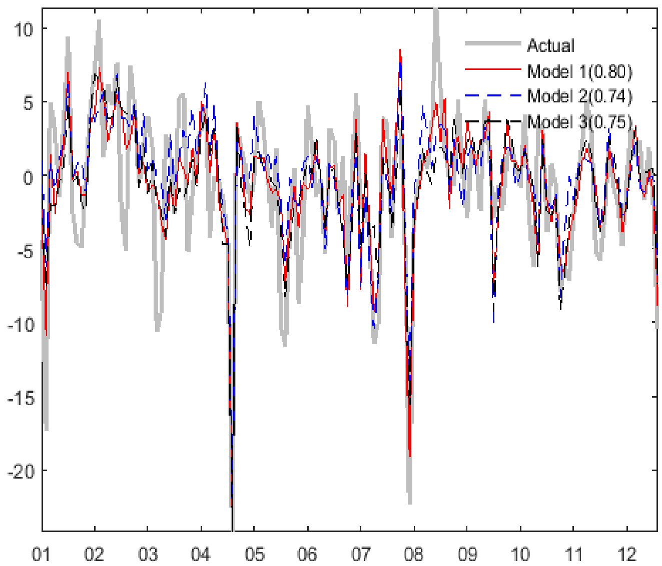
Table 3.9: Contribution of the Principal Components to New Set of Bilateral Exchange Rates.

Principal Component	Explained Variation
PC1	61.6070
PC2	15.9919
PC3	9.5456
PC4	5.4489
PC5	4.8057
PC6	2.6010

correlation coefficient increasing slightly from 73 percent to 75 percent. The same applies for the adjusted $\bar{R}^2$; with the new data, all three models have more or less similar values of the adjusted $\bar{R}^2$ as the extended data, with model 3 having an adjusted $\bar{R}^2$ of 0.499.

Figure 3.6 shows the actual and fitted values of our models using the new data set.

Figure 3.6: Actual and Fitted Values of the First Principal Component



There is no major difference in the results, we therefore conclude that our use of cross currencies does not significantly impact on our results as they still hold even with the new data set.

3.7 Conclusion

This study employs a principal component analysis in order to determine the latent factors driving ten of Botswana's bilateral exchange rates over the period January 2001 to December 2015. The findings indicate that the first principal component explains up to 66 percent of fluctuations in the exchange rates. This estimated factor is also found to be related to current and lagged values of selected South African and US financial and macroeconomic variables, namely, the VIX index, the federal funds rate, the yield spread between the two countries, the US growth of capacity utilization and the yield slope, as well as the policy rate of the South African Reserve Bank. It is also explained by Botswana's prevailing exchange rate regime.

The results also show that the soft peg between the pula and the South African rand dampens the full of effect of movements in the latter, ensuring a less volatile relationship between the two currencies.

We also utilize rolling regressions to determine the usefulness of the first principal component in forecasting a panel of bilateral exchange rates, by comparing the performance of a model incorporating the estimated factor with the random walk without drift model. The results indicate that the first principal component model outperforms the random walk in forecasting one-week-ahead rand/pula exchange rates, as well as daily exchange rates of the British pound, The US dollar, the Japanese yen, the Israeli new shekel, the Hong Kong dollar, the Indian rupee and the Chinese yuan. However, the forecasting performance of the principal component model breaks down when monthly forecasts are considered.

Based on the results, the findings of the study answer some of the questions posed in Ponomareva et al. (2015) regarding the information content or usefulness of bilateral panels for small, developing and commodity-exporting countries. It also reinforces the role of unobservable variables in explaining exchange rate variations. In this regard, the Bank of Botswana ought to incorporate information contained in bilateral panels of Botswana's most important trading partner currencies in the management of the pula exchange rate.

This study only focuses on the first principal component since the proportion of variation captured by the factor is considered sufficient. Further research could extend the analysis by examining and interpreting the second and third principal components, and in particular whether these factors are domestic or related to the South African economy.

Chapter 4

Did Botswana Really Escape the Resource Curse?

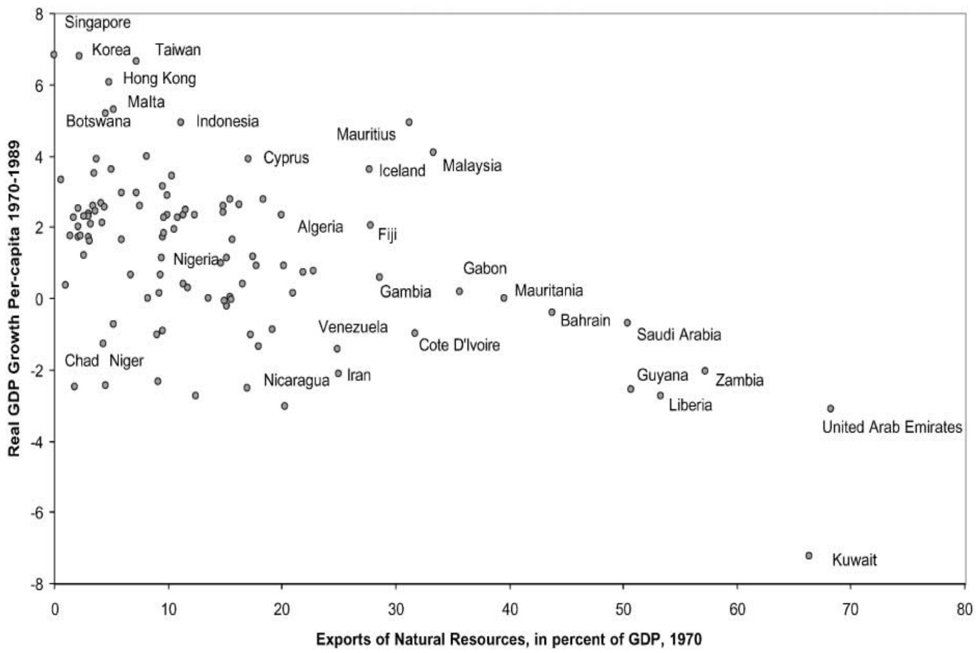
4.1 Introduction

"Africa is poor and getting poorer." Robinson et al. (2003)'s opening statement is a rather bleak and pessimistic outlook on the economic prospects of the world's most natural resource-endowed continent. This view however is not in isolation. It is backed by numerous empirical works, including the seminal discovery of a negative 'African dummy' by Barro (1991). This was a continent dummy variable that turned out to negatively influence human capital and economic growth rates in the case of Africa. Easterly and Levine (1997) also discuss what they termed "Africa's growth tragedy," where they found that there is a host of factors undermining the continent's economic growth, such as political instability and high ethnic diversity, which fuels low education and creates market distortions.

Natural resource wealth should be an important catalyst for economic growth. This is because the resultant revenue abundance can help countries address capital and foreign exchange restraints, overcome human capital deficits and infrastructural challenges, improve social indicators and consequently fuel growth and development (Lundgren et al., 2013). Furthermore, natural resource exploitation can lead to increased foreign direct investment, greater imported technologies and foreign capital, as well as skilled labour entering the economy. This initial stimuli and injection of wealth can be used to diversify the existing production structure and hence achieve sustained economic growth (Di John, 2011).

However, empirical evidence shows that natural resource wealth is not a sufficient condition for economic growth. In reality, many resource abundant countries, in particular those in sub-Saharan Africa, have lower rates of economic growth, poor welfare indicators and high incidence of poverty (see Barro, 1991; Gylfason, 2001; Sachs and Warner, 1997, 1999) . On the other hand, resource-poor countries such as Hong Kong and South Korea have significantly outperformed their resource-rich counterparts, such as Nigeria and Venezuela, and have gone on to attain high levels and rates of sustained growth. The evidence on the negative relation between natural resource wealth and economic growth is quite strong. This phenomenon has come to be known as the "resource curse" or the "paradox of plenty".

Figure 4.1: Natural Resource Abundance and Economic Growth



Source: Sachs and Warner (2001)

The figure above, obtained from Sachs and Warner (2001) highlights the apparent negative relationship between natural resource abundance and economic growth, for the period between 1970 and 1989. It shows that some of the most resource rich countries in the world failed to achieve strong and sustained growth in the two decades considered here, with some even experiencing negative rates of growth.

In this chapter, we revisit the resource curse and Dutch disease literature, and combine this with a structural vector autoregression (SVAR) analysis to examine the impact of Botswana's diamond boom on sectoral performance and the macroeconomy, and to answer the question of whether the country really escaped the different dimensions of the resource curse. Our analysis utilizes quarterly data for the period 1994:Q1 to 2014:Q3. The model comprises some of the key variables used in the Dutch disease literature to represent a traded sector made up of a booming mining sub-sector and a flailing non-mining sub-sector, and includes a non-traded sector. The real exchange rate and the real interest rate also play vital roles. We also include a proxy for a sovereign wealth fund to enable us to assess the effectiveness of foreign exchange reserve accumulation in mitigating Dutch disease effects. Three positive shocks are identified: a global output shock that potentially increases the demand for Botswana's exports, a diamond price shock that increases resource rents and foreign exchange revenues and lastly a positive export shock that could potentially result following favorable trade conditions. We also identify a natural resource shock, defined as one that stimulates exports in the presence of high diamond prices and increased global economic activity.

By investigating Dutch disease effects in Botswana within an SVAR framework, we are able to investigate the sectoral interactions in the economy following a positive natural resource shock. In addition to this, by including a natural resource fund variable in out model, we are able to determine the success of the sterilization efforts of the central bank in response to a resource windfall.

The results of our study show that Botswana has escaped the resource curse in terms of the political and social dimensions of the phenomenon. That is, mineral wealth did not compromise the quality of institutions and governance framework, and policy formulation and implementation has been sound and effective for the most part. This conclusion reinforces the general consensus in the resource curse literature that for the most part, Botswana escaped the resource curse (see for example Harvey, 1992; Hjort, 2006; Iimi, 2006a; Leith, 2000; Lewin, 2011; Sachs and Warner, 1997). However, in terms of the economic aspects, the economy exhibits some *mild* but *short-lived* Dutch disease effects. We attribute this to the successful sterilization of the mining windfall, which helped to adequately pace out the disbursement of mineral revenues, thus ensuring that the economy's absorptive capacity of the excess funds was not exceeded. In the last shock we see a potential 'over-correcting' problem as a monetary contraction in response to the positive shock results in an appreciation of the exchange rate, even in the presence of an accumulation of foreign reserves. This emphasizes the importance of harmonizing macroeconomic policy so that actions in one part of the economy are not being offset elsewhere. We also see some mild "de-industrialization" effects for all shocks. However since in all four cases the non-mining sectoral contraction is accompanied by an accumulation of official reserves and an eventual exchange rate depreciation, we cannot fully attribute the loss in productivity to the resource boom. The poor performance of the non-mining traded sectors can be partially explained by other factors such as geographical location, climate and size of the domestic market.

As stated earlier, Botswana is often cited in the literature as one of the few countries in the world who are said to have successfully avoided the resource curse. This is usually attributed to the country's record of uninterrupted high economic growth rates for over three decades, rising formal sector employment and an accumulation of relatively large foreign exchange reserves. However, even with this impressive track record, low non-mining sector growth rates and the persistent failure to diversify away from the minerals sector remain an important concern. The sustained heavy reliance on diamond revenues, coupled with a stunted manufacturing sector and a flailing agriculture sector, high unemployment rate and high income inequality may indicate that the country's institutional success and economic performance cannot be taken at face value. These factors may even indicate some underlying Dutch disease effects, which is one of the many problems associated with the curse of natural resources.

Mogotsi (2002) asserts that Botswana did in fact suffer from a *mild* case of the Dutch disease over the mining boom period. The main argument given is that in the presence of a high initial unemployment rate, the escalating booming sector and non-traded sector wages need not be accompanied by a decline in the manufacturing sector. This is because the latter draws labour from the unemployment pool, to replace the workers lost to the progressing sectors.

Hillbom (2008) goes further to dispute the relevance of the Dutch disease model in the Botswana case, especially since there was no manufacturing sector to speak of at the time when diamonds were discovered. The argument here is that even though the pre-conditions for a Dutch disease are present, there is no significant resource movement effect. While the paper acknowledges the existence of the pre-conditions for a Dutch disease, (as evidenced by a traded sector comprising a booming mining sector and a weak, under-performing manufacturing sector, and an expanding non-traded sector mostly supported by the mining sector) it attributes the poor performance of the manufacturing sector in Botswana to the fact that the sector was non-existent at independence, therefore the resource movement effect if any, has been minimal. However, Hillbom (2008) proposes that the country is stuck in a natural resource *trap* as opposed to a curse, which the paper describes in short as the structural change-inhibiting effects of the fact that the government budget is heavily reliant on diamond revenues. These negative effects include an indirect discrimination towards economic diversification efforts and limited incentives for productivity and industrial growth.

Our study therefore contributes to the resource curse body of work on Botswana by using an SVAR approach, which to our knowledge has not been applied to this country case in Dutch disease literature, to investigate the effects of a mineral boom on the country's economy. This approach allows for the analysis of the dynamic interactions of the different economic sectors following a natural resource shock. Further, our introduction of a natural resource fund variable to the model is an important contribution which makes it possible to determine the role of such a fund in mitigating the adverse effects of natural resource wealth, that is, it enables us to examine the success of sterilization efforts of the mineral revenues by the central bank. In addition, by using Botswana as a case study, we are able to draw some important conclusions which may be insightful to economists since the country has relatively fewer policy distortions.

The remainder of the chapter is structured as follows: section 4.2 provides an overview of the resource curse phenomenon, and highlights both the economic and political aspects of the problem while section 4.3 is a discussion of the policies and best practices for mitigating the Dutch disease and minimizing the incidence of the natural resource curse. Section 4.4 provides a brief overview of the role of sovereign wealth funds in managing natural resource wealth, while section 4.5 discusses Botswana's experience and some of the factors attributed to the country's economic growth record. In section 4.6, we introduce the empirical framework of our econometric analysis. Sections 4.7 outlines the data sections respectively, while the empirical results are presented in section 4.8. Section 4.9 concludes.

4.2 Resource Curse Overview

The paradoxical nature of the natural resource curse arises from the fact that intuitively, large injections of resource revenues should stimulate growth and development. This is because of the resultant increase in access to foreign exchange, increased inflow of foreign direct investment, a higher import of skills and technologies, and depending on the natural resource, they can be an important supplier of raw materials for other sectors as well as provide a market for manufactures Mikesell (1997).

The paradox was first observed in the sixteenth century when large infusions of foreign exchange in the form of gold and other precious metals obtained from Spanish colonies resulted in huge disruptions and changes in the structure of the country's economy.

More recently, the resource curse has been observed in almost all natural resource exporters, particularly following the commodity price booms of the 1970s where escalating prices resulted in huges influxes of foreign exchange revenues to oil and gas exporters. The post-war period saw many resource-rich developing countries gaining independence, and expectations were that the resource wealth would become an important foundation for growth and development (Hillbom, 2008). Growth rates for mineral exporters were relatively high during the periods coinciding with escalating commodity prices, that is between 1960 and 1980; this trend was then reversed between the early 1980s and 1990s, with growth rates going on to become negative by the late 1990s. Mikesell (1997) finds that in the decade between 1980 and 1992, only five out of a sample of 23 developing mineral exporting countries recorded positive growth rates. The five were Botswana, Chile, Columbia, Indonesia and Oman. This can be seen as a case against the role of natural resource wealth in sustaining economic growth for a majority of resource-abundant countries.

The seminal work by Sachs and Warner (2001) provides strong support for the resource curse. This study shows that countries rich in natural resources are more inclined to fail to achieve strong and sustained economic growth. Their study controls for various factors which have previously been claimed to explain the resource curse, and yet still finds results strongly in support of the existence of the paradox. Sachs and Warner (2001) thus conclude that natural resource exporters have relatively weaker development prospects; furthermore, this resource curse cannot be explained by structural attributes such as previous growth rates, openness policies, geographical factors and climatic conditions, or even by some other unobserved variable purported to inhibit growth.

Interestingly, the incidence of the resource curse is more pronounced in extractive industries such as oil, minerals and natural gas than in agricultural sectors. These extractive industries tend to be characterized by exhaustibility, large initial costs, volatile world prices, long production timelines, site-specific production, huge resource rents and less industry transparency. Consequently, they tend to undermine the quality of institutions and serve as a breeding ground for corruption and rent-seeking behavior.

In spite of the seemingly strong case, the debate continues with some researchers doubting the existence of the resource curse altogether and dismissing it as a myth (for example Wright and Czelusta, 2004), and some arguing that the problem does not lie with resource abundance or wealth, but rather with the resource rents and how they are managed (see Kolstad and Wiig, 2009). In attempts to dispute this paradox of plenty, studies have shown that it is usually the case that economies remain stunted because of their resource dependence, but even then, resource wealth may stimulate economic growth. The examples often cited to support this are Australia, Canada, Chile, Norway and the U.S. who have benefited from positive natural resource export led growth (Lewin, 2011).

There are many facets to the resource curse phenomenon which collectively and in any combination can result in natural resource abundance being viewed as a curse instead of a blessing. Furthermore, there are a number of channels through which the resource curse can manifest, the most commonly cited include the Dutch disease; governance and institutional quality; volatility of commodity prices and inefficient fiscal spending. This section provides a discussion of these mechanisms through which resource endowment can translate to economic stagnation and possibly a decline as well.

4.2.1 Dutch Disease

Corden and Neary (1982) define the Dutch disease as "the coexistence within the traded goods sector of progressing and declining sub-sectors." The term essentially refers to the adverse side affects of the exchange rate appreciation associated with temporary surges of export income; this may be as a result of upward swings in international commodity prices or because of a windfall discovery of new mineral deposits. Here, the booming sector is often an extractive natural resource activity such as mining, while the lagging sector is manufacturing, and as is often the case in developing countries, agriculture.

The term "Dutch disease" was first coined in *The Economist* in 1977 to describe the negative effect of natural gas discoveries on the Netherlands' manufacturing sector in the 1950s. The discovery of oil in the North Sea generated a resource boom which resulted in a contraction of output and employment in the manufacturing sector.

The temporary surge of foreign exchange arising from a mineral boom creates distortions that affect the structure of investment and production. These disruptions are permanent and do not disappear even when the boom period ends, which has important implications as they may inhibit future economic growth. This is because the effects of increased export income are not contained within a particular sector or component of production. These natural resource booms affect not only national income, but also the government's fiscal position, national saving, investment expenditures and relative prices.

The Dutch disease arises due to large injections of foreign exchange into the domestic economy, resulting in a real exchange rate appreciation (due to an appreciation of the nominal exchange rate and rising inflationary pressures) and an increase in domestic incomes. Consequently, the surge of income (received from higher tax revenues or from resource royalties) stimulates aggregate spending, particularly by the government. The real appreciation leads to an increase in the price of non-traded goods, such as construction and services, relative to that of the traded sector, for example agriculture and manufacturing goods. This causes a sectoral reallocation of inputs such as labour, land and capital as they shift out of the non-booming tradable sector and into the non-traded sector, due to the more lucrative booming resource and non-tradable sectors . There is an increase in imports and declining exports of the non-booming sectors. The government may respond to the worsening trade balance by pursuing import substitution policies, which often result in further distortions. The real exchange rate may appreciate further in response to inflows of foreign capital to take advantage of the booming resource sector. The resultant shift in production inputs adversely affects capital accumulation, and may exert upward pressure on wages and reduce returns to capital in cases where the non-tradable sector is labour intensive and the tradable sector is capital intensive. There is an increase in production costs and a loss of competitiveness in the tradable sectors. In this way, the booming sector crowds out other important tradable sectors, resulting in an economy with fewer prospects for diversification, high resource abundance and increased vulnerability to external shocks. The end of the boom period usually brings about a current account deficit, which leads to an increase in debt obligations which may be difficult to service (Frankel, 2010; Mikesell, 1997; Pegg, 2010).

Corden and Neary (1982) highlight two distinct channels through which the Dutch disease operates, namely the *spending effect* and the *resource movement effect.*

The spending effect captures the resultant increase in spending on domestic goods and services, due to higher resource rents and hence income. That is, if some fraction of the resource rents is spent, then there will be an increase in the price of non-traded goods, which leads to a real appreciation of the exchange rate. As previously discussed, productive resources then shift out of the tradables sector and into the non-tradables sector.

The resource movement effect, on the other hand, captures the resultant movement of labour inputs out of the lagging manufacturing sector, that is the progressing tradable sector draws labour away from other sectors due to temporarily higher wages. This exerts upward pressure on wages, which then causes output in the non-booming tradable sector to contract.

In a nutshell, the discovery of minerals and/or an increase in world prices of primary commodities results in distortions in the structure of the economy. The resultant increase in incomes and expenditure causes a real appreciation of the exchange rate which causes factor inputs to shift from the non-booming tradable sectors to the non-traded sectors. Consequently, output in the non-traded sector increases while it falls in the non-booming tradable sector. Overall, based on the discussion above, a resource export boom results in permanent distortions to the economy, which may lead to stagnant and even declining growth rates once the boom period elapses. In this way, the booming natural resource sector is said to crowd out other tradable sectors. In the end, the economy is severely distorted as evidenced by the low output and loss of international competitiveness of the non-mining tradable goods sectors. National saving and investment may also decline, and the economy may be faced with higher external debt which cannot be serviced, and in a worst case scenario, capital flight and debt crises (Mikesell, 1997).

4.2.2 Bad Governance and Institutional Failure

Governance and institutional quality and structure are often cited as some of the main determinants of an economy's ability to avoid the resource curse. This is because for excellent economic policies to yield the desired outcomes, they have to be implemented within a framework backed by good governance and strong, relatively corruption-free institutions.

It is often observed that resource booms weaken the quality of governments and institutions. Van der Ploeg (2011) finds that mineral wealth hinders wealth distribution within the economy and stands in the way of growth-promoting policies. This can then encourage rent-seeking behavior and breed corruption, encourage dictatorships, autocracies and political unrest, fuel internal conflicts, promote misappropriation of resource revenues and lead to efficiency losses and worsening inequalities. This has been especially true in many mineral exporting, developing countries where mineral ownership is vested with governments. In this instance, ascent to political power is often seen as a means to wealth and encourages predatory regimes, which results in rent-seeking, rampant corruption and even civil wars. Resource rents are squandered and consequently these economies fail to take advantage of the initial 'push' from large injections of foreign exchange that might help them achieve sustainable growth.

Robinson et al. (2003) talks about the notion of "good economics, bad politics" where sound economic policies often decrease the chance of re-election or increase the likelihood of a government being overthrown, especially in Africa. As a result, governments then tend to make bad economic decisions in order to ensure the longevity of their political careers.

Studies have shown a strong relationship between the type of government in place and rent-seeking behavior. In such cases, authoritarian governments are highly correlated with strong resource dependence and overall mismanagement of funds, while democracies are found to be less corrupt and therefore perform better economically. Lewin (2011) asserts that mineral endowed countries tend to be a breeding ground for predatory regimes and dictatorships when compared with the benevolent institutions found in the resource poor countries such as those in East Asia.

Another institutional failure, highlighted by Frankel (2010), is the resultant anarchy and unsustainable extraction practices which usually befall mineral-rich countries. This extends the bad governance factor by explicitly focusing on three mechanisms through which a natural resource boom can translate into a curse instead of a blessing, namely exhaustibility of the natural resource, poor enforcement of property rights and the incidence of civil wars.

Most natural resources are finite and exhaustible. Depletion may lead to an economic downturn if resource rents are not saved and invested well during the boom period, and if the economy has not been diversified away from the resource sector into other productive sectors.

Saving a portion of the windfall can help smooth out spending as well as ensure that future generations benefit from the mineral wealth even after the resource is depleted. Diversification on the other hand, ensures that there are other sources of revenues and engines of growth when mineral deposits have been exhausted (Frankel, 2010; Lewin, 2011). Bad governance, in the form of weak institutions, rent-seeking behavior and politicians too intent on garnering votes and assuaging coup attempts, often results in resource extraction rates that exceed the optimal extraction rate. This then accelerates the rate of depletion of the resource.

Unenforceable property rights and disregard for the rule of law can also act as catalysts in the exhaustion of natural resources. This mainly applies to open access resources such as fish, grazing lands and timber, where individual economic agents, acting independently have no incentive to constrain their extraction rates, even when the resource stock approaches depletion. However, addressing this market failure can also be extended to cover mineral resources. In cases where mineral property rights are well defined, their enforceability through strong and efficient institutions can reduce the incidence of corruption and rent-seeking behavior, and this may aid in avoiding the detrimental effects of the resource curse.

The discovery of natural resource deposits, especially diamonds and oil, has often provoked and sustained internal conflicts, civil war and dissolution of the state, as factions fight over the right to control the resources, for instance, diamonds in Sierra Leone and the Democratic Republic of Congo, and oil in Angola and Sudan. Expectedly, the wars and conflict adversely affect growth and development.

4.2.3 Volatile World Commodity Prices

Mineral prices are characterized by high volatility and can therefore disrupt economic activity and hinder growth. This volatility in prices is largely attributed to low demand and supply elasticities in the short run. That is, the response of demand to changes in price is relatively small, due to the somewhat fixed capital applied to a given input-to-output ratio. On the other hand, the sluggish response on the supply side is due to the fact that it is not possible to instantly increase output when prices rise. The implication here is that the price increases will have to be much bigger to restore equilibrium in the market (Frankel, 2010). This is particularly the case for mineral resources, but it is also true for many other commodities.

These rapid swings in commodity prices are typically transmitted to the economy through the exchange rate, which appreciates and depreciates with booms and busts respectively. Consequently, fiscal expenditure patterns will also become pro-cyclical as government spending follows the booms and busts of commodity price cycles. This may result in inefficiencies and deadweight losses such as the inefficient provision of public goods and services and inadequate construction of infrastructure. Furthermore, debt overhangs may result in cases where the government takes out loans against expected future mineral rents during boom periods. The debt overhang becomes a significant burden when the boom period comes to an end. The destabilization that arises due to volatile commodity prices also affects foreign direct investment as volatility is often perceived as risky, which causes potential investors to take their funds to 'safer' markets.

4.2.4 Inefficient Public Spending

Finite natural resources are usually a windfall, therefore any rents from them should be treated as transient. Unfortunately, in the wake of natural resource discoveries and the commodity price booms of the 1970s, most developing resource exporters treated the foreign exchange inflows from the resource revenues as permanent shocks. They failed to sterilize part of their resource revenues, which would have allowed them to control liquidity injections into the economy as well as earn returns on their investment, ensure stability and smooth out spending in the event of negative economic shocks.

A key point already mentioned and related to the volatility of international commodity prices is the resultant pro-cyclical spending of fiscal balances. That is, increased government spending often follows the surge of foreign exchange into the economy. This increased spending becomes difficult to reverse when resource revenues fall. It also has political implications as governments become hesitant to take back some of their campaign promises, for example cutting salaries in the civil service.

Inefficient spending may also arise where there are limited investment opportunities to sufficiently channel the resource funds, or where the revenues are spent on recurrent non-productive expenditures with low long-term returns. Historically, many of the rich countries that succumbed to the resource curse failed to set adequate spending targets and prioritize public expenditure on long-term investments such as education, health, infrastructure and the growth of non-resource tradable sectors, all of which could benefit the economy in the long run, even after the natural resources have been depleted.

4.3 Avoiding the Resource Curse

There are a number of policies and best practices recommended for mitigating the Dutch disease and minimizing the incidence of the resource curse. This section discusses some of these recommendations.

4.3.1 Governance and Institutions

Here we focus on both the government system in place and and the quality of institutions. Robinson et al. (2003) highlight the role of governance and institutional quality in successfully avoiding the natural resource curse, in particular the type of government in place; the presence of respect for private property rights and the extent of corruption and transparency in the governing system. Kolstad and Wiig (2009) emphasize that the impartiality of institutions is of vital importance, and that the adverse effects of patronage and rent-seeking behavior in resource-rich countries tend to be exacerbated by weak institutions of governance, such as the absence of democratic accountability, low corruption control and a poor upholding of the rule of law.

Kolstad and Wiig (2009) make mention of what they term “impartiality enhancing institutions”. These are essentially benevolent institutions that reduce the likelihood of resource exploitation for personal gain. Such institutions may be characterized by a high degree of transparency, democracy and systems of accountability, and respect for private property rights and the rule of law. In their presence, corruption tends to be less rampant and it is possible for citizens to hold the government accountable for its actions. In such instances, the government’s interests tend to be aligned with the public's interests, and economic agents are more likely to behave in a socially optimal manner.

Lewin (2011) emphasizes that good governance and high quality institutions are vital for fostering a high degree of trust in the government by the citizens, which is important for continued stability and social and economic development.

4.3.2 Economic Diversification

Auty (2001) notes that countries rich in natural resources tend to remain primary commodity dependent for much longer that their resource-poor counterparts. This is because commodity booms have been found to crowd out other sectors of the economy, particularly manufacturing, which can be detrimental to long-term growth, particularly given the finite nature of most natural resources, especially minerals. Even though classical economic theory states that countries ought to specialize in whatever is their comparative advantage, mineral exporters may be better off strengthening their manufacturing sectors and diversifying away from mineral resources. Frankel (2010) asserts that there is a need for strong diversification and industrial policies due to the enclave nature of most natural resource sectors; they have fewer linkages with the broader economy. These sectors tend to be highly capital intensive and they generally employ a very small fraction of the labour force. These resultant low spill-over effects reduce the extent to which the initial injection of wealth can influence investment in the non-mining industries. This therefore makes an argument for active diversification efforts away from the natural resource sector.

Meijia and Castel (2012) emphasize the importance of differentiating between 'inherited wealth' and 'created wealth'. The argument here is that inherited wealth in the form of natural resources, particularly finite resources, cannot provide sustainable growth and development in themselves. This is because of their exhaustible and non-renewable nature. Created wealth on the other hand, has the capacity to be an engine of growth even long after the natural resource reserves have been depleted. It is therefore crucial to use the inherited wealth to build up alternative sources of wealth for when the natural resource sector is no longer the mainstay of the economy.

Investing in human capital through education is an important step towards economic diversification. This can help to shift the country's comparative advantage away from the extractive industry towards other sectors such as agriculture, services and manufacturing, which have better linkages with the broader economy and could potentially be new engines of sustained growth.

4.3.3 Ownership of the Natural Resource

The ownership of the natural resource sector plays a crucial role in how resource rents are distributed, and therefore has important implications for avoiding the resource curse and ensuring sustainable growth and development. In most mineral-rich countries, natural resource ownership tends to rest with the government, which consequently politicizes the natural resources process and often fuels internal conflict, giving rise to predatory regimes and malevolent dictatorships (Lewin, 2011).

Privatization of the natural resource sector on the other hand, can be a long and costly venture, which may also breed corruption and also result in capital flight in cases of foreign private ownership.

Another important point to note here is that of the state's right to the resource as opposed to tribal rights. That is, as is often the case with point resources, it is better for resource ownership to lie with the state instead of with the tribe or ethnic group on whose land the mining operations occur. This will limit the possibility of ethnic polarization, internal discord and civil war.

4.3.4 Fiscal and Exchange Rate Policies

Fiscal policy can play an important role in avoiding the resource curse. The effect of fiscal policy on resource-rich economies can be amplified by expenditure patterns of resource funds which follows the booms and busts cycles of commodity markets. This can complicate macroeconomic management and stability. Procyclical fiscal policy is characterized by high expenditure (and low taxes) when commodity prices are high and low spending during price busts. Fiscal policy can also be an important channel through which commodity price shocks are propagated into the commodity exporting economy, going so far as to determine the level of exposure of domestic fundamentals to these price shocks Pieschacon (2012).

Collier et al. (2010) caution against unsustainable increases in consumption following a resource boom, such as making commitments against future revenues. It is important to recognize that mineral revenues are transient due to the fact that they are based on finite resources with a fixed stock. They are also unreliable due to the volatility of commodity prices. Increased spending following a natural resource boom is accompanied by high debt, resulting from increased borrowing against expected high revenues and prices in the future, as the government fails to realize that the boom period is only temporary. The government is then left with debt obligations that it is unable to service when revenues are low. This can lead to complications arising from the need to cut fiscal spending when the boom period is over (Harvey, 1992).

Lewin (2011) highlights three key policy actions that are crucial for preventing the incidence of the Dutch disease in primary commodity-exporting countries, namely high fiscal saving, maintaining a current account surplus and increasing expenditure on public infrastructure and education.

A prudent fiscal policy, which is characterized by a high saving rate of resource revenues will constrain current consumption, which in turn dampens domestic inflationary pressures and therefore counteracts one of the adverse effects of the Dutch disease. Furthermore, counter-cyclical fiscal spending should be geared especially towards public investments and human capital. This not only mitigates the volatility of spending, which in mineral-based economies typically follows the boom and slump cycles of the primary commodity markets, it also stimulates growth without adversely affecting private sector investment (Lewin, 2011). In this regard, Frankel (2010) discusses the "Chile-style fiscal rules", which were counter-cyclical policy actions put by place in copper exporting Chile. This approach to fiscal policy in Chile highlights the following rules: setting a government budget target that allows for deficits only in cases of a recession, a below-trend output level or a below trend copper price level; and providing independently determined (and depoliticized) ten-year trend projections.

Another key factor here is the role of taxation. Resource-poor governments usually have to rely on tax revenue to meet their budgetary obligations. Under this scenario, the government is more likely to be transparent in how funds are spent and it is easier therefore, for the citizens to hold the government accountable. The situation is a little different in most resource-abundant countries, where there is usually more secrecy surrounding resource revenues. Since the bulk of public expenditures is financed by extractive industry taxes, citizens are less likely to participate in public budgeting. One solution to this problem may be an overhaul of the taxation system in resource-exporting countries, which will not only foster accountability and transparency in how resource funds are spent, it will also form additional tax revenue for the government.

The right exchange rate regime can play a crucial role in avoiding the resource curse. Most mineral-rich countries of the 1970s had the choice of a flexible exchange rate, or a pegging of their currency to another (or to a basket of currencies) and maintaining a fixed exchange rate.

A fixed exchange rate regime is typically encouraged for very small open economies, as this is not only cost effective, but can also help subdue inflationary pressures that may arise due to the resource boom. Frankel (2010) recommends a form of exchange rate targeting which allows for the central bank's intervention in the foreign exchange market as well as for an initial accumulation of foreign exchange reserves, while at the same time mopping up any excess liquidity in the economy. This strategy can assist in curbing likely Dutch disease effects through maintaining the international competitiveness of all export activities, and keeping inflation under control. Frankel (2010) also argues that accumulating reserves is another way of keeping resource revenues away from predatory governments where necessary.

4.3.5 Natural Resource Funds

An important task for policy makers in countries that are exporters of exhaustible primary commodities, is to plan for a future without the natural resource. Frankel

(2010) highlights the role of transparent natural resource funds in the management of the windfall. This does not only help in sterilizing resource revenues, and providing a means to avoid the pitfalls of pro-cyclical fiscal spending, it also helps in smoothing consumption over the long run when resource deposits have been depleted, and for providing an inheritance for future generations. In addition to this, the interest earned on the resource funds can be an alternative source of revenue for the government, though that interest rate is simply compensation for the optimal delay in consumption.

A popular way of managing resource revenues is through the establishment of a sovereign wealth fund, which can offset the difficulties arising from the exhaustion of the natural resource and help to smooth consumption during boom and bust periods and when the resource revenues are high and low. Frankel (2010) argues that it is important to ensure that the wealth fund is transparent and managed independently of political influence.

The next section provides a detailed discussion on the more popular sovereign wealth funds as a way to minimize the adverse effects of the resource curse.

4.4 The Role of Sovereign Wealth Funds (SWFs)

A sovereign wealth fund (SWF) is a government-controlled investment vehicle which holds and manages investments in foreign assets, although domestic assets may form part of the portfolio (Aizenman and Glick, 2009; Devlin and Brummitt, 2007). SWFs are categorized into *commodity* and *non-commodity* funds, depending on their source of assets. Commodity SWFs are those established through foreign exchange earnings from natural resource exploitation, while non-commodity funds are funded from historically sustained balance of payments surpluses and excess fiscal revenues. SWFs manage assets separately from official exchange reserves. International reserve portfolios tend to be relatively more conservative and risk-intolerant and have a shorter investment horizon. SWFs on the other hand are more aggressive in their investments, usually in high yielding and long-term assets including corporate bonds, long term government bonds, agency backed securities, commodities and so on (Aizenman and Glick, 2009).

SWFs are usually set up for any one or a combination of the following main reasons: as a macroeconomic stabilization tool; for saving for future generations and/or in order to meet long term liabilities; and finally as a buffer or means to sterilize foreign exchange revenues from primary commodity exports. There are broadly five types of SWFs, distinguished based on their policy mandates and asset allocations. These are stabilization funds, savings funds, reserve investment funds, pension reserve funds and development funds. The type of SWF is determined by the sovereign state's key objectives in setting up the fund, although it is possible to have a fund with multiple objectives, and also to have a country with more than one SWF, each one maintained to achieve different investment objectives and mandates. For a more detailed discussion on the different SWF types, see Al-Hassan et al. (2013) and Petrova et al. (2011).

While SWFs are not a new phenomenon,[1] they have been growing in size and popularity in recent years. This rather rapid growth has come with increasing concerns about their effect on global financial stability due to fund governance structures, particularly with regard to issues of "the politicization of global capital flows" which could potentially lead to financial protectionism (Devlin and Brummitt, 2007). This fear arises from attempts by foreign entities, through their SWFs, to acquire controlling stakes in key domestic industries of other countries. This raises concerns about the true motive behind the acquisition, which could potentially threaten national security.

Concerns about the impact of poor governance structures on international financial stability are driven by the possibility of SWFs being subject to political pressures, rent-seeking behavior and corruption. Given the growing influence of the funds on global markets, a particularly huge but poorly governed SWF could have a significant impact on the international financial landscape. Devlin and Brummitt (2007) argue however, that SWFs need not carry much threat to the stability of the global financial system if the lack of transparency and "non-commercial investment motives" are addressed, and if governance structures are strengthened. Furthermore, they propose the adoption of common international standards of best practice for managing SWFs.

[1] The oldest SWF is the Kuwait Investment Authority established in 1953 in Kuwait.

There are several reasons for the recent growth in SWFs. The first is attributable to recent commodity price booms, which have afforded many resource exporters (particularly oil producing countries) high revenues. In order to prevent the macroeconomic disasters that followed the oil price boom and the natural resource discoveries of the 1970s, many resource-rich countries now seek to sterilize part of the export revenues in sovereign wealth funds (Aizenman and Glick, 2009). Natural resource-rich Africa currently has 25 SWFs. Of the 15 out of these 25 SWFs in the continent, 13 are commodity funds. The sizes of these SWFs are small when compared with other funds in the world, but they are an important part of development and sustainable growth efforts. The oldest is Botswana's Pula Fund, established in 1994, and the only commodity SWF not funded by the exploitation of hydrocarbons. The second oldest is the Revenue Regulation Fund of Algeria, established in the year 2000. Nine out of the top 15 funds were established in the last five years. The total amount of these funds in 2016 was USD120.75 billion. This information, obtained from Dixon (2016), is summarized in Table 4.1 below.

Table 4.1: Top 15 African SWFs–June 2016

Country	**Fund Name**	**Year est.**	**Size (USD)**
Libya	Libyan Investment Authority	2006	$67 billion
Algeria	Revenue Regulation Fund	2000	$34 billion
Botswana	Pula Fund	1994	$5.4 billion
Angola	*Fundo Soberano de Angola*	2012	$4.9 billion
Morocco	Moroccan Fund for Tourism Development	2011	$1.8 billion
DRC	*Fonds de Stabilisation des recetts budgetaries*	2005	$1.6 billion
Nigeria	Nigeria Sovereign Investment Authority	2011	$1.3 billion
Senegal	Strategic Investment Fund	2012	$1 billion
Gabon	Gabonese Strategic Investment Fund	2012	$1 billion
Ghana	Ghana Heritage Fund	2011	$0.26 billion
Ghana	Ghana Stabilization Fund	2011	$0.25 billion
Equitorial Guinea	Fund for Future Generations	2002	$0.15 billion
Mauritania	National Fund for Hydrocarbon Reserves	2006	$0.04 billion
Rwanda	*Agaciro* Development Fund	2014	$0.04 billion
São Tomẽ and Príncipe	Permanent Fund for Future Generations	2004	$0.01 billion
Total			$118.8billion

Adopted from Dixon (2016).

The recent growth of SWFs is also due to the efforts by emerging economies, particularly in Asia, to diversify a fraction of their vast reserves built from persistent current account surpluses. Aizenman and Glick (2009) argue that this larger than needed "hoarding of international reserves"[2] has led to an increase in the establishment of SWFs as a means to maximize returns from holding higher yielding long term investments for these emerging economies.[3]

4.4.1 SWFs and the Dutch Disease

The operations of an SWF have important impacts on the economy's key macroeconomic fundamentals and policies. The operations and the returns from the fund's asset holdings can significantly impact the conduct of fiscal, monetary and exchange rate policies. The fund's withdrawals and revenue stream affect the government budget and thus fiscal policy. The cyclicality of fiscal expenditures has a significant impact on the economy's overall demand, which in turn influences inflation and the real exchange rate. The fund can thus be ideally used for tax smoothing and enabling counter-cyclical fiscal responses. Further, this sort of SWF activity can assist the country's monetary policy actions and exchange rate management (Al-Hassan et al., 2013).

It is for this reason that SWFs have been proposed as one way of avoiding some of the pitfalls associated with natural resource wealth.

Recall that transient windfall gains from a commodity price boom result in a loss of competitiveness for domestic tradables due to a real appreciation of the exchange rate. One way of combating this Dutch disease symptom is to constrain the foreign exchange coming into the economy by consigning part of the resource windfall to a sovereign wealth fund, thus limiting excessive domestic spending and relieving some of the pressure on non-resource tradable sectors. This can assist in pacing the disbursements of funds, therefore ensuring that the economy's absorptive capacity is not exceeded (Gelb et al., 2014).

Secondly, an SWF can help counter the adverse effects of the cyclicality of commodity prices by smoothing out consumption during boom and bust periods. Saving the resource income in a sovereign wealth fund can limit the extent to which

[2] See Aizenman (2008)

[3] The combined SWFs for East Asia was over USD740 trillion (Griffith-Jones and Ocampo, 2009).

revenues are recycled back into the economy, either through high government expenditure or lower taxes. In this way a pro-cyclical fiscal policy can be avoided. Furthermore, apart from the benefit of the fund being used to transfer wealth across generations, it can also insulate public assets against exposure to commodity price risks by providing a more stable and diversified investment climate.

SWFs are also suited to long term investment horizons and high risk, high return assets, which makes them ideal for mineral-dependent economies to invest and plan for a future without minerals. Savings SWFs, that is those mandated to save part of the resource revenues to ensure intergenerational equity, are more popular in this regard. Here, the SWF portfolio will take on more long-term investments with high-risk return profiles (Al-Hassan et al., 2013), thus making it possible to smooth out inter-temporal consumption as well as earn high returns for future generations. Even then, Griffith-Jones and Ocampo (2009) caution that there is a need for developing country SWFs to be more prudent and avoid taking on excessive risk because these countries do not have much to fall back on if their investment ventures fail.

4.4.2 The Economics of SWFs

This subsection provides a brief discussion of the mechanism through which an SWF can affect the exchange rate and hence counter any Dutch disease effects in the economy. For a more detailed discussion see Garton (2012).

Consider a small open economy with a tradable and a non-tradable sector. A fiscal stance with a high government budget surplus may result in low overall spending in the economy. This would mean a lower demand for goods in the non-traded sector, and therefore a lower real exchange rate is required for the goods market to clear.[4] At the same time, the tight fiscal rule also implies a low domestic interest rate relative to the foreign interest rate, as monetary authorities respond to the subdued demand. The low interest rate makes domestic assets less

[4] The goods market equilibrium requires equality of demand and supply for non-tradables only. The economy faces world prices for its traded goods, and any 'disequilibria' are captured by the trade balance.

attractive, leading to a fall in the demand for the domestic currency and a nominal depreciation.[5]

Now, to see the effect of an offshore investment of the fiscal surplus via a sovereign wealth fund, we first have to make a few assumptions. We have a small open economy whose assets are perfect substitutes for foreign assets. This implies a perfect elasticity of supply of foreign funds. Investing the fiscal surplus in foreign assets increases their demand relative to that of domestic assets, implying an excess relative supply of domestic assets in the financial market. As foreign investors increase their acquisition of domestic assets, the demand for the domestic currency increases until it offsets the initial increase in demand for the foreign currency. As the substitutability between domestic and foreign assets becomes more imperfect, the effect discussed above will depend more on which of the two outweigh the other, that is, the share of foreign assets in domestic portfolios versus the foreign holdings of domestic assets.

4.4.3 Governance and Investment Strategies of SWFs

The governance structure and investment strategies play a crucial role in the management of SWFs, ensuring that the desired fund objectives are met as well as contributing to national wealth, reducing resource wastage and curbing corruption (Gelb et al., 2014).

Sovereign wealth funds can comprise domestic asset holdings and investments in foreign financial assets. Investing domestically may have high social returns and boost overall spending. Furthermore, when foreign asset holdings yield a lower rate of return than the domestic risk adjusted rate, it is more profitable to invest domestically. However, building up a sovereign wealth fund that invests domestically may not always be optimal, especially in developing countries with unstable governments and high corruption rates. Funds with a domestic investment mandate have to be backed by a sound budgetary system and an efficient use of the revenues for productive purposes. Gelb et al. (2014) caution that even if domestic

[5]The same argument can be applied to a case where domestic assets are deemed riskier, leading to higher risk premia on the assets. In this case, expectations of higher rates of return require the exchange rate to fall in order to ensure a future appreciation.

investments are successful, the country will still need to invest part of their revenue externally, for stabilization and precautionary purposes.

Care should be taken when establishing and running a sovereign wealth fund to maintain transparency, accountability and disclosure on the management of the fund. It is important to recognize that the funds' activities will have important implications for the broader economy, in particular the fiscal balances, the trade balance and monetary policy. Therefore the fund's objectives and mandates should be in harmony with other macroeconomic policies (Al-Hassan et al., 2013; Garton, 2012). This will ensure that the gains from having an SWF are not offset elsewhere in the economy and vice versa.

Another issue that ties in with the resource curse is that SWFs need to be backed by good governance (of the sovereign state as well as the fund) and strong institutional quality. Furthermore, governance of the fund has to be independent of political influence. This is especially crucial in the case of developing countries that tend to have a more volatile political system. Bernstein et al. (2013) find that sovereign wealth funds that are subject to political influence tend to invest domestically and perform worse than those with external managers and more foreign asset holdings. This builds a case for independently managed funds that invest mainly in foreign financial assets, this will ensure higher returns for the country and limit the incidence of predatory systems of government.

4.5 Botswana's Experience

When Botswana gained independence from British rule in September 1966, it was one of the poorest countries in the world with few prospects for growth and development. The landlocked country had a per capita income of only USD70 and was severely underdeveloped, with high inequality, very little infrastructure and a largely unskilled population.[6] The economy was heavily reliant on foreign aid and an agricultural sector plagued by persistent drought and infertile soils. The country was written off as a "dependent, underdeveloped labour reserve for

[6] There were only 12 kilometers of tarred road, 22 university graduates and 100 secondary school graduates, 2 secondary schools which offered poor quality education characterized by high failure rates and large class sizes (Robinson et al., 2003).

South Africa" (Robinson et al., 2003). However, Botswana went on to become one of the largest resource exporters in the world,[7] and in 1998, just 32 years after independence, the country graduated to become an upper-middle income country. Two of Botswana's diamond mines, namely the Orapa and Jwaneng mines are respectively, the largest and richest mines (in diamond value terms) in the world.

Table 4.2 below, adopted and modified from Leith (2000), compares Botswana's growth performance with that of selected Asian economies for the 30 years between 1966 and 1996.

Table 4.2: Botswana's Growth Performance

Country	Per Capita GDP (USD)	10yr Growth Rate	20yr Growth Rate	30yr Growth Rate
Botswana	3,296	4.9	5.2	8.2
Chile	4,800	6.2	4.0	2.8
Hong Kong	24,898	4.6	5.3	6.0
Indonesia	1,146	5.2	4.5	5.7
Korea	10,641	7.2	6.8	7.7
Singapore	30,942	7.0	6.4	7.8
Thailand	3,007	8.0	6.1	6.4

Source: Leith (2000)

[7]It was ranked 18th out of 161 resource exporters in 2002 (Iimi, 2006a).

Diamond prospecting started in Botswana in the late 1950s, but it was not until 1967 that mineral deposits were first discovered, and mining operations began in 1973. In the 35 years post-independence to 2001, the country had the highest per capita growth rates in the world. GDP per capita growth rates for the period between 1965 and 2006 averaged 7.8 percent, with 40 percent of this attributed to mineral production. In 1998, the country had a per capita GDP of USD3,070 compared to USD4,890, USD510 and USD990 for the world, Sub-Saharan Africa and East Asia and the Pacific regions respectively (Iimi, 2006a; Robinson et al., 2003). From table 4.2, it is evident that Botswana's growth performance in the 30 years between 1966 and 1996 exceeded even that of some of the "Asian tigers". In this way, Botswana is said to have successfully transformed its mineral wealth into high and sustained economic growth.

There are several reasons that have been advanced for Botswana's exceptional economic performance, despite being a landlocked, mineral-endowed country in a region characterized by discord and frequent conflict. Considerable emphasis has been placed on the country's adoption of sound policies in the management of its diamond revenues as well as economic policies which were geared towards avoiding high external debt and ensuring economic growth, stability and diversification. However, Botswana's success was due to a combination of factors, some deliberate policy actions and others cultural. These factors together worked to guard against the adverse effects of mineral wealth that plagued other resource-rich countries. There is also strong support for the argument about the role of institutional quality in mitigating the resource curse.

We incorporate some of the reasons advanced in the literature into four main categories: governance and institutions; ownership of the resource; fiscal discipline and the management of the resource revenues.

4.5.1 Governance and Institutions

Iimi (2006a) defines good governance as comprising "a strong public voice with accountability, high government efficiency, good regulation and powerful anti-corruption policies," while good institutions are characterized by a system of largely well defined and respected property rights. Unfortunately in the post-independence era of many sub-Saharan countries, the quality of governance and institutions was of the self-serving, extractive kind where property rights were not secure and the risk of property seizure by the government and predation was high. The blame for such institutional failures on the continent have been largely placed on Africa's colonial history.

In the case of Botswana however, the adverse impacts of colonialism were minimized due to the peripheral nature of the country to colonists' objectives. The Tswana territory was unattractive and held very little interest to the colonists, the country only becoming a British colony purely for its strategic location in hindering the spread of rival foreign empires as well as providing a route into the interior of the African continent (Harvey, 2015; Robinson et al., 2003).

Historians and political economists agree that this relative lack of interest, and the subsequent non-extractive colonial regime laid a foundation for a post-independence system that fostered development and respected the law. This, together with the ethnic homogeneity of the Tswana people, ensured that traditional pre-colonial institutions, which would later play a key role in the country's development process, were not distorted and remained preserved. Further, this homogenous population lessened the risk of ethnic polarization, a situation which could have exacerbated conflict and discord when combined with diamond resource wealth (Lewin, 2011).

One such pre-colonial cultural practice is the tribal assembly, known as the '*kgotla*' meeting. It is a consultative system of Tswana political institutions where the chiefs or leaders consult with the people on issues of communal concern. This system, which is still in practice today, ensures that the common man is consulted and included in the decision making process. It also provides a platform for people to publicly criticize the leadership and air out issues of concern and conflict. Robinson et al. (2003) and Lewin (2011) both agree that this integrative practice fosters transparency and stability; enforces property rights and the rule of law; provides a framework in which the political elite can be held accountable; and encourages broad based participation of the tribes in making decisions.

These practices continued even in the post-independence era. Right from the onset, leaders of the newly-formed Botswana sought to create and promote conditions of governance which were conducive for fostering political and economic stability, as well as improving social indicators and attaining sustainable growth and development.

As already noted, respect for private property rights and the rule of law was another key factor for ensuring a strong institutional framework. This was another area where pre-colonial cultural practices played a important role. The Tswana people's respect for private property rights dates back to historic times where although tribal land was communal, livestock was privately owned. Political economists argue that it was in the elite's best interests to ensure that the newly-formed country continued in this tradition of respecting property rights. This is because in Botswana, livestock is viewed as a great form of wealth, and the elite at the time possessed large herds of cattle (Harvey, 2015; Hillbom, 2008).

Mineral-dependent countries are more likely to have autocratic or predatory-type governments prone to conflict. In contrast, Botswana has maintained a peaceful democracy, and has held free and fair national elections every five years since independence.

Table 4.3: Governance Indicators (1996-2015)

Indicator	Botswana	Ghana	Kenya	Namibia	Nigeria	S. Africa
Corruption Control	0.89	-0.12	-0.97	0.30	-1.13	0.26
Government Effectiveness	0.53	-0.08	-0.52	0.16	-1.02	0.53
Political Stability	0.98	-0.05	-1.20	0.66	-1.79	-0.14
Regulatory Quality	0.60	-0.09	-0.24	0.14	-0.87	0.47
Rule of Law	0.61	-0.06	-0.88	0.18	-1.21	0.09
Voice & Accountability	0.55	0.25	-0.37	0.38	-0.80	0.65

Source: Author's compilations using Worldwide Governance Indicators - World Bank.
Note: A higher value indicates better governance.

Table 4.3 above shows the 17-year average of six governance indicators for selected African countries for the period 1996 to 2015. Botswana's performance is compared to that of selected countries in the region, namely Ghana, Kenya, Namibia, Nigeria and South Africa. From the table, it is evident that Botswana performs very well in all indicators and far outscores most countries in the region. The country has repeatedly topped the list of the least corrupt African countries, ranking even higher than some European countries such as Greece. Botswana's scores are comparable with those from middle and income countries. For example, in 2002, the average political stability scores for middle and high-income countries were 0.59 and 0.82 respectively, while Botswana scored 0.78 (Iimi, 2006a).

Corruption control captures the extent of rent-seeking behavior and patronage in public office. Botswana's 17-year average score for this indicator is 0.89, well above its counterparts. Voice and accountability is largely defined as the ability of citizens to elect their government of choice and freedom of speech in expressing their opinions. Here, a score of 0.55 is still high by regional standards but lower than South Africa's score of 0.65. This is the only indicator where Botswana does not top the list from the sample of countries under consideration, however this score is still higher than that of Greece, whose 17-year average is 0.53. Governance effectiveness captures the quality of public sector service, the formulation of public policy and whether civil service is subject to political influence. Botswana performs best in the political stability indicator with an average score of 0.98. This indicator measures the likelihood of political unrest including politically influenced violence. The rule of law here indicates the level of confidence in the establishment and enforcement of societal rules by the judicial system, as well as respect for private property rights. Lastly, regulatory quality deals with agents' confidence in the government's ability to formulate policies and a regulatory environment conducive for private sector development.

These statistics are in line with the literature on Botswana's performance in terms of governance and institutional quality. Citizens have the ability to elect a government of their choice and the public can hold those in power accountable for how mineral revenues are utilized. This ensures that resource rents are not misappropriated. There is also a separation of powers between the branches of government, which ensures that the judiciary is independent of political influence and does not shy away from prosecuting corruption. The Directorate of Corruption and Economic Crime (DCEC) is an independent body that was first set up in 1994, with the main purpose of policing and exposing corruption in government. Botswana has also maintained transparency in the government's budgetary process and the management of the country's diamond resources, in particular the profit-sharing with mining companies.

4.5.2 The Ownership of the Diamond Resource

Prior to the discovery of diamonds, the government of the newly-formed Botswana passed a law which vested all mineral rights in the state. This effectively served to prevent potential future tribal conflict regarding the ownership and management of mineral resource wealth. The government also negotiated an equal profit-sharing scheme with the diamond mining company De Beers, securing 50 percent of profits from the mining operations and forming the Debswana Mining Company, which went on to become one of the world's leading producers of diamonds in value terms.

This arrangement has resulted in substantial diamond rents for the government of Botswana. Since the government is also the biggest spender and employer in the country, some linkages with other sectors of the economy have been formed in this way, despite the enclave nature of the mining industry. A more detailed analysis of Botswana's minerals policy and the government's relationship with international investors in the mining sector can be found in Matshediso (2005).

4.5.3 Strong Fiscal Discipline

The government of Botswana adopted a policy of twin surpluses, that is, a balance of payments surplus together with fiscal budget surplus. This was achieved through setting up two main funds as instruments of public sector saving of the resultant windfall from diamond operations, namely the Public Debt Service Fund and the Revenue Stabilization Fund in 1972. This successfully restrained current consumption expenditures and dampened domestic price inflation. This high saving also created alternative sources of foreign revenues, while also providing a type of insurance against short-run fluctuations in diamond rents as well as future reductions in revenue when the resource is depleted.[8]

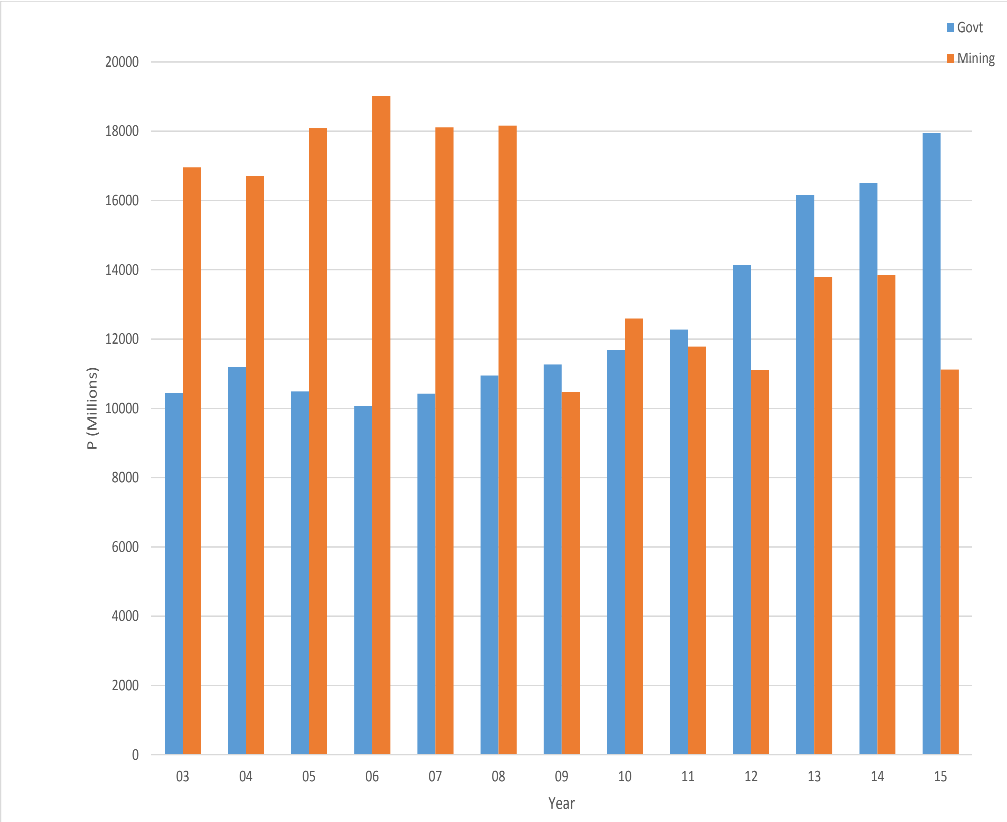
Fiscal saving was positive in the period between 1975 and 1996, and fluctuated between 10 and 40 percent of output, while public sector investment was constant

[8] Lewin (2011) discusses "Windfall Economics 101" and explains as follows: for countries with a fixed exchange rate regime, the excess supply of foreign exchange arising from a resource windfall leads to an exchange rate appreciation, which will cause an erosion of domestic productivity and a loss of competitiveness.

at approximately 20 percent of GDP (Lewin, 2011). In addition to this, the Bank of Botswana's profits and other income from the accumulated saving of mineral revenues comprise about 30 percent of government revenues, most of its income coming from the accumulated saving of mineral revenues.

In order to combat the cyclical nature of the resource industry and therefore guard against the revenue volatility associated with it, coupled with its hyper-prudential fiscal discipline, the government of Botswana put in place a strategy to manage the booms and slumps of the industry. National Development Plans (NDPs), which are under the control of the Ministry of Finance and Development (MFDP), are a series of development expenditure plans for the government. These development plans have to be approved by the national assembly before they can be effected and the MFDP exercises strict control over the funding of projects approved in the plans. Once they are approved, it is illegal to fund any project which was not originally included in the plan without the approval of parliament. NDPs are a way of prioritizing government spending and setting spending targets based on expected future government revenues and economic performance (Leith, 2000). The annual budgeting process is another key feature of the public expenditure framework.

Figure 4.2: Fiscal Spending and Mining Production (2003-2015)



Source: Author's compilations using Bank of Botswana data.

Figure 4.2 above shows the relationship between mining sector output and government spending. From the figure, it is evident that government spending does not appear to follow output levels in the mineral sector. In 2009/2010 when mining output contracted due to the GFC, public expenditure did not decline as a result and from 2012, it has been higher than mineral production. This indicates that fiscal expenditure patterns are not counter-cyclical in that they do not follow commodity market cycles.

Fiscal spending in Botswana also follows an implicit self-disciplinary rule which requires that recurrent non-education and non-health expenditures, such as the day-to-day running of government operations, are financed from non-mining revenues. Once a sufficient portion of non-mineral earnings has been set aside for these types of expenditures, the remaining amount, together with all of the income from mining revenues is divided between investment spending, that is expenditures on public health, education and infrastructure, and fiscal saving in the SWF.

Another point to note here is the type of activities that have been prioritized in the fiscal budget. The government aims to improve domestic productivity through investments in infrastructure and human capital (that is, health and education). These investments in themselves can act as long-run shock absorbers, in that when diamond rents dry up, these worthwhile investments in human and physical capital, as well as in off-shore financial assets, can facilitate a smooth transition period for the economy.

Policy makers in Botswana were aware of some of the challenges faced by mineral-based economies, and so they sought to create a policy environment where these adverse effects could be avoided or mitigated. This hyper-prudential fiscal stance over time successfully acted as a shock absorber and ensured that the economy was relatively well insulated against business cycle volatilities and the periodic downturns of the global diamond market. This also maintained inflation rates within reasonable bounds. In this way, Botswana has been able to sustain mostly positive real growth rates even in periods when the mining sector contracted.

4.5.4 The Management of Diamond Revenues

This subsection highlights how Botswana has managed its diamond wealth. The government of Botswana sought to set aside a portion of the resource windfall for intergenerational wealth transfers as well as to create an effective shock absorber and to ensure stability for the economy in leaner times. This required the government to avoid excessive public spending when diamond revenues were high, and to allow for fiscal budget surpluses so that additional income could be channeled into foreign exchange reserves. These accumulated reserves would also play an important role in pacing the disbursements of diamond revenues into the economy and in the management of the nominal exchange rate (Sarraf and Jiwanji, 2001).

International reserves still play a crucial role in the Botswana economy today, particularly in stabilizing the economy and in the management of the crawling peg exchange rate. Botswana's foreign exchange reserves are made up of a Liquidity Portfolio and a long-term investment component, the Pula Fund. The Liquidity

Portfolio houses foreign currency that is required for regular international transactions of both public and private sectors in the short term.[9] Botswana's foreign exchange reserves stood at USD8.7 billion in November 2014, which was equivalent to 16 and a half months of import cover (Bank of Botswana, 2015).

4.5.4.1 The Pula Fund

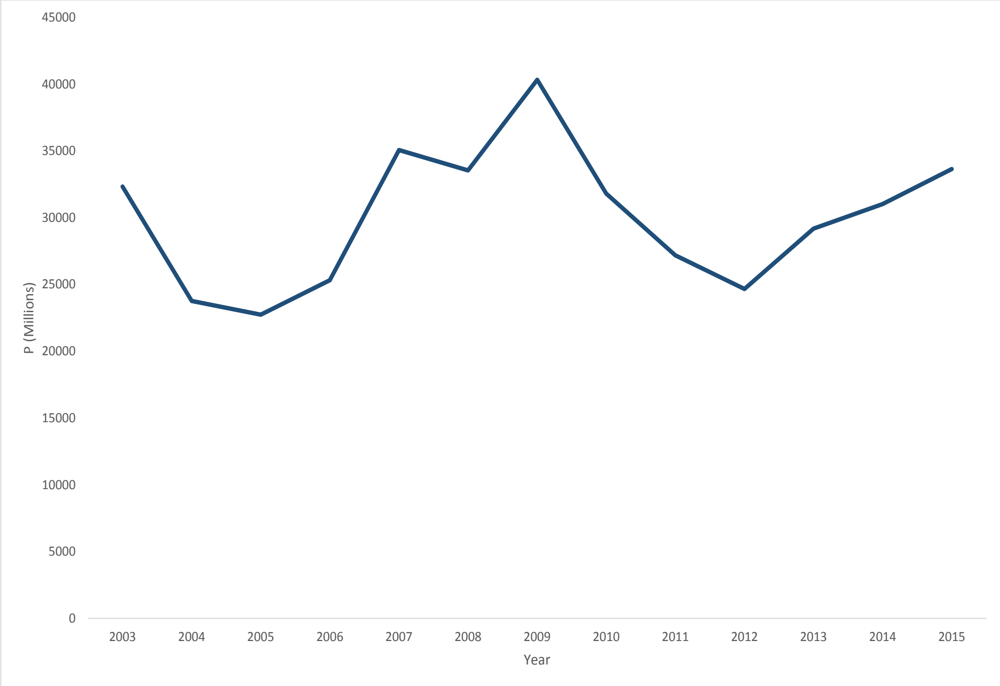
The Pula Fund component of the foreign exchange reserves is an SWF that contains funds in excess of medium-term requirements. It differs from the Liquidity Portfolio in that it is more of a long-term investment portfolio and exhibits the key features of an SWF as outlined in section 4. The fund was established in 1994 under the Bank of Botswana Act of 1975, with the main objective of saving a portion of the country's foreign exchange revenue from diamond exports for future generations, and to a lesser extent as a revenue stabilization tool when needed. In 1996, the original Act was amended and was replaced by the Bank of Botswana Act of 1996. As a result, the Pula Fund was re-established under its current format and the legal framework governing the fund was promulgated.

The fund is under the management of the Bank of Botswana, and it comprises two accounts; a Government Investment Account, which is under the control of the Ministry of Finance and Development Planning, and a foreign exchange account belonging to the Bank of Botswana. As a result of this shared ownership of the fund between the government and the central bank, the two parties have recurring consultations in order to ensure consistency and cohesion of macroeconomic policies. Part of the success of the Pula Fund is due to the fact that all investments are external, which means that the fund has been largely insulated from domestic economic pressures and political influence.

The successful management of the fund requires a sound framework that fosters transparency and accountability. As such, there are a number of rules and procedures in place to guide several aspects of the fund, for instance, deposits into the Pula Fund are subject to a predetermined ratio of non-investment spending to non-mineral earnings, called a sustainable budget index.

[9] The current benchmark level for the Liquidity Portfolio is equivalent to six months of import cover.

FIGURE 4.3: Pula Fund Real Balances (2003-2015)



Source: Author's compilations using Bank of Botswana data.

The figure above shows the evolution of the fund's real balances between 2003 and 2015. The largest balances over the period were recorded in 2009, when assets in the fund were worth BWP40,332.9 million[10]. This represents a 20 percent increase in balances from 2008. This rapid accumulation in SWF balances coincided with the GFC, and therefore could have been a precautionary measure to create a buffer for the economy in anticipation of shocks to commodity markets, particularly diamonds.

Overall, the Pula Fund has been found to be an efficient stabilization tool and an effective shock absorber for the economy. It is also an important tool for saving part of the diamond wealth for future generations, and an alternative source of foreign revenue for the government.

4.5.5 Summary

The main theme that emerges from the preceding section is that Botswana has been able to successfully manage its vast resource wealth and consequently, the

[10]This is equivalent to USD3,737.99 million at the exchange rate of USD1:BWP10.79.

country has been able to avoid the problems associated with the resource curse. The country has benefited from well preserved pre-colonial institutions, which laid a good foundation for a strong and sound framework for governance, rule of law and respect for property rights. In this way, rent-seeking behavior, predatory-type regimes and conflict over the diamond resource were avoided, while fostering transparency and accountability in how mineral revenues were being used. Secondly, vesting the rights to minerals with the state, as opposed to with the tribes, helped to prevent ethnic polarization and internal discord, and made it possible for everyone to benefit from the resource wealth. In addition to this, careful negotiations with mining companies minimized the repatriation of mineral rents and afforded the government a large source of revenue. Adopting a hyper-prudential policy of twin surpluses has created a good shock absorber for the economy, fiscal policy has not fallen into a pro-cyclical trap and investments in both physical and human capital have been prioritized. Lastly, the mineral revenues have been well managed and a sovereign wealth fund established. The management of the Pula Fund has been sound and free from political influence, and as a consequence, part of the diamond wealth has been saved for future generations with the interest earnings now an important revenue source.

While it is evident that the country has been able to avoid the political and social problems of the resource curse, it cannot be said with certainty that the economic problems associated the Dutch disease have been entirely avoided. Therefore, the next part of our analysis is to apply some econometric procedures to test the incidence of the Dutch disease in the Botswana economy. There are several approaches in the literature to investigating Dutch disease effects. For instance, Benjamin et al. (1989) developed a Computable General Equilibrium (CGE) model of Cameroon to examine the effects of oil revenues on the country's economy. Berg et al. (2010) explore Dutch disease effects in Uganda within a DSGE model while Dagher et al. (2012) developed a similar DSGE model in their analysis of the Dutch disease effects following oil windfalls in Ghana. Dungey et al. (2014) find evidence of Dutch disease effects in the Australian economy with an structural VAR (SVAR) framework.

Following Dungey et al. (2014), we employ a SVAR methodology to model the effect of a resource boom on sectoral output growth. We also consider the behavior of the real exchange rate and the real economy in response to these shocks. Our model includes a proxy for a sovereign wealth fund (SWF), which allows for the analysis of policy action in response to the boom.

According to Dutch disease theory, a positive shock to the resource sector, whether due to increased demand for resources, higher commodity prices or to favorable trade conditions that increase the value of exports, should stimulate output growth of the sector. However, since the effects of the boom cannot be contained within one sector, there will be widespread effects on the rest of the economy. The exchange rate will appreciate, and output in the non-resource traded sector should contract while that of the non-traded sector increases. Recall that this is due to a sectoral reallocation of factor inputs in response to the positive shock, as well as the resultant loss of competitiveness from the higher exchange rate. The central bank has the option to increase SWF balances in order to relieve the pressure on the exchange rate. If this action is successful, there will be an exchange rate depreciation, restoring the competitiveness of all traded sectors (Corden, 2012).

These are the interactions that are tested in our SVAR model with sign restrictions, and conclusions are drawn based on the analyses of the impulse response functions and variance decompositions.

4.6 Empirical Framework

We investigate the Dutch disease phenomenon in Botswana within a structural VAR framework. This approach is in line with Dungey et al. (2014) who estimated an SVAR to determine the effects of shocks to China's demand for Australia's natural resources, commodity prices and world output on the Australian resource export sector. This methodology has become popular in the literature as a means of deducing crucial information about the macroeconomy, such as quantifying the response of key fundamentals to shocks, measuring the degree of uncertainty about these responses and lastly, determining how much each shock contributes to forecasting performance and business cycles (Fry and Pagan, 2007). By utilizing the SVAR methodology we are, therefore, able to extract important information regarding the interactions between our variables of interest. This will allow us to determine the responses of the macroeconomy to shocks to the resource sector, and to draw important conclusions about the effect of mineral wealth on the broader economy.

The SVAR approach is better suited to answer our research questions as it provides the economic interpretation of the results obtained from multivariate models (Issaoui et al., 2013). In addition to this, all variables are treated as endogenous, thus overcoming one of the major flaws of traditional identification techniques by negating the need to find 'truly' exogenous variables.

The identification problem of this approach is essentially how to convert the reduced form VAR into a structural VAR. This requires additional assumptions. As discussed in Chapter 2, this requires additional restrictions may be imposed on the short run or on the long run dynamics of the model. A more recent approach is to impose qualitative and quantitative restrictions on the direction of impulse responses. Identification constraints are typically based on economic theory or past empirical work in the area. These restrictions essentially give an economic interpretation to the otherwise meaningless reduced form innovations.

In subsection 4.6.1 below, we outline the transition from a reduced form VAR to a structural VAR and the identification problem for this approach.

4.6.1 The SVAR Approach

Suppose we have the following reduced VAR model comprised of two variables:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \alpha z_t + \sum_{i=1}^{p} C_i \begin{bmatrix} x_{t-i} \\ y_{t-i} \end{bmatrix} + \begin{bmatrix} u_t^x \\ u_t^y \end{bmatrix} \tag{4.1}$$

where x_t and y_t are the two endogenous variables, z_t is a vector of exogenous variables. x_{t-i} and y_{t-i} are the lagged values of the endogenous variables. C_i is the matrix of coefficients to be estimated, and u_t^x and u_t^y are the undefined reduced form errors with covariance matrix V.

The SVAR representation of equation (4.1) above is therefore:

$$A_0 \begin{bmatrix} x_t \\ y_t \end{bmatrix} = az_t + \sum_{i=1}^{p} A_i \begin{bmatrix} x_{t-i} \\ y_{t-i} \end{bmatrix} + B \begin{bmatrix} \mu_t^x \\ \mu_t^y \end{bmatrix} \tag{4.2}$$

where A_0 is a matrix capturing the contemporaneous relations between the variables. A_i captures the model dynamics and is defined such that $C_i = A_0^{-1} \times A_i$. The B matrix is an impact matrix, while μ_t^x and μ_t^y are the orthogonal structural shocks that replace the reduced form disturbances, they have zero mean and variance covariance matrix Ω.

The reduced form errors can be expressed as linear functions of structural innovations as follows $u_t = A^{-1}B\mu_t$. Let $P = A^{-1}B$, then:

$$u_t = P\mu_t \tag{4.3}$$

while,

$$V = E(u_t u_t') = HH' \tag{4.4}$$

Here, H is some matrix so that $HH' = P\Omega P'$.

The SVAR methodology aims to disentangle the reduced form errors described by V, the estimated variance covariance matrix, into the unobserved structural innovations characterized by the matrix Ω (Liu, 2008). For this to be achieved, appropriate restrictions have to be imposed on the P matrix. These restrictions are guided by predetermined assumptions about the response of variables of interest in the system.

4.6.2 Model Specification and Identification Scheme

In analyzing the response of the Botswana economy to a mining boom, we impose sign restrictions on the response of variables to identify the shocks. This identification technique overcomes a lot of the shortfalls of short run and long run restrictions in that it is less stringent and the selection criteria for choosing among competing models is clear.

Before proceeding with the details of the identification scheme, the model to be estimated is:

$$\begin{bmatrix} y_t^g \\ dpi_t \\ x_t \\ min_t \\ res_t \\ manuf_t \\ serv_t \\ r_t \\ q_t \end{bmatrix} = \alpha z_t + \sum_{i=1}^{p} C_i \begin{bmatrix} y_{t-i}^g \\ dpi_{t-i} \\ x_{t-i} \\ min_{t-i} \\ res_{t-i} \\ manuf_{t-i} \\ serv_{t-i} \\ r_{t-i} \\ q_{t-i} \end{bmatrix} + \begin{bmatrix} u_t^{y^g} \\ u_t^{dpi} \\ u_t^{x} \\ u_t^{min} \\ u_t^{res} \\ u_t^{manuf} \\ u_t^{serv} \\ u_t^{r} \\ u_t^{q} \end{bmatrix} \tag{4.5}$$

where the left-hand side is a vector of endogenous variables containing global output (y^g), diamond prices (dpi), value of exports (x), mining sector output (min), official reserve balances (res), non-mining sector output ($manuf$), services sector value added ($serv$), the real interest rate (r) and real effective exchange rate (q) respectively. The vector of $u's$ contains the reduced form errors, which have no structural interpretation.

However, following from equation (4.3), the reduced form innovations can be expressed in terms of the structural disturbances, making it possible for us to obtain some economic interpretation. Recall that for these shocks to be identified, assumptions have to be made regarding the behavior of the variables in the system.

Table 4.4 below shows the sign restrictions imposed to identify the three shocks taken to represent a mining boom in each case. A positive sign ($0 <$) means that the impulse response of the variable is constrained to be positive, while a 'u' means that no restrictions are imposed on the variable in question.

Four positive resource boom shocks are identified. The first three are identified by restricting the impulse responses of one of the more "exogenous" world variables to be positive, while leaving the responses of all others unrestricted. The first

Table 4.4: SVAR Sign Restrictions

	Global GDP	Diamond Prices	Exports	Domestic Variables
Global Output Shock	0 <	u	u	u
Diamond Price Shock	u	0 <	u	u
Exports Shock	u	u	0 <	u
Natural Resource Shock	0 <	0 <	0 <	u

shock that is identified is a global output shock, which is expected to positively impact world GDP. Therefore, the response of this variable is constrained to be positive. A positive global output shock will typically increase foreign demand for domestic exports, which could translate to a higher resource windfall for the economy. The second shock considered is a positive diamond price shock, which just like the foreign demand shock, could also represent a resource boom due to higher resource sector output growth and foreign exchange revenues. Once again, a positive restriction is imposed on the response of diamond prices. We identify a positive shock to exports by constraining the impulse response of export growth to be positive.

We also identify a natural resource shock. This is one that stimulates exports in the presence of increased global economic activity and a boom in the commodity price cycle. For this shock, the impulse responses of world GDP, diamond prices and exports are all restricted to be positive.

The four shocks discussed above allow for an analysis of how such shocks to each individual variable affect traded and non-traded sector output growth as well as the exchange rate and the real macroeconomy.

After the restrictions have been imposed, the model is estimated. A lag length of one is used, as suggested by the Akaike Information Criterion and the Schwartz Bayesian Information Criterion. Restrictions are imposed for the first period only, that is one quarter and the analysis is based on 2000 draws. Discussions and conclusions are based on the results from impulse response and forecast error variance decompositions analyses.

4.7 Data

The data for our Dutch disease SVAR model of Botswana comprises ten variables that capture the dynamics of the different sectors crucial for our study of the Dutch disease phenomenon. The variables that we consider are: a measure of global output; a diamond price index; value of exports; mining production; agricultural and manufacturing output; value added of the services sector; the real interest rate; and the exchange rate. The data frequency is quarterly and the sample period runs from 1994:Q1 to 2014:Q3. These variables are selected to capture the key sectors in Dutch disease literature.

Global output is the trade-weighted real GDP of trading partner countries, calculated using trade data, CPI and output data for Botswana's trading partners. This variable is included in the model to capture foreign demand for Botswana's mineral exports. We also include a diamond price index where a positive shock to the variable is treated as a resource boom. The third variable in our model is the growth of exports since increased mining activities are expected to have an impact on the country's exports. Recall that the Dutch disease phenomenon is characterized by a booming resource sector, a lagging traded sector and a progressing non-traded sector. We therefore include mining output to represent the booming sector and services value added as the non-traded sector. Manufacturing and agricultural production accounts for the non-progressing traded sectors. Our model also includes official foreign exchange reserve balances as a proxy for a resource funds. The real interest rate is calculated from the yield on the three-month nominal Bank of Botswana Certificate, and lastly the real effective exchange rate (REER).

Data for trading partner GDP and CPI were obtained from the IFS database. The diamond price index series is the Polished Price Diamond Index obtained from the Bloomberg database. All other data on Botswana macroeconomic fundamentals were obtained from the Bank of Botswana and Statistics Botswana.

4.8 Empirical Results

This section discusses the results of the experiments carried out in the analysis. These illustrate the dynamic interactions of the variables in our model and contribute to our understanding of the effect of resource wealth on the Botswana economy.

4.8.1 Impulse Response Analysis

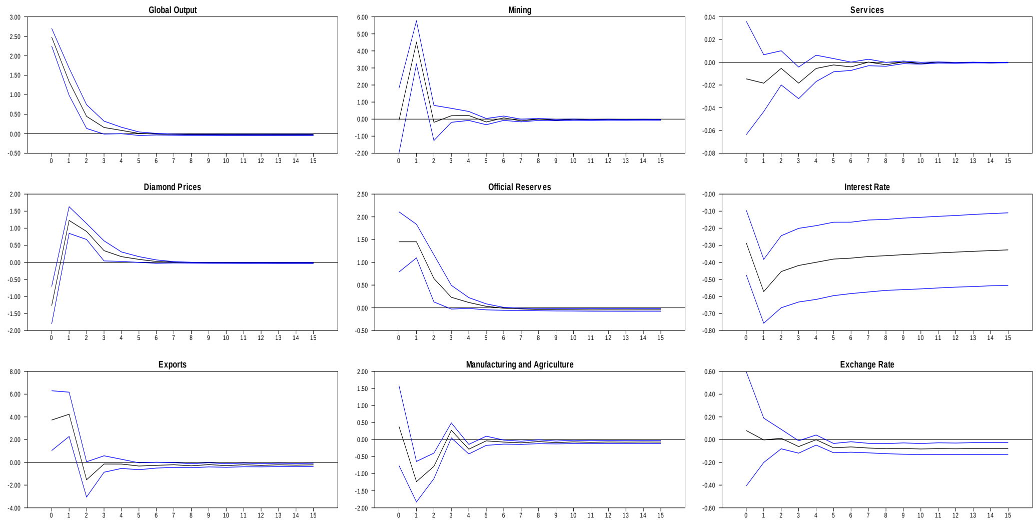
The responses of the different sectors in the economy to a mining boom are analyzed through the interpretation of impulse response functions. This enables us to determine the behavior of the variables of interest following one standard deviation shocks to global demand, diamond prices and export growth. The impulse responses are reported for 20 quarters. We present the median impulse response (black line) and the 16^{th} and 84^{th} percentiles (blue lines). We also minimize a penalty for the impulse responses that do not agree with the sign constraints. Imposing a penalty function helps us to exactly identify the best impulse response out of all those that satisfy the sign conditions, thus avoiding the multiple models problem discussed in Fry and Pagan (2007).

4.8.1.1 Responses to a Shock to Global Output

Figure 4.4 shows the responses of the variables to a positive global output shock. Recall that this is one that positively impacts world GDP, which may translate to an increase in global demand. Here, a positive restriction to the response of world output is imposed. This shock represents a natural resource boom in that an increase in global demand for domestic exports will result in higher export revenues.

A positive shock to world GDP results in higher export growth. This may be a reflection of increased foreign incomes and therefore higher foreign demand for Botswana's exports. The response of the mining sector, though sluggish on impact, quickly becomes positive. This response lasts up to about eight and a half quarters. Expectedly, the central back responds to the positive shock by increasing

FIGURE 4.4: Responses to a Shock to Global Output



official reserve balances substantially. This action appears to somewhat successfully mitigate the adverse effects of the higher foreign revenues on the exchange rate, as evidenced by the small and short-lived positive response of the exchange rate. The central bank's intervention ensures an eventual exchange rate depreciation within three periods of the shock. Consequently, the response of the non-mining tradable sector, though insignificant, is positive on impact. Agriculture and manufacturing output growth, however, declines before the end of the first quarter, which may indicate a brief crowding out of the two sectors by the mining sector. The long-lasting depreciation corrects for this by ensuring external competitiveness of exports, and non-mining growth increases briefly before returning to below trend growth for some time. This negative response may be attributable to other factors at play that may be inhibiting the growth performance of Botswana's non-traditional export sectors, even when the exchange rate is competitive.

The contemporaneous response of diamond prices, though negative on impact, quickly becomes positive before the end of the first quarter to take advantage of the higher foreign demand. Diamond prices peak within the second quarter before returning to their baseline levels by the end of the first year. The initial negative response on diamond prices in response to the shock could capture the short-term role of diamonds and other gems and precious metals as a haven of safety in times of economic downturns. So, in this case, diamond prices initially fall as a result of increased risk appetite in the booming global economy. Investors therefore move their wealth away from the safe haven assets and towards riskier assets. However, this effect is short-lived and diamond prices recover over time as global demand increases due to accelerated economic activity.

The response of the real interest rate is strong and negative. This may be an indication that the resource boom stimulates domestic demand and is therefore inflationary. It also reflects higher domestic output levels due to increased production in the mining sector.

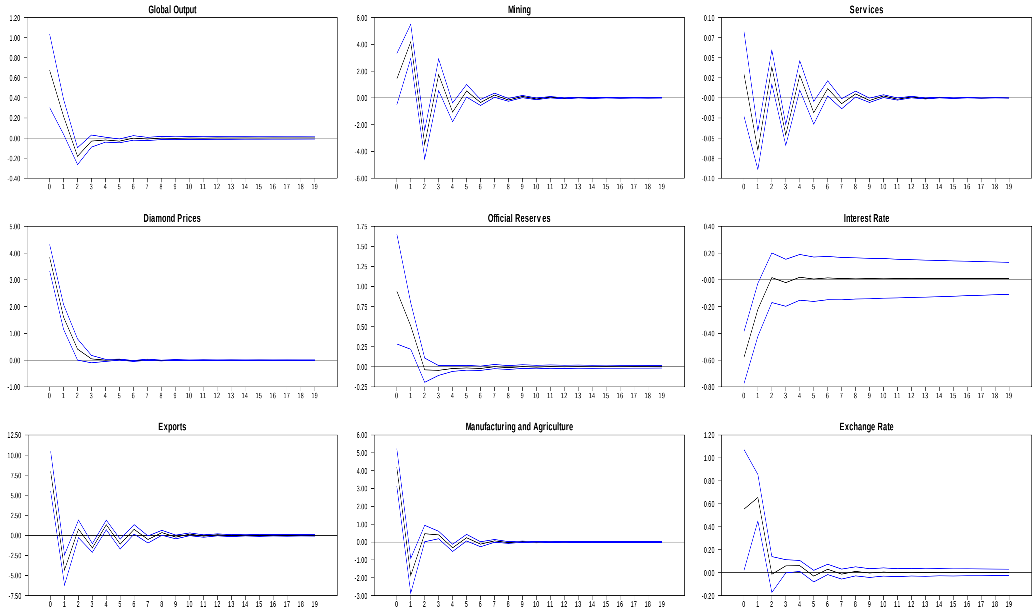
To summarize, a positive global output shock stimulates export and mining growth. Even though non-mining traded sector output increases instantaneously, this positive effect is temporary and output growth in these sectors declines and remains below trend growth over the impulse horizon and therefore signaling weak Dutch disease effects. However, these effects are muted by the central bank's policy action of building up foreign exchange reserves with the resource revenues in excess of what is required, thus ensuring that the economy's absorptive capacity of the additional funds is not exceeded. By purchasing foreign exchange and thus accumulating official reserves, this creates an excess supply of the domestic currency which results in a depreciation.

4.8.1.2 Responses to a Shock to Diamond Prices

To reiterate, a positive diamond price shock leads to growth in diamond prices. It is considered to also represent a booming resource sector in that it is expected to lead to higher mining growth and increased foreign exchange earnings. Here, the response of diamond prices is restrained to be positive. The impulse responses to the shock are summarized in figure 4.5 below.

Expectedly, the shock results in positive contemporaneous responses of exports and mining output as the two sectors take advantage of the higher commodity prices. The positive shock also causes an initial increase in non-mining production as well as in the growth of the services sector. These positive responses are however transitory and are quickly reversed within months of the shock before returning to their baseline levels.

FIGURE 4.5: Responses to a Shock to Diamond Prices



The exchange rate appreciates on impact due to the higher diamond prices. However, the shock also results in an accumulation of official foreign exchange reserves as the central bank responds to the influx of foreign exchange. This reverses the initial exchange rate appreciation and consequently, we see a brief recovery of the non-mining tradable sectors as they return to trend growth by the medium term. The real interest rate responds negatively, most likely reflecting increasing inflationary pressures in the booming economy.

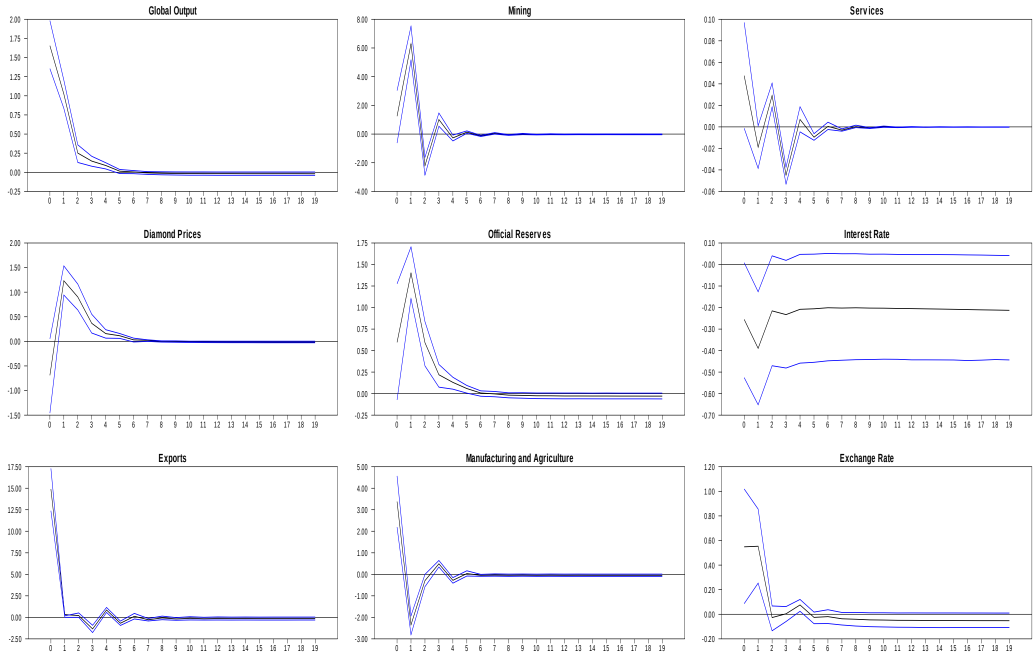
A monetary tightening could relieve the inflationary pressures, however, the central bank would have to be vigilant to ensure that the risks of an exchange rate appreciation are minimized by sterilizing any excess foreign exchange.

In summary, a diamond price shock behaves much like the shock to global output in that they both initially stimulate output growth of all sectors in the economy, however the brief exchange rate appreciation offsets some of this growth, with the effect lasting longer for the first shock. In both instances, the central bank increases foreign reserve holdings to correct for the exchange rate misalignment (which is higher for the diamond price shock). While non-mining sector output returns to trend growth over time for a diamond price shock, it appears to remain just below trend growth at longer horizons for the global output shock.

4.8.1.3 Responses to a Shock to Exports

A positive shock to exports is one that stimulates growth of the traded sector, therefore we constrain the response of exports to be positive. The impulse responses to a positive shock are summarized in the figure below.

FIGURE 4.6: Responses to a Shock to Exports



Interestingly, the positive shock results in a sluggish and briefly negative response of the mining sector. This response is quickly reversed within a few months of the shock and may be a reflection of the inability of the diamond industry to *instantaneously* adjust production levels to match the increase in demand. Though manufacturing and agriculture initially increase in response to the shock, the positive effects appear to be transient and the growth of the non-mining output shrinks before the end of the first quarter.

There is an exchange rate appreciation on impact due to the increase in the demand for exports. Consequently, the central bank accumulates more international reserves to relieve the economy of the excess foreign exchange and we see a brief marginal depreciation by the second period following the shock. There is a recovery in the non-resource traded sector and output returns to trend growth after one and a half years.

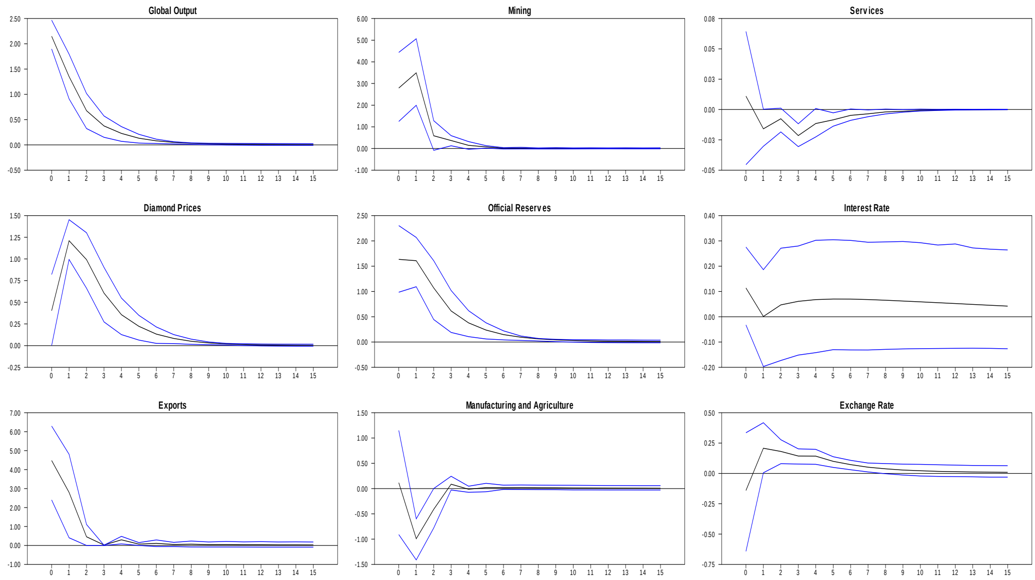
Once again, the effects of the shock are qualitatively similar to the first two shocks. The only difference being that the initial response of the mining sector to a shock to exports is sluggish on impact. The exchange rate appreciates in response to all three shocks, which overturns the initial output growth in the non-booming traded sectors. Reserve accumulation and the low interest rate however negate the loss of external competitiveness by lowering the exchange rate.

4.8.1.4 Responses to a Natural Resource Shock

The analysis is extended by identifying a positive natural resource shock. Recall that this shock is identified by restricting the impulse responses of global output, diamond prices and the growth of exports to be positive. The results of this exercise are discussed below.

The response of the economy to the natural resource shock are in line with those in the preceding subsections for the most part. The shock results in an increase in mining operations as expected, this positive response lasts for six quarters before normalizing. There is an immediate accumulation of foreign exchange reserves, and it appears that this policy action is effective as evidenced by the contemporaneous depreciation of the exchange rate. Consequently, non-mining traded sector output

FIGURE 4.7: Responses to a Natural Resource Shock



benefits and there is a strong positive response in output growth. However, the central bank appears to over correct with monetary tightening as shown by the high real interest rates and the eventual appreciation of the exchange rate. The higher domestic interest rates become more attractive to foreign investors, and there is an exchange rate appreciation. This result highlights the importance of harmonizing economic policy to ensure that the positive effects of one policy action are not being offset elsewhere in the economy. In this instance, it would appear that the accumulation of foreign reserves by the central bank is not enough to reverse the adverse effects of the excessive inflow of foreign exchange into the economy.

Our results overall suggest that the adverse effects of a resource boom in Botswana, are mild and short-lived. This is mainly due to the sterilization efforts of the diamond windfall by the central bank and the subsequent depreciation of the exchange rate under each of the three scenarios discussed above. In addition to this, as noted in Chapter 3, the Bank of Botswana is constantly intervening in the foreign exchange market to guard against an overvalued currency and to ensure export competitiveness.

4.8.2 Forecast Error Variance Decompositions

The next step in our analysis is to determine the fraction of variance in each of the variables that is due to the shocks of interest. The results of the reduced form forecast error variance decomposition exercise are summarized in the tables below. The shocks here are identified through a Cholesky decomposition and the variables are ordered as they appear in the tables, that is: global output, diamond prices, exports, mining output, official reserves, agriculture and manufacturing output, the real interest rate and the real exchange rate. We report results for forecast horizons one, four, twelve and twenty. Even though reduced form shocks are correlated and may be limited in their interpretation, this exercise can still provide important information for understanding the effect of a natural resource boom on the economy.

4.8.2.1 Proportion of Variance Explained for Exports

Table 4.5 shows the fraction of variation in exports that is explained by the other variables in the model.

Table 4.5: Fraction of Variance Explained for Exports

Shock	1	4	12	20
Global Output	9.415	8.258	8.178	8.188
Diamond Prices	9.582	14.360	14.424	14.331
Exports	81.003	62.904	61.869	61.430
Mining	0.000	4.126	4.342	4.340
Official Reserves	0.000	2.531	2.499	2.482
Manuf. & Agric.	0.000	5.510	5.505	5.471
Services	0.000	0.163	0.201	0.204
Interest Rate	0.000	0.552	1.319	1.878
REER	0.000	1.596	1.663	1.677

Even though the export sector is treated like an external sector in our model, it is the one most directly affected by a resource boom, so the forecast error variance decompositions for export growth are included in the discussion. Apart from shocks to itself, variations in this sector are mostly explained by shocks to global output growth and diamond prices at all horizons, with the latter becoming increasingly more important. Diamond price shocks account for between 9.6 and 15.0 percent of fluctuations in the value of Botswana's exports over all forecast horizons while global output shocks contribute 8 to 9 percent of variations. Shocks to mining and other traded sectors also contribute significantly to variations in exports.

4.8.2.2 Proportion of Variance Explained for Mining

Table 4.6 below reports the proportion of variation in mining sector output that is explained by the other variables in the model.

TABLE 4.6: Fraction of Variance Explained for Mining

Shock	1	4	12	20
Global Output	1.075	5.662	5.637	5.638
Diamond Prices	0.002	3.523	3.695	3.694
Exports	5.293	6.225	6.475	6.473
Mining	93.630	66.317	65.943	65.922
Official Reserves	0.000	4.049	4.033	4.032
Manuf. & Agric.	0.000	10.097	10.040	10.037
Services	0.000	3.126	3.108	3.107
Interest Rate	0.000	0.092	0.129	0.156
REER	0.000	0.909	0.940	0.941

The results also show that external shocks become increasingly important in explaining the fluctuations in mining production, with shocks to exports and global output contributing approximately 5.6 percent and 6.5 percent of the long-horizon variation respectively. Diamond price shocks account for up to nearly 4 percent of fluctuations. Domestically, foreign exchange reserves are the most important, contributing nearly 5 percent of the variation in the growth of mining at all forecast horizons. This might be a reflection of the influence of official reserve holdings on the exchange rate, which directly impacts on the demand for mining exports.

Interestingly, the non-resource traded sector also contributes significantly to the mining fluctuations, which could indicate potential linkages between the sectors despite the enclave nature of the mining industry.

4.8.2.3 Proportion of Variance Explained for Official Reserves

Table 4.7 below shows the proportion of variation in official reserves sector output that is explained by the other variables in the model.

TABLE 4.7: Fraction of Variance Explained for Reserves

Shock	1	4	12	20
Global Output	8.583	18.061	17.982	17.929
Diamond Prices	2.615	2.421	2.410	2.403
Exports	2.920	2.965	2.948	2.931
Mining	1.174	1.137	1.157	1.176
Official Reserves	84.709	73.903	73.287	72.827
Manuf. & Agric.	0.000	1.023	1.022	1.020
Services	0.000	0.047	0.052	0.056
Interest Rate	0.000	0.325	1.006	1.500
REER	0.000	0.117	0.135	0.157

Other than shocks to itself, global output shocks account for the majority of variations in official foreign exchange reserves at all horizons. These external shocks are responsible for 8 to 18 percent of all fluctuations over the 20 forecast horizons. This is in line with the discussion in the preceding section on our observation that higher global output stimulates demand for Botswana's exports, which contributes significantly to foreign exchange and export revenues. Diamond price shocks and export shocks each contribute approximately 3 percent, while shocks to mining account for just over 1 percent to variations. This may suggest that diamond prices and exports (of diamonds) contribute little volatility to official reserve holdings.

4.8.2.4 Proportion of Variance Explained for Manufacturing and Agriculture

Table 4.8 below shows the fraction of variance that is attributable to shocks to each of the other variables in our Dutch disease model.

TABLE 4.8: Fraction of Variance Explained for Manufacturing and Agriculture

Shock	1	4	12	20
Global Output	0.188	3.169	3.241	3.266
Diamond Prices	6.518	5.444	5.440	5.424
Exports	2.265	5.297	5.336	5.315
Mining	0.131	4.209	4.205	4.204
Official Reserves	0.088	2.061	2.079	2.072
Manuf. & Agric.	90.811	77.834	77.290	76.985
Services	0.000	1.562	1.552	1.549
Interest Rate	0.000	0.208	0.617	0.931
REER	0.000	0.216	0.240	0.253

Shocks to global output, diamond prices and exports play an increasingly important role in explaining movements in non-mining tradable sector output, with diamond prices and exports contributing just over 5 percent each at 20 quarters. The long-horizon contribution of mining is 4.5 percent, ranking fourth after own shocks, diamond prices and global demand shocks. This result may indicate that any potential Dutch disease effects of a mineral boom on the non-resource tradable sector, are neutralized or at least reduced. Therefore, any observed deindustrialization effects cannot be fully attributed to the resource boom. This is in line with our observation that, at times, non-mining traded sector output continued to contract even when the exchange rate was maintained at competitive levels.

4.8.2.5 Proportion of Variance Explained for Services

Table 4.9 below shows the fraction of variance that is attributable to shocks to each of the other variables in our Dutch disease model.

TABLE 4.9: Fraction of Variance Explained for Services

Shock	1	4	12	20
Global Output	0.095	0.429	0.435	0.436
Diamond Prices	0.206	4.840	5.095	5.95
Exports	3.552	3.485	3.867	3.867
Mining	4.696	13.939	13.886	13.885
Official Reserves	0.068	1.085	1.089	1.089
Manuf. & Agric.	0.285	1.217	1.263	1.263
Services	91.098	73.498	72.827	72.825
Interest Rate	0.000	0.131	0.136	0.139
REER	0.000	1.375	1.402	1.402

The forecast error variance decompositions for the growth of the services sector show that in the short to medium run, shocks to diamond prices, exports and mining, as well as own shocks are the most important. Shocks to the mining sector contribute approximately 14 percent of variations in the services sector value added, while diamond price shocks contribute nearly 6 percent in the 20^{th} forecast horizon. Recall that the Dutch disease theory asserts that a resource boom will benefit the non-traded sector, and this may be through increased productivity as resources relocate from the lagging tradable sector. In addition, this sector can also benefit from investment in infrastructure and human capital, both of which are financed by mineral resource revenues. So, any fluctuations to these revenues are most likely to have an impact on the services sector.

4.9 Conclusion

This study revisits the Dutch disease phenomenon in Botswana within a structural vector autoregression (SVAR) framework. This enables us to investigate the dynamic interactions of the different sectors of the Botswana economy in response to a resource boom. Our model comprises key variables in the Dutch disease literature to represent a natural resource traded sector, a non-resource traded sector, a non-traded sector, the real exchange rate and a measure of the real macroeconomy, the real interest rate. We also include the growth of official exchange rate reserves to represent a resource fund which could potentially be used to sterilize part of the natural resource windfall and relieve pressure on the non-mining sectors of the economy.

The study focuses on Botswana, an economy that has been cited in Dutch disease literature as having successfully avoided the disease. Our analysis involves an extensive review of literature on the resource curse and the Dutch disease, which is complemented by an SVAR analysis using quarterly data for the period 1994:Q1 to 2014:Q3. We examine the response of the Botswana economy to shocks to global output, diamond prices and exports, and we determine the proportion of variation in key sectors that is explained by these shocks.

The findings of the study show that while the Botswana economy does exhibit some mild symptoms of the Dutch disease, however any potential adverse effects are quickly reversed by policy action in all four shocks. That is, the Bank of Botswana's intervention in the foreign exchange market helps to maintain the exchange rate within desired levels and this contains the adverse effects of the mineral wealth. However, stunted growth within the manufacturing and agriculture sectors still exists even in instances where the exchange rate is competitive.

In the case of a shock to foreign demand, both the mining and non-mining sectors contemporaneously increase, however, the positive effect on the non-mining traded sector is short-lived. The exchange rate appreciates on impact but policy action helps to mitigate this effect by increasing international reserve holdings. In dealing with this shock, the central bank can employ a tighter monetary policy to deal with resulting inflationary pressures, however care should be taken that external competitiveness is not compromised.

The diamond price shock also results in positive contemporaneous responses of exports, mining and the non-mining resource sector. Just like the global output shock, there is a brief appreciation of the exchange rate, consequently we see a fall in agriculture and manufacturing output growth. Once again, there is a build up of official reserves in response to additional revenues and the exchange rate appreciation is eliminated. The non-mining sector output returns to trend growth within seven and a half periods. The shock to exports delivers similar results, with instantaneous expansion in all sectors, which only lasts a few periods due to the brief contemporaneous appreciation of the real exchange rate.

The natural resource shock increases mineral production on impact. There is a brief marginal increase in the non-mining traded sector due to the brief depreciation of the exchange rate and the official reserve accumulation. Real interest rates increase on impact and since the booming economy is more likely to be faced with positive inflationary pressures, this increase could typically be attributed to a monetary contraction. Over time agriculture and manufacturing production returns to its baseline levels.

All four positive shocks result in an increase in mining sector output growth. Even though the non-mining sector responds positively on impact for all the shocks, this response is brief and quickly becomes negative within the first year of the shocks. Expectedly all four shocks are expansionary, and result in an exchange rate appreciation. The central bank responds to each shock by accumulating foreign exchange reserves. Consequently, there is an eventual depreciation of the exchange rate in all cases except for the last one. Over time, non-resource tradable output growth returns to its baseline levels following shocks to diamond prices and exports. In the case of a global output shock however, agriculture and manufacturing output appears to stay below trend growth permanently.

Taking into consideration the results of our analysis, together with the arguments in the literature regarding the Botswana case, we conclude that the Botswana economy did in fact escape the political and social aspects of the resource curse. On the economic side however, the economy does exhibit some *mild* but *short-lived* Dutch disease effects. These effects appear to be temporary because in all instances, the central bank appears to act accordingly to maintain external competitiveness by building up foreign reserves and mopping any excess foreign exchange. However we note that the non-mining traded sector under-performs even when the exchange rate is competitive, which may indicate that there are other factors inhibiting the growth of these sectors. Botswana has semi-arid climatic conditions, frequent and prolonged droughts and poor, sandy soils. These factors severely hamper both arable and livestock production in the country, thus restricting growth of the agricultural sector. The country is also landlocked and faces high transport costs, this therefore makes it undesirable for cost effective FDI. Furthermore, Botswana's close proximity to a regional economic giant with a much larger domestic market and superior infrastructure implies that there is stiff competition when it comes to attracting foreign investors. These are some of the reasons that could partially explain what may be viewed as a "de-industrialization" effect of resource wealth.

Our conclusions are based on an extensive literature review and an analysis utilizing a SVAR approach which allowed us to examine the interactions between key sectors in the Dutch disease literature, in particular traded and non-traded sectors of the economy. In our analysis, we focused on the size of the tradable sector. Future research could therefore extend this work by considering the *relative* size of the tradable to the non-tradable sector in Botswana in the analysis. Further research could also be carried out within a DSGE framework to better understand the different interactions between households, traded and non-traded sectors, and policy.

Chapter 5

Conclusion

5.1 Summary and Main Findings

This thesis comprises three empirical papers, each of which answers a question pertaining to the impact of external shocks on macroeconomic variability in small developing commodity-exporting countries, using Botswana as a case study. We employ recent innovative techniques in macroeconometrics to extract, identify and examine the effects of these shocks on key macroeconomic fundamentals. The first empirical chapter focuses on terms of trade shocks, the second paper determines the unobservable factors driving Botswana's bilateral exchange rates, while the last paper considers shocks to a natural resource sector giving rise to a mining boom.

Our findings make significant contributions to the meagre body of work on the external shocks faced by the Botswana economy. In Chapter 2, we use a structural VAR with sign constraints to identify four terms of trade shocks crucial for commodity-exporting economies such as Botswana. We find that the response of the economy to these shocks is mainly determined by the global economic conditions driving each shock. In addition to this, policy action in response to the different shocks is determined by the underlying characteristics of each shock. Our results show that even in instances where the qualitative response of policy is the same, there will be notable differences in the quantitative response.

In Chapter 3, the use of a principal component analysis to extract the unobservable variables allows us to determine the most important latent factor behind variations in the pula bilateral exchange rates. Our findings in this paper emphasize the role of latent factors in the evolution of Botswana's bilateral exchange rates. An interesting result here is that the largest principal component is not a Botswana factor as would be expected, instead it is mostly related to conditions in the US and South African economies. In addition to this, the factor improves on one day ahead forecasts for seven out of the ten bilateral exchange rates considered and weekly forecasts for the rand/pula exchange rate. The main policy recommendation here is that the central bank ought to include bilateral exchange rate panels in the management of the pula exchange rate.

In Chapter 4, we revisit the resource curse and the Dutch disease debate in the Botswana economy. We combine an extensive review of the literature with econometric procedures to determine the effects of resource wealth on the economy. We examine the relationship between Botswana's mining and non-mining sectors, as well as the real exchange rate and the real interest rate within a structural VAR framework. Our main conclusions are that through strong institutions and good governance, Botswana has been able to escape the political aspects of the resource curse. However, the economy still exhibits evidence of short-lived Dutch disease effects. These are mitigated by the adoption of sound macroeconomic policies and the effective use of a sovereign wealth fund, they are therefore not fully propagated to the rest of the economy. The poor performance of the non-mining traded sector production cannot be fully attributed to a Dutch disease as there are other factors which inhibit growth in these sectors. Here, we recommend ensuring a harmonious policy mix to ensure that policy actions across the economy are consistent to meet a combined objective.

5.2 Directions for Future Research

One of the main findings of this thesis highlights the role of global economic conditions in driving domestic fundamentals. The conclusions drawn here are based on analyses within a sign restricted VAR framework. The next step in this line of research would be to identify terms of trade shocks pertinent to the Botswana economy within a DSGE approach in order to fully ascertain the effects of these shocks.In addition, since this study solely identifies external shocks, future research could extend the analysis by also identifying some domestic shocks such as monetary policy shocks. Another notable extension could be undertaking an analysis which combines sign restrictions with short and long run restrictions.

In the second empirical chapter, we identify a global risk appetite related factor as one of the main components driving Botswana's bilateral exchange rates. As an extension of this work, other multivariate models such as Bayesian VARs that incorporate this factor could be developed and their predictive accuracy performance assessed.

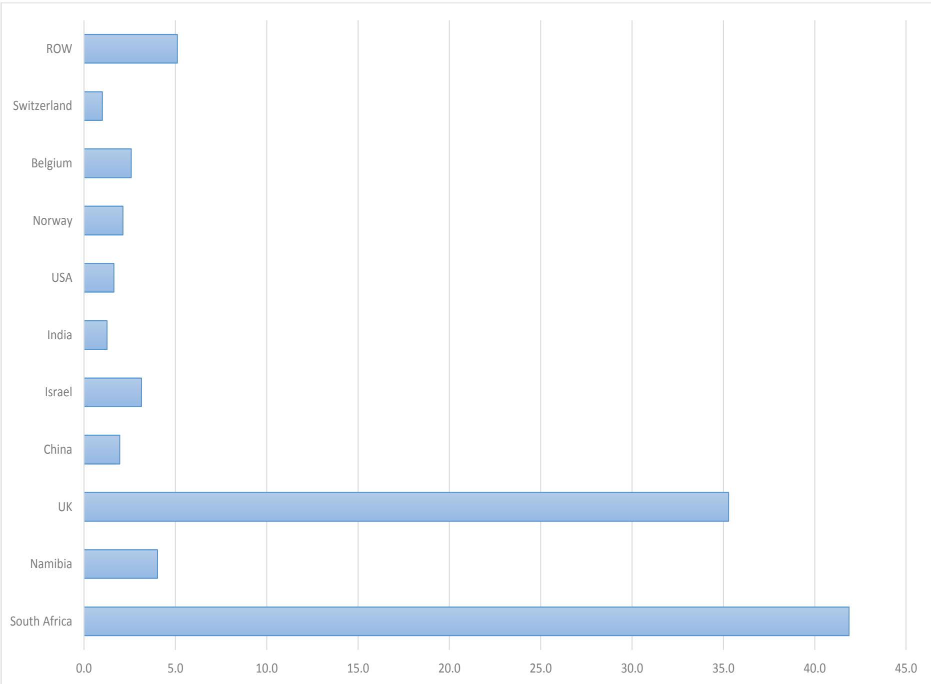
The use of the structural VAR methodology in Chapter 4 to investigate the effects of a resource boom on the economy is a novel contribution to the Dutch disease literature on Botswana. However, future work could extend our analysis by developing a DSGE model as a way to investigate the possible impact of increased diamond revenues on the Botswana economy. The model could include structural features that are key to developing countries as in Dagher et al. (2012). This framework could allow for an examination of both the short-term and medium-term effects of a mining boom, as well as for an analysis of how different fiscal, monetary and international reserve policies impact the economy in response to a natural resource shock.

Appendix A

A.1 Trade Weights

The figure below shows the trade weights for Botswana's most important trading partners in 2012.

Figure A.1: Trade Weights



A.2 Unit Root Tests

Table A.1 below shows the results of the Augmented Dickey-Fuller test for a unit root. The null hypothesis for the test is that the series contains a unit root. Since the results show that the null hypothesis is rejected for all the variables, we conclude that the variables are stationary in levels or do not contain a unit root.

TABLE A.1: Unit Root Test

Variable	Test Statistic
Export Price Inflation	-4.172**
Import Price Inflation	-4.687**
World Output Growth	-5.012**
Domestic Output Growth	-3.115***
Domestic Inflation	-3.381***
Real Effective Exchange Rate	-7.328**
Lending Interest rate	-3.521***

Note: *,**,*** represent significance at 1 percent, 5 percent and 10 percent levels of significance.

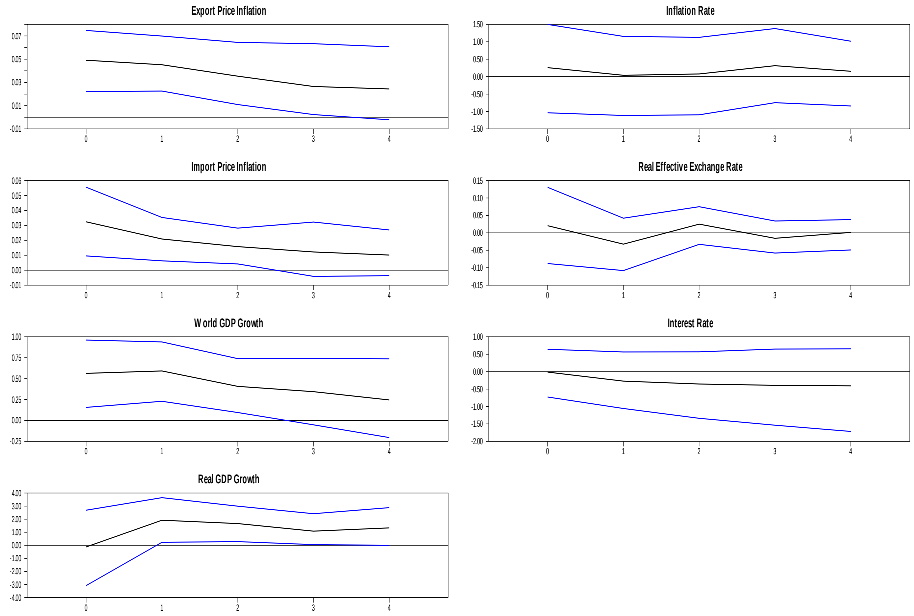
A.3 Impulse Response Analysis: Pure Sign Restrictions Approach

The section shows the impulse response functions for the experiments using the pure sign restrictions approach.

A.3.1 Responses to a Global Demand Shock

Figure A.2 below shows the responses of the variables following a positive global demand shock. The same restrictions as before are applied to identify the shock.

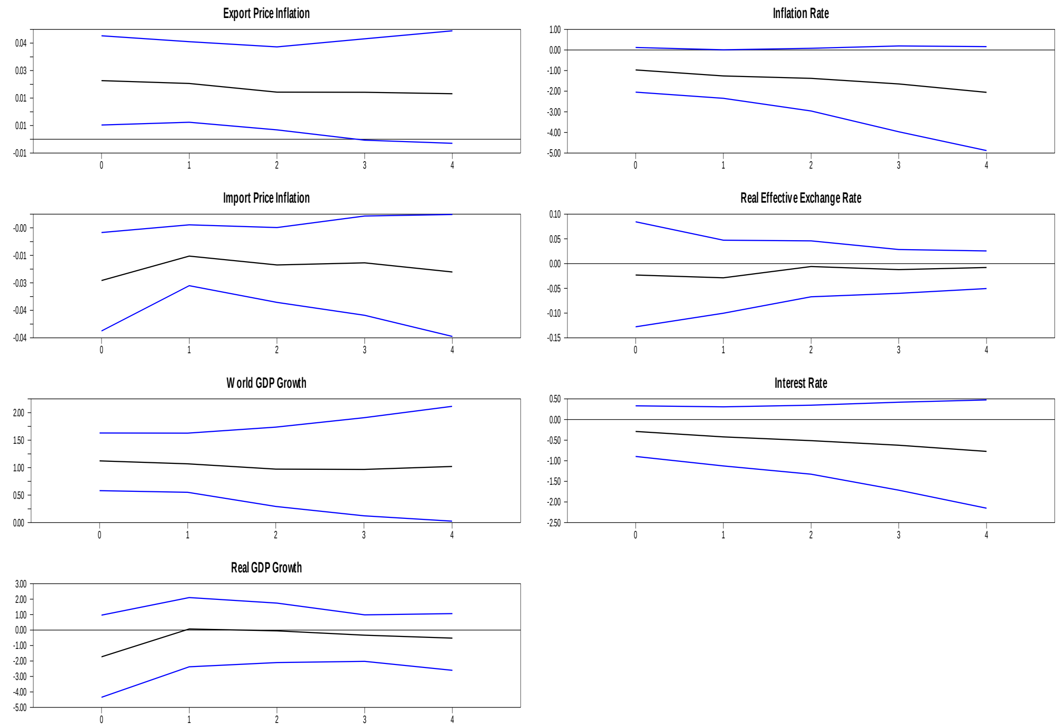
FIGURE A.2: Responses to a Positive Global Demand Shock—Pure Sign Restrictions



A.3.2 Responses to a Globalization Shock

Figure A.3 below shows the responses of the variables to a positive globalization shock.

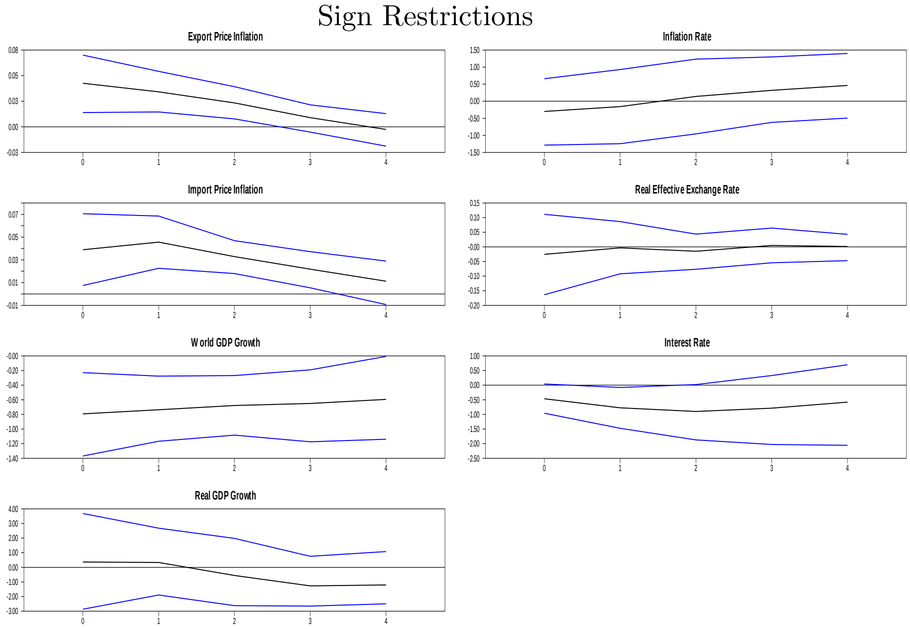
FIGURE A.3: Responses to a Positive Globalization Shock—Pure Sign Restrictions



A.3.3 Responses to a Commodity-Market Specific Shock

Figure A.4 below shows the response of the variables in the model to a positive commodity-market specific shock.

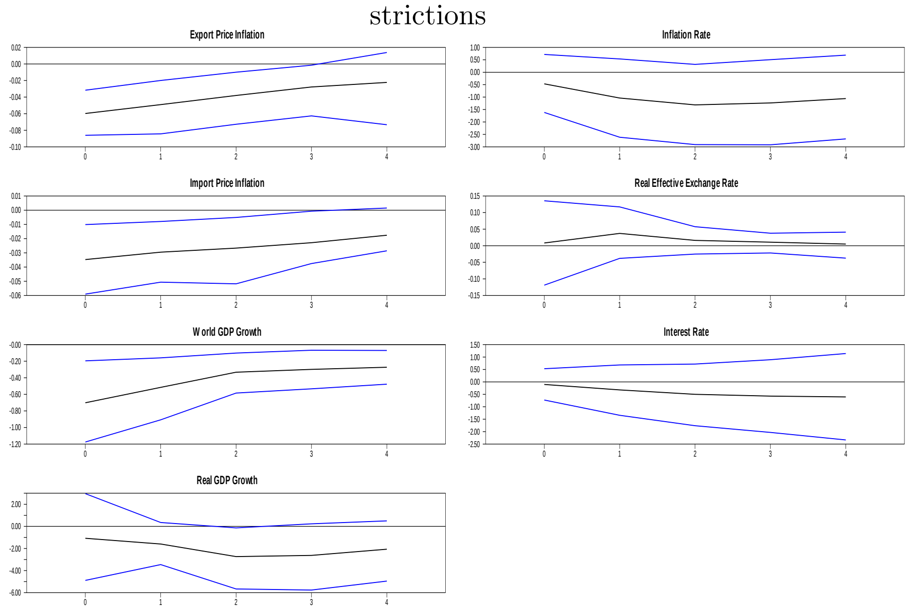
Figure A.4: Responses to a Positive Commodity-Market Specific Shock—Pure Sign Restrictions



A.3.4 Responses to a Global Supply Shock

Figure A.5 below shows the responses to a negative oil price shock.

Figure A.5: Responses to a Negative Global Supply Shock—Pure Sign Restrictions



Appendix B

B.1 Preliminary Analysis

B.1.1 Correlation between Growth Rates of Currencies

Table B.1: Correlation between Growth Rates of Currencies.

	ZAR	GBP	EUR	USD	JPY	NOK	ILS	HKD	INR	CNY
ZAR	1.0000									
GBP	-0.3965	1.0000								
EUR	-0.4660	0.7810	1.0000							
USD	-0.4639	0.6931	0.5969	1.0000						
JPY	-0.4332	0.5734	0.5921	0.7241	1.0000					
NOK	-0.0209	0.1508	0.0483	0.1368	-0.0172	1.0000				
ILS	-0.4049	0.6605	0.6650	0.7597	0.6108	0.0848	1.0000			
HKD	-0.4648	0.6956	0.6021	0.9992	0.7297	0.1324	0.7607	1.0000		
INR	-0.2617	0.5707	0.5327	0.7694	0.5245	0.0936	0.6902	0.7681	1.0000	
CNY	-0.4670	0.6733	0.6041	0.9801	0.7136	0.1706	0.7850	0.9791	0.7858	1.0000

B.1.2 Correlation between the Principal Components and the Bilateral Exchange Rates

The table below shows the correlation between the first three principal components and the bilateral exchange rates.

Once again, the South African Rand is found to be negatively correlated to the first and second principal components while the Norwegian Krone is least correlated to the first principal component.

Table B.2: Correlation between the Principal Components and the Bilateral Exchange Rates.

Currency	PC1	PC2	PC3
ZAR	-0.4922	-0.0726	0.1007
GBP	0.8072	-0.0357	0.4670
EUR	0.7898	0.1180	0.5124
USD	0.9607	-0.0534	-0.2057
JPY	0.8258	0.2610	-0.1319
NOK	0.1609	-0.9447	0.0384
ILS	0.8643	0.0074	0.1383
HKD	0.9624	-0.0460	-0.2011
INR	0.8275	-0.0866	-0.0865
CNY	0.9630	-0.0757	-0.1925

B.2 Lasso Shrinkage Method

This subsection provides a brief overview of the lasso estimate for better understanding of this novel technique. The discussion closely follows Tibshirani (1996) and Hastie et al. (2011).

Let $\mathbf{x}' = (x_1, x_2..., x_p)$ be a vector of predictors, with y_i as the response for the i^{th} variable. The model is linear in parameters, therefore our regression model will take the following form:

$$f(x) = \beta_0 + \sum_{j=1}^{p} x_j \beta_j. \tag{B.1}$$

where β_j's are model parameters. These are estimated so that we obtain $\beta = (\beta_0, \beta_1, ..., \beta_p)'$ to minimize the residual sum of squares (RSS).

$$RSS(\beta) = \sum_{i=1}^{N} (y_i - f(x_i))^2 = \sum_{i=1}^{N} (y_i - \beta_0 - \sum_{j=1}^{p} x_{ij}\beta_j)^2 \tag{B.2}$$

Recall that regression shrinkage techniques aim to minimize a penalty on the residual sum of squares, subject to the sum of the absolute value of the coefficients being less than a constant. The Lasso estimate is therefore given by:

$$\hat{\beta}^{lasso} = \arg min_{\beta} \textstyle\sum_{i=1}^{N} (y_i - \beta_0 - \sum_{j=1}^{p} x_{ij}\beta_j)^2 \tag{B.3}$$

Subject to : $\sum_{j=1}^{p} |\beta_j| \leq t$.

The lasso optimization problem above can be re-written in Lagrangian form as follows:

$$\hat{\beta}^{lasso} = \arg min_{\beta} \, \{\frac{1}{2}\sum_{i=1}^{N}(y_i - \beta_0 - \sum_{j=1}^{p} x_{ij}\beta_j)^2 + \lambda \sum_{j=1}^{p} |\beta_j|\}. \quad \text{(B.4)}$$

$\sum |\beta_j| \leq t$ is the lasso constraint, and $t \geq 0$ is the lasso or tuning parameter. The constant β_0 is re-parameterized by standardizing the explanatory variables, such that $\beta_0 = \bar{y}$ for all t, thus enabling us to fit a model without an intercept. Due to the nature of the constraint, allowing the tuning parameter (t), to take a sufficiently small value causes some of the model coefficients to be exactly equal zero. In this way, the lasso technique behaves like a continuous form of the subset selection method (Hastie *et al.* 2010) and a more parsimonious model is obtained with better prediction accuracy.

If $t > \sum_{j=1}^{p} |\hat{\beta}_j^0|$, where $\hat{\beta}_j^0$ is the least squares estimates, then the lasso estimates will be the same as the least squares estimates. When $\sum_{j=1}^{p} |\hat{\beta}_j^0| > t$, the coefficients are shrunk towards zero, with some being exactly equal to zero.

B.3 Evaluating Forecasting Performance

This subsection outlines a process for evaluating forecasting performance as discussed in Rossi (2013).

Let s_t be the log of the exchange rate, while f_t is the some economic fundamental. Assuming a linear relationship between s_t and f_t,

$$E_t(s_{t+h} - s_t) = \alpha f_t \tag{B.5}$$

where $t = 1, 2, ...T$ and h is the forecast horizon.

In order to evaluate the forecasting performance of the model, we have to examine how it compares with some benchmark model. Typically, the driftless random walk is used as a good benchmark since it has been proved to be the toughest one to beat. Therefore our benchmark is given as:

$$E_t(s_{t+h} - s_t) = 0 \tag{B.6}$$

To determine whether the predictive ability of the economic fundamental f_t, two approaches can be taken, the in-sample fit or the out-of-sample forecasting. In this study, we consider the latter approach. The sample is divided into an in-sample part running from time $1 to R$, and an out-of-sample segment comprising observations $R + h$ to $T + h$, where R is the size of the regression estimation window for obtaining $\hat{\alpha}$. We utilize a rolling window forecasting technique where we use the most recent data to progressively estimate the model parameter over time such that:

$$\hat{\alpha} = [\sum_{j=t-R+h+1}^{t} f_{j-h}^2]^{-1} \times [\sum_{j=t-R+h+1}^{t} f_{j-h}(s_j - s_{j-h})] \tag{B.7}$$

where $t = R, R + 1, ...T$.

From equation B.7 above, we obtain:

$$s_{t+h} - s_t - \hat{\alpha}_t f_t \tag{B.8}$$

which is equivalent to a sequence of P out-of-sample forecast errors $\varepsilon^f_{t+h|h}$.

The next step is to evaluate the predictive ability of the model. This is achieved by means of a loss function. For our purposes, we compare the Mean Squared Prediction Error (MSPE) obtained from our model with that obtained from the benchmark model, the driftless random walk.

The statistical significance of the results is evaluated using two popular out-of-sample tests for relative forecast performance, namely the Clark-West (CW) test and the Diebold-Mariano (DM) test.

B.3.1 The Diebold -Mariano (DM) Test

The DM test is a predictive performance test developed by Diebold and Mariano (1995). It is popularly used to ascertain the statistical significance of loss functions used in evaluating forecasting accuracy.

Consider a series, y_t, for which we obtain forecasts $\hat{y_{1,t}}$ and $\hat{y_{2,t}}$ using two competitor models 1 and 2. We obtain prediction errors e_1, t and e_2, t. The squared forecast errors are defined as $e_t = [y_{t+h}(\tau) - \hat{y_{t+h}}(\tau)]^2$.

In order to assess the predictive performance of the two models, we consider loss differential, say d_t which is a direct function of the prediction error such that $d_t = e_{1,t} - e_{2,t}$. The null hypothesis of equal forecasting accuracy of the competitor models is therefore $E(d_t) = 0$, that is, $E(e_{1,t}) = E(e_{2,t})$.

Imposing the assumption of covariance stationarity, the DM test statistic for evaluating the null hypothesis is given as:

$$DM = \frac{\bar{d}}{\sqrt{\frac{\hat{\sigma}_{\bar{d}}}{T}}} \tag{B.9}$$

where $\bar{d} = \frac{1}{T}\sum_{t=1}^{T}[e_{1,t} - e_{2,t}]$ is the sample mean loss differential and $\hat{\sigma}_d$ is a consistent estimator of the weighted sum of auto-covariances Diebold and Mariano (1995). The competitor model is said to outperform the benchmark model, that is the random walk, when the DM statistic is significant and positive.

B.3.2 The Clark-West (CW) Test

The CW test by Clark and West (2006) is designed to overcome some of the shortfalls of the DM test. The CW tests therefore builds on the DM tests and provides modifications to the test statistic. The null hypothesis for the test states that the fundamental follows a random walk, thus taking into to account the fact that the competitor models are nested (Rogoff and Stavrakeva, 2008).

To derive the CW test statistic, let y_t be the series of interest, and assume two competitor models, the driftless random walk and a structural model, that we are comparing to evaluate predictive accuracy.

The random walk without drift model is expressed as:

$$y_t = e_{1,t} \tag{B.10}$$

while the competitor model is:

$$y_t = aX_{t-1} + e_{2,t} \tag{B.11}$$

where a is a population parameter and $e_{1,t}$ and $e_{2,t}$ are error terms. Under the null hypothesis for the CW test, the population parameter a is equal to zero, therefore the forecast errors are equal.

The CW statistic for evaluating forecasting performance is:

$$CW = \frac{P^{0.5}\bar{d}}{\sqrt{\Omega_{\bar{d}}}} \tag{B.12}$$

Here, P is the number of predictions and Ω is the variance of $\bar{d}$ (Rogoff and Stavrakeva, 2008).

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