The role of Non-Traded Goods in Current Account and Exchange Rate Determination: A DSGE Analysis

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August 2015

Abstract

Most general equilibrium models of the current account focus on developed countries and assume that the evolution of the current account is caused by changes in the traded goods sector. However, emerging markets are typically characterised by a relatively large non-traded goods sector, which also affects macroeconomic fundamentals. This study contributes to the literature by calibrating a Dynamic Stochastic General Equilibrium (DSGE) model to analyse the impact of non-traded goods on the current account and exchange rate. The model is calibrated to South Africa, an economy with a large current account deficit and a large non-traded goods sector. The results show that non-traded goods play a significant role in the determination of the current account, with half the variation in the current account explained by non-traded goods productivity shocks. A large proportion of variation in the exchange rate is explained by risk premium shocks, but the contribution of these shocks decreases with the introduction of non traded goods in the model. The model provides a good fit to stylised facts, suggesting that the non-traded goods sector is vital for the evolution of the current account and exchange rate.

JEL Classification: F32, F41, F47, F49

Keywords: Current Account, Non-Traded Goods, Exchange rate, New Open Economy Macroeconomics, DSGE, Emerging Market Economies

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†I would like to thank Dr. Amos Peters and Professor J. Paul Dunne for their insightful and invaluable comments in this work.

1 Introduction

External imbalances have continued to get attention in international macroeconomics for decades, with several studies arguing that current account imbalances are one of the main reasons for financial sector fragility due to the ease of financing imbalances through the more integrated global financial system (e.g. Obstfeld and Rogoff, 2009; Milesi-Ferretti and Blanchard, 2009; Obstfeld, 2012). These studies argue that current account dynamics play an important role in the macroeconomic stability of emerging market economies and remain a policy-relevant variable on both financial and macroeconomic grounds. The recognition of the significance of the current account for macroeconomic stability urges researchers to find the best possible policy solutions for current account stability (Milesi-Ferretti and Blanchard, 2009). However, finding solutions to large external imbalances remains a challenge for researchers, particularly in emerging markets, where there is still little research on current account dynamics.

Current account research in the context of general equilibrium models has so far focused on the evolution of the current account in developed countries (e.g. Bergin, 2006; Lu, 2012; Herz and Hohberger, 2013), and most models that have been developed assume that the current account balance is a direct result of the traded goods sector. However, because of structural rigidities in the production process, multi-sector middle and low income economies are normally characterised by high levels of consumption of the non-traded good in addition to traded goods, and shocks emanating from the non traded goods sector can have destabilising effects on the economy, a feature overlooked in most current account models. This is because when consumption is an aggregate of both traded and non-traded goods in a dynamic model, the non-separability of consumption between these two types of goods in constant elasticity of substitution form implies that shocks to the non-traded goods sector have effects which may influence tradeables consumption, and consequently spillover on the current account (see Obstfeld and Rogoff, 1996; Lu, 2009). Such a scenario can be illustrated by an example in which the consumption of tradeables increases together with the consumption of non-tradeables. Under such circumstances, a boom in the non-traded goods sector would increase demand for tradeables, thereby increasing demand for imports and worsening the current account deficit. This implies that non-traded goods play a vital role in current account determination and should not be overlooked as one of the drivers of the current account. This aspect is particularly relevant in developing countries and emerging markets where the size of the non-traded goods sector can be relatively large. The significance of the non-traded goods sector suggests that to fully understand how the current account evolves in emerging markets and developing economies, there is need for a fully specified current account model that accounts for all the sectors that contribute to economic development in a multi-sector economy. The inclusion of the non-traded goods sector facilitates in answering questions that cannot be answered by single sector models since different sectors in the economy have different driving forces and react differently to exogenous shocks (Batini, Harrison and Millard, 2003). This makes the separate treatment of different sectors in the economy of paramount importance as it facilitates in the design of efficient macroeconomic policy.

The lack of investigation into the current account dynamics of emerging markets, and the size of the non-traded goods sector in emerging markets and developing economies motivate us to present the notion that the non-traded goods sector is relevant for current account dynamics, and developed country models cannot be relied upon for inference of the evolution of the current account in emerging and developing countries as they may be misspecified. We investigate the hypothesis that shocks to the non-traded goods sector have spillover effects on the current account and exchange rate, and develop a model of the current account that allows for a distinction between the traded and non-traded goods sectors. This model is used to explore the extent to which the non-traded goods sector influences the dynamics of the current account and the exchange rate, by analysing the response of the current account to exogenous shocks in a dual sector setting with both traded and non traded goods. This provides a platform to examine the model's ability to replicate stylised facts established from data, thereby testing the fit of the model. It is important to analyse the importance of the non-traded goods sector in the evolution of the current account by analysing how important shocks from the non-traded goods sector are in determining the current account and macroeconomic variables, compared to those from the traded goods sector. The main contribution we make is in the advancement of current account models to provide a role for non-traded goods in emerging markets, and in analysing the importance of this sector. The model is calibrated to suit features of most emerging markets, with focus on South Africa as an appropriate case study.

The next section discusses the advances made in current account modelling in literature, and evaluates the implications of the non-traded goods sector for such models. We start of by evaluating the shortfalls of single sector current account models, and identify the gaps in the few current account models that have included non-traded goods. Section 3 then describes the size and significance of the non-traded goods sector in South Africa, and the current account in relation to other emerging markets so as to highlight the salient features that make South Africa a suitable case study. In section 4, we develop the model, with focus on the alterations made to existing models, so as to incorporate the dynamics of the non-traded goods sector. Section 5 discusses the calibration technique, with section 6 discussing the results. Finally, section 7 presents some conclusions.

2 Literature Review

New Open Economy Macroeconomic (NOEM) models are increasingly accepted as the basis for analysing the macroeconomic behaviour of countries as they combine microeconomic foundations with the macroeconomic structure of an economy to incorporate nominal rigidities and dynamic optimisation. These attractive features have led these models to become the dominant theoretical model used to study structural current account and trade balance issues (Yamamoto, 2013) . However, a shortcoming of these models is that, because of their complexity, little work has been done to advance the theoretical work, and as a result, aspects key to the evolution of the current account, such as the relevance of the non-traded goods sector in emerging markets has been overlooked in these models.

Some structural current account models still consider the current account to be a result of traded goods only, and by so doing, eliminate the effects of non-traded goods on the current account in a dual sector economy (e.g. Bergin, 2006; Lombardo, 2002). These models assume that domestic households consume a domestically produced good which can be exported, and imported goods only. Adopting such a model usually yields results that show that the direction of response (surplus or deficit) of the current account to exogenous shocks is determined by intertemporal consumption smoothing, and the magnitude of the response of the current account to shocks is affected by the degree of real rigidity in the economy as in Lombardo (2002). In a two country model that tries to explain the exchange rate and the current account, Bergin (2006), by developing a traded goods model finds that deviations from uncovered interest parity (UIP) are strongly related to shifts in the current account, whilst monetary shocks are not. This result is in line with the findings of Herz and Hohberger (2013) who analyse the response of the current account to stochastic shocks when fiscal rules are implemented under various exchange rate regimes in a small open economy. Although Herz and Hohberger (2013)'s study analyses the dynamics of the current account in a monetary union, like Bergin (2006), the study analyses the effect of a negative risk premium shock on the current account, with the finding that negative risk premium shock appreciates the exchange rate, which reduces output through loss of competitiveness and worsens the current account deficit. In these single sector models, a large proportion of the variation in the exchange rate and current account is explained by risk premium shocks, with little role for other exogenous shocks.

An interesting issue which Herz and Hohberger (2013) further address is the impact of negative productivity shock on the current account, and they find that the decline in output increases government spending, which further increases inflation, appreciates the exchange rate, and ultimately worsens the current account deficit. However, by implying that all goods in the model are traded, the productivity shock modelled in the analysis implicitly becomes a traded goods productivity shock. Exclusion of the non-traded goods sector in these models means they fail to adequately characterise the response of the current account and exchange rate to exogenous shocks, and this raises the question of whether the findings would still hold in a model with a fully characterised production sector.

In middle income and low income economies, the non-traded goods sector can arise for various reasons. This sector can arise endogenously because less productive firms decide not to export their products, such that traded and non-traded goods become substitutes (Ghironi and Melitz, 2004). As the ease of substitutability between traded and non-traded goods increases, an appreciation of the real exchange rate is caused by aggregate productivity shocks as opposed to shocks specific to the traded-goods sector, implying the impact of productivity shocks on the current account would be expected to vary from the case of single sector models. Another reason that could lead to a dominant non-traded goods sector in an economy is the home bias in consumption. Home bias implies that residents of the domestic economy place a relatively higher weight on consumption of goods produced in the domestic economy, implying demand expansion is biased towards home produced goods. As a result, the current account is then defined by the path of both tradeables and non-tradeables due to non separability of consumption.

Studies that argue for the inclusion of non-traded goods in a structural model find that incorporating this sector increases the initial size of the response of the exchange rate in response to a monetary shock, and also increases the volatility of the exchange rate in the model. This is particularly useful as NOEM models are often criticised in literature for failing to generate sufficient exchange rate volatility as is displayed in the data, and in some instances, productivity shocks from the non-traded goods sector explain as much as a third of the variation in macroeconomic aggregates (e.g. Hau, 2000; Rabanal and Tuesta, 2013). The inclusion of non traded goods may help in explaining the volatility of the exchange rate and current account in many emerging market economies and could significantly alter the manner in which the current account and exchange age rate are affected by risk premium shocks or deviations from UIP.

Given the advancement of structural models towards the inclusion of non-traded goods (e.g. Dotsey and Duarte, 2008; Benigno and Thoenissen, 2008; Corsetti, Dedola and Viani, 2011), authors in the field of current account dynamics are reverting back to the Obstfeld and Rogoff (1995) Intertemporal Current Account model to include non-traded goods in this framework, but this practice is still largely restricted to current account models of developed countries. When the non-traded goods sector is included in the model, the findings suggest that the initial response of the current account to a monetary shock is affected by the intratemporal elasticity of substitution between traded and non-traded goods, and the intertemporal consumption smoothing (e.g. Lu, 2012; Lu, 2009). This result is in line with Obstfeld and Rogoff (1995)'s initial finding which suggests that the direction of response of the current account (surplus or deficit) may depend on the inverse of the intertemporal elasticity of substitution in consumption and on the intratemporal elasticity of substitution between traded and non-traded goods. If the former is less than the latter, we should expect an increase in non-tradeables as people substitute more non-traded goods for traded goods, such that a positive monetary shock leads to a current account surplus as households prefer to consume more of the home produced good. If the former is greater than the latter, a current account deficit will emerge, and a current account balance will theoretically be expected when the two are equal.

In addition to the significance of the intratemporal elasticity, exchange rate changes are found to have intratemporal effects which can cause substitution between traded and non-traded goods. These intratemporal effects are the reason most current account models argue that to fully understand the evolution of the current account in a structural and dynamic framework, the current account and exchange rate should be jointly determined. Bergin and Sheffrin (2000) demonstrate this by including the interest rate and exchange rate in a current account model with both traded and non-traded goods, and their findings show that inclusion of the exchange rate improves the model's ability to predict current account movements and the model is better able to replicate the volatility of the current account that is displayed in the data. Studies that concur with the importance of the exchange rate in current account determination include the exchange rate as a key variable in the current account model with traded and non-traded goods, but most of these studies only go so far as to analyse current account adjustment or response under alternative monetary rules or exchange rate regimes such as CPI targeting, exchange rate targeting, and various specifications of the Taylor rule. The results generally show that monetary rules are important for domestic variables, but less important for international variables such as the exchange rate and the current account (e.g. Ferrero, Gertler and Svensson, 2008; Lu, 2009).

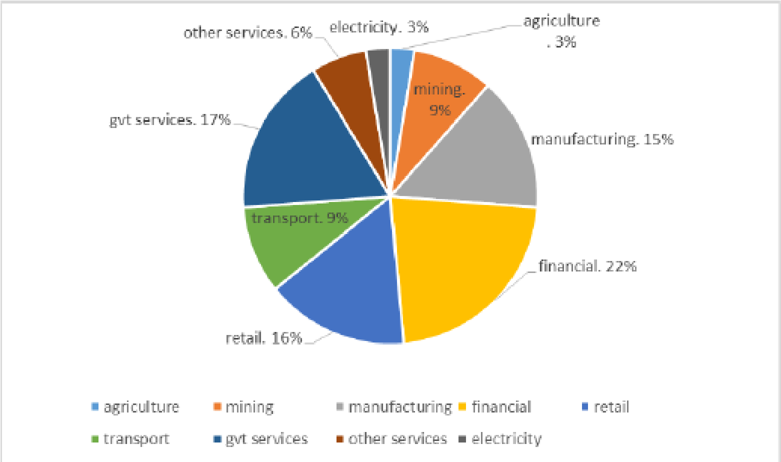
Several shortfalls emerge from these studies. First, studies that model the current account as a function of non-traded goods are mostly limited to developed countries. However, because of the structural rigidities in production faced by lower income countries, developing countries and emerging markets are likely to be affected more than developed countries by the non-traded goods component. The second shortfall is that although there is a general consensus on the importance of the exchange rate in current account models, the discussed studies account for the macroeconomic exchange rate only. The inclusion of non-traded goods in a model raises an interesting question of how the relative price between tradeables and non-tradeables (microeconomic exchange rate) affects the dynamics of the current account, an issue which is not addressed in these studies. Finally, the aforementioned studies do not analyse the relative importance of shocks emanating from the production sectors in determining current account movements. This is important because one of the implications of separate treatment of the traded and non-traded goods sectors is that technology shocks emanating from these sector will not have similar effects on the current account. Productivity shocks are a feature that has long attracted attention in current account dynamics literature (e.g. Glick and Rogoff, 1995; Bussière, Fratzscher and Müller, 2010), but focus the of this analysis has so far been on the differentiation between global and country specific productivity shocks, with the finding that global productivity shocks have no significant impact on the current account, whilst country specific productivity shocks worsen the current account deficit. To the best of our knowledge, given the relative importance of the non-traded goods sector, and the significance of country specific productivity shocks, no study has yet analysed the importance of traded goods productivity shocks in relation to non-traded goods productivity shocks for current account determination.

To address these shortfalls, this study develops a small open economy current account model that accounts for the dynamics of non-traded goods and is representative of an emerging market. The model is used to analyse the significance of the non-traded goods sector for current account dynamics in emerging markets, by analysing how productivity shocks and dynamics of the non-traded goods sector impact the current account and exchange rate vis-a-vis shocks from the traded goods sector. The study is expected to produce a well specified model of the current account with salient emerging market features, which can provide a basis for understanding the evolution of the current account in these economies. Understanding current account dynamics is important in order to be able to come up with any policy prescriptions for current account management. We calibrate the model to the South African economy, an emerging market characterised by a dominant non-traded goods sector and a large current account deficit, features which are discussed in more detail in the next section. To the best of our knowledge, although there has been extensive research on NOEM modelling in South Africa, particularly in the aspects of optimal monetary policy and forecasting (e.g. Steinbach, Mathuloe and Smit, 2009; Alpanda, Kotze and Woglom, 2010; Liu, Gupta and Schaling, 2009), the literature in this field has neither tried to explain current account dynamics nor investigated the role of the non-traded goods sector in the macroeconomy in South Africa.

3 South Africa's Non-Traded Goods Sector

The nature of the different goods produced and consumed in the South African economy is reflective of two distinct sectors, the traded and non-traded goods sectors. SARB (2014) classifies South Africa's economic activities into 9 key sectors, agriculture, mining, manufacturing, financial services, retail, transport, government services, electricity (including water and other utilities), and other services (inclusive of health and education). Following studies that decompose the South African economy into traded and non-traded goods sectors (e.g. Rodrik, 2008), this section decomposes the South African economy into these two sectors to give an indication of the magnitude and contribution of each sector. The traded goods sector comprises of mining, manufacturing and agriculture, whilst the rest of the sectors are classified as non-tradable[1]. From figure 1, the dominant sectors in the economy in 2013 were manufacturing, financial services, government services and retail. The size of the agriculture and mining sectors is small, so following Rodrik (2008)'s categorisation, the non-traded goods sector accounts for about 74% of the value addition to GDP. Rodrik (2008) categorises financial services as non-traded because the variable includes transactions from insurance, real estate and other business transactions. However, because of the well developed financial sector in South Africa and the degree of financial sector liberalisation, financial services may well be categorised as traded, and following this categorisation implies that the non-traded goods sector becomes 52% of all sectors as opposed to 74%, whilst the traded goods sector is 48%. Regardless of the manner in which financial services are categorised, the non-traded goods sector is still the dominant sector in the South African economy. Moreover, the traded goods sectors (except financial services) experienced a decline in growth from 2000, whilst the sectors that experienced an expansion are government services, retail and transport (see figure 2).

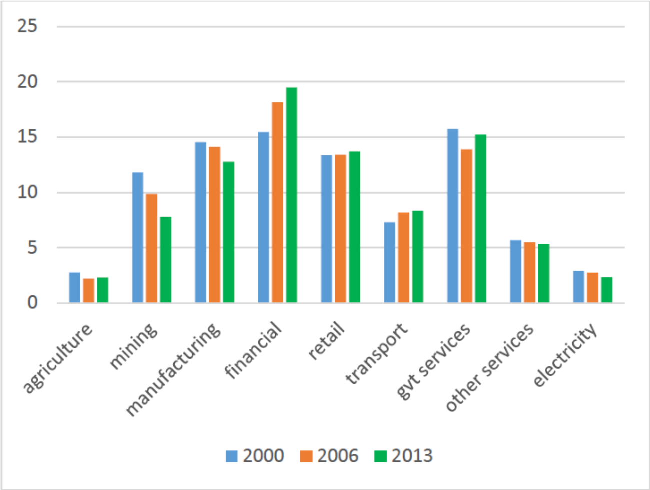
Figure 1: Contribution of Sectors to the Economy in 2013



Source: SARB (2014)

[1] Traded goods are generally defined as those that can traded a distance from their point of location with the law of one price holding. Non-traded goods cannot be provided from a distance because of high transport costs or a significant loss of utility.

Figure 2: Growth in Sectors: 2000, 2006 and 2013



Source: SARB (2014)

Of interest is that given the relative size of the non-traded goods sector, which is more than half of the South African economy, and the manner in which this sector has been expanding, South Africa's current account deficit has continued to widen, and is the second highest current account deficit amongst EMEs[2]. The deficit is characterised by macroeconomic instability which includes above target inflation and a highly depreciated currency. The problem of a widening current account deficit financed by short term capital inflows in spite of an expanding non-traded goods sector is not only specific to South Africa, but is evident in other emerging markets (see table 1), indicating the need for emerging markets to address external sector vulnerability. However, addressing these risks faced by EMEs requires rethinking of the manner in which current account models that guide policy formulation are designed, so as the focus on the particular macroeconomic issues faced by EMEs.

Table 1: Performance of the Fragile 5 Economies as at 2013

Country	YTD performance vs USD	GDP growth	Inflation	CA Deficit
Brazil	-7.6%	3.28%	6.09%	3.23%
South Africa	-14.4%	2%	6.4%	6.5%
India	-12.1%	4.4%	6.1%	5.07%
Turkey	-9.9%	4.4%	8.17%	6.62%
Indonesia	-15.4%	5.81%	8.79%	3.27%

Source : *Morgan Stanely / Bloomberg* (2014)

The importance of addressing macroeconomic stability in emerging markets implies it is necessary to explore the problem of growing current account deficits, and the role played

[2]Decomposition of sectors in other emerging markets shows that the non-traded goods sector is growing in terms of value addition to GDP, whilst the traded goods sector is also deteriorating.

by the non-traded goods sector in driving the current account in emerging markets. To address these goals, we develop a current account model that resembles the features and rigidities faced by most EMEs, with particular focus on the role and size of the non-traded goods sector. Our analysis uses South Africa as an emerging market case study as the country provides a rich data set of parameters from previously estimated NOEM models, and resembles all the features of an emerging market that are of interest in this study (i.e. high current account deficit, dominant non-traded goods sector, depreciated exchange rate). In the next section, we develop a current account model with non-traded goods and describe in detail the features of South Africa that make the model characteristic of an emerging market.

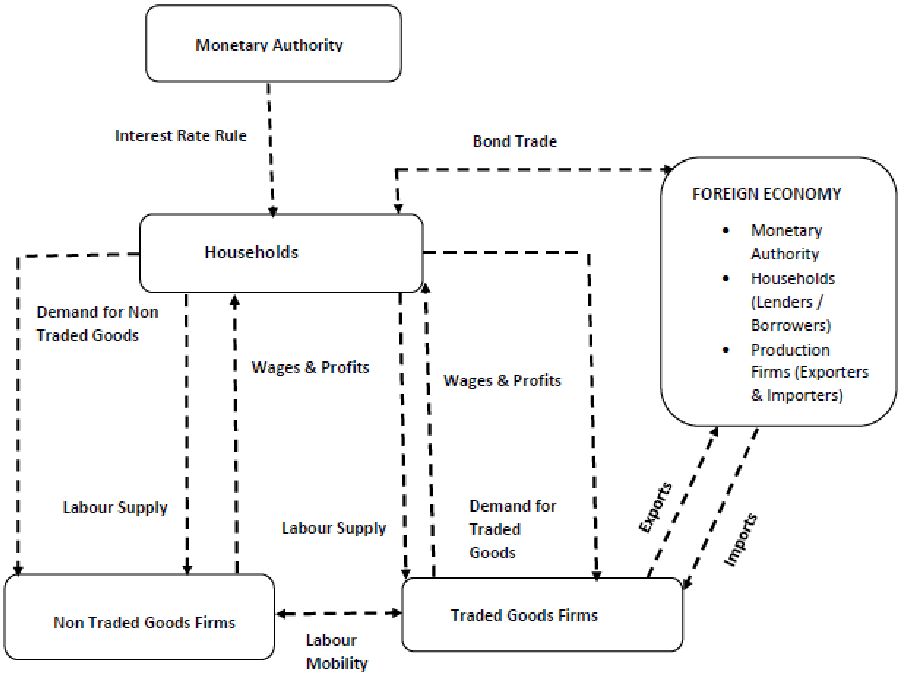
4 Model

A useful starting point for laying the foundations of the model is a dynamic stochastic general equilibrium (DSGE) model which builds on the work of Gali and Monacelli (2005), Justiniano and Preston (2010) and Alpanda et al. (2010). These studies provide the basic framework for a small open economy DSGE model with nominal rigidities, a framework which this paper adopts. The model is based on an economy with three domestic agents, namely households, firms, and a monetary authority that models monetary policy through a Taylor rule. Given that the small open economy cannot affect world prices, the rest of the world is regarded as exogenous to the domestic economy. This basic model is modified to meet the objectives of this paper by incorporating a production sector characterised by both traded goods firms and non-traded goods firms. We assume, domestic households consume the non-traded good, the domestically produced traded goods, and the imported good, and both production sectors face monopolistic competition. The current account is jointly determined by the exports and imports of goods, as well as the trade in financial assets between domestic and foreign households, and the link between these various sectors and agents in the economy is illustrated in figure 3.

Some key features are incorporated in the model to make it more representative of South Africa. Firstly, labour market rigidities are central to a model reflecting emerging markets and developing countries as they prevent the labour market from adjusting to exogenous shocks, and prevent the wage from adjusting to market clearing conditions. In addition, such frictions affect the response of the economy to shocks and including them in the model enhances the model's ability to generate realistic dynamics. The study includes nominal rigidities applicable to South Africa as guided by Alpanda et al. (2010), with focus on wage rigidities included to reflect labour market frictions[3]. Rigidities are also modelled through

[3] Fedderke (2012) gives a detailed discussion of labour market rigidities in the South African Economy.

Figure 3: Flow Chart of the Economy



price adjustment costs which are reflective of sluggish price adjustment in emerging markets and developing countries. Next, South Africa has high levels of household debt, almost 80% of disposable income, and government debt of 46% of GDP (SARB, 2014). A large proportion of this debt is in the form of foreign borrowing, so a risk premium on foreign debt is included to reflect that domestic households do not equally share risk with foreign households when they borrow. The risk premium is also useful for incorporating the incomplete assets market assumption, which enables the current account to be defined as the change in net foreign assets in reflection of the debt levels. Lastly, South Africa, being a commodity exporter is prone to terms of trade shocks, hence terms of trade shocks are also included in the model to capture movements in world prices. In addition, an interest rate rule is used to model monetary policy in line with the Taylor rule which is used in South Africa's inflation targeting framework.

Key modifications from Justiniano and Preston (2010) and Alpanda et al. (2010) are the introduction of the current account and the non-traded goods sector, and the model notation closely follows Alpanda et al. (2010) and Lu (2009).

4.1 Households

The model is based on a representative utility maximising household whose instantaneous utility (equation 1) depends positively on consumption C_t, and negatively on labour effort H_t.

$\beta \in (0,1)$ is the discount factor and σ represents the inverse of the intertemporal elasticity of aggregate consumption, ζ is a consumption habit parameter where present consumption depends on past aggregate consumption.

$$E_t \sum_{T=t}^{\infty} \beta^{T-t} \left[\Theta_T^d \left\{ \frac{(C_T - \zeta C_{T-1})^{1-\sigma}}{1-\sigma} \right\} - \frac{H_T^{1+\psi}}{1+\psi} \right] \quad (1)$$

Θ_t is an AR(1) exogenous demand shock, E_t is the expectations operator, and income sources and expenditure choices are governed by the budget constraint (equation 2).

$$\frac{C_t}{P_t} + \frac{B_t}{P_t} + \frac{S_t B_t^*}{P_t} \leq \frac{W_t}{P_t} H_t + r_{t-1} \frac{B_{t-1}}{P_t} + r_{t-1}^* \phi_{t-1} \frac{S_t B_{t-1}^*}{P_t} + \frac{\Pi_t}{P_t} \quad (2)$$

The household earns labour income, where W_t is the nominal wage rate and P_t is the price level, and earns firm profits Π_t . In addition, the household holds two assets, non contingent bonds denominated in domestic currency B_t, and paying return r_t, and a foreign currency denominated bond B_t^*, paying return $r_t^* \phi_t$ where r_t^* is the foreign interest rate and ϕ_t is the risk premium factor. S_t is the current exchange rate used to convert foreign bonds to domestic currency, with Ponzi schemes ruled out. Households consume the traded good C_{Tt} and the non-traded good C_{Nt}, which together form aggregate consumption C_t modelled in CES form with non separability between traded and non-traded goods (equation 3);

$$C_t = \left[a_1^{\frac{1}{\rho_1}} C_{Nt}^{\frac{\rho_1 - 1}{\rho_1}} + (1-a_1)^{\frac{1}{\rho_1}} C_{Tt}^{\frac{\rho_1 - 1}{\rho_1}} \right]^{\frac{\rho_1}{\rho_1 - 1}} \quad (3)$$

where $\rho_1 > 0$ is the constant elasticity of substitution between traded and non-traded goods, with a large value of ρ_1 showing that the goods are stronger substitutes and a_1 measures the share of non-traded goods in the household's aggregate consumption bundle. C_{Tt} is a homogenous traded good composed of the domestically produced traded good C_{Ht} and the imported good C_{Ft}, hence C_{Tt} is defined by the following CES index;

$$C_{Tt} = \left[a_2^{\frac{1}{\rho_2}} C_{Ft}^{\frac{\rho_2 - 1}{\rho_2}} + (1-a_2)^{\frac{1}{\rho_2}} C_{Ht}^{\frac{\rho_2 - 1}{\rho_2}} \right]^{\frac{\rho_2}{\rho_2 - 1}} \quad (4)$$

ρ_2 is the intratemporal elasticity of substitution between domestically produced traded goods and imports whilst a_2 is the share of the imported good in the traded goods consumption bundle. The aggregate consumption based price index, P_t, is an aggregate of the prices of traded goods P_{Tt} and non-traded goods P_{Nt} .

$$P_t = \left[a_1 P_{Nt}^{1-\rho_1} + (1-a_1) P_{Tt}^{1-\rho_1} \right]^{\frac{1}{1-\rho_1}} \quad (5)$$

Likewise, P_{Tt} is a CES aggregate of the price of domestically produced traded goods P_{Ht}, and the price of imported goods imported goods P_{Ft}.Optimising with respect to P_{Nt} and P_{Tt} gives the demand functions for both traded and non-traded goods as below

$$C_{Tt} = (1 - a_1) \left(\frac{P_{Tt}}{P_t} \right)^{-\rho_1} C_t \tag{6}$$

$$C_{Nt} = a_1 \left(\frac{P_{Nt}}{P_t} \right)^{-\rho_1} C_t \tag{7}$$

Substituting for the home produced and imported traded goods also gives their respective demand functions. The total expenditure on consumption is therefore given by the sum of expenditure on the domestic traded good, the non-traded good and the imported good. Optimal conditions are determined by the first order conditions from the household's maximisation problem and comprise of first the intertemporal Euler condition (equation 8), where λ_t is the Lagrange multiplier, second, the intratemporal optimal labour supply schedule (equation 9), which shows the marginal rate of substitution of labour for consumption, and is found by equating the marginal disutility from labour effort to the marginal utility from increased wages, and third, optimal bond holdings (equation 9), determined by differentiating the objective function with respect to domestic bonds, and gives the asset pricing equation for domestic bonds.

$$\Phi_t^d (C_t - \zeta C_{t-1})^{-\sigma} = \lambda_t \tag{8}$$

$$\Phi_t^d H_t^{\psi} = \lambda_t \frac{W_t}{P_t} \tag{9}$$

$$1 = E_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{r_t}{\pi_{t+1}} \right) \right] \tag{10}$$

In equation 9, $\beta \frac{\lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor and π_{t+1} is inflation defined as $\pi_{t+1} = \frac{P_{t+1}}{P_t}$. Likewise, differentiating the objective function with respect to foreign bonds also gives the asset pricing equation for foreign bonds where D_{t+1} is the depreciation of the domestic currency defined as $\frac{S_{t+1}}{S_t}$

$$1 = E_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{D_{t+1} r_t^* \phi_t}{\pi_{t+1}} \right) \right] \tag{11}$$

The model is represented as a log-linear approximation around the steady state using the first order Taylor approximation and lower case variables indicate deviations from the unique deterministic steady state[4].

Recent studies incorporate the current account into the intertemporal framework by incorporating the incomplete asset markets assumption (e.g. Bergin, 2006; Lu, 2009). This assumption reflects current account dynamics as the inability of households to smooth consumption in all periods, so the disparities in interest rates charged on lending and borrowing across countries are the underlying causes of current account imbalances. By assuming that the domestic bond is in zero net supply, incomplete asset markets assist in characterising the dynamics of the current account[5]. However, one of the consequences of the incomplete assets markets assumption is that the model will exhibit non stationarity (see Lewis, 1994) which could lead to poor approximation of the non linear model when the model is linearised around the steady state. A common solution to this problem is to impose a premium on the assets return (e.g. Schmitt-Grohe and Uribe, 2003; Bergin, 2006), which implies that the interest rate faced by an economy increases with an increase in the aggregate debt held, such that when consumers borrow, they will be charged a premium over the foreign interest rate and when they lend, they will receive interest that is lower than the foreign rate. The premium is proportional to the outstanding stock on foreign debt, implying that wealth allocations are in the long run forced to return to their original allocations and converge to a unique steady state, hence ensuring stationarity.

Combining the optimal domestic and foreign bond equations gives the Uncovered Interest Parity (UIP) condition which when loglinearised, gives the basic UIP condition with the risk premium added to the right, as a share of debt (equation 12).

$$r_t - r_t^* = E_t \left[d_{t+1} + (\Phi_t - \chi z_t) \right] \tag{12}$$

The UIP condition shows that an increase in the interest differential causes the currency to appreciate today but depreciate in future, whilst an increase in the risk premium depreciates the currency today but reduces the expected future depreciation. The risk premium factor Φ_t is an exogenous AR(1) risk premium shock , and χ regulates the sensitivity of the risk premium to changes in foreign bond holdings or foreign debt to trend GDP (z_t) where

$$Z_{t-1} = \frac{S_{t-1} B_{t-1}^*}{P_{t-1} \overline{Y}} \tag{13}$$

[4]The loglinearised model is found in the appendix.

[5]Obstfeld and Rogoff (1995) discuss the shotfalls of the complete markets assumption and demonstrate how monetary policy will affect real variables with market imperfections. The inability of households to fully insure against risk when they borrow implies asset markets are incomplete.

The steady state of the trade balance is set to zero implying that the steady state value of foreign debt to GDP is also zero. This is attained by setting the risk-premium shock's mean value $\overline{\Phi}$ to $-\log\left(\beta\bar{i}^{*}\right)$, ensuring that $nx_t/y_t = a_t = 0$.

$$Z_t = -\frac{NX_t/Y_t}{\bar{i}-1}$$

4.2 Production

In the production sector of the model there are two categories, the traded goods sector and the non-traded goods sector. In each sector there are two types of firms, intermediate goods producers, and final goods producers. Intermediate goods producers produce differentiated products and are monopolistically competitive. In the traded goods sector, final goods firms aggregate the intermediate goods into a homogenous product that can be used for either home consumption, C_{Ht} or exports C_{Ht}^{*}. On the other hand, in the non-traded goods sector, final goods firms aggregate the intermediate goods into a homogenous product that is only used for home consumption, C_{Nt}. Final goods firms are perfectly competitive and are only introduced into the model for tractability. Labour is assumed to be the only factor of production and is internationally immobile, but mobile across sectors, implying the wage rate is equalised across sectors[6].

4.2.1 Non-Traded Goods Sector

The contribution of the study is in the evaluation of the role of non-traded goods in current account dynamics and exchange rate dynamics given the size of this sector in emerging markets, so there is need to discuss how the non-traded goods sector is modelled in detail. Final producers of non-traded goods are perfectly competitive and purchase differentiated goods $Y_{Nt}(i)$ from an intermediate goods producer i. The goods are then aggregated into a final good using the following production function;

$$Y_{Nt} = \left[\int_0^1 Y_{Nt}\left(i\right)^{\frac{\theta_{Nt}-1}{\theta_{Nt}}} \partial\left(i\right)\right]^{\frac{\theta_{Nt}}{\theta_{Nt}-1}} \tag{14}$$

where θ_{Nt} is the elasticity of substitution between non-traded intermediate goods. θ_N is the steady state value of θ_{Nt} and the non-traded goods markup shock is given by $\mu_{Nt} = \frac{\theta_{Nt}}{\theta_{Nt}-1}$. Perfect competition in the production of final non-traded goods implies the profit

[6] Capital is assumed to be constant in this model based on empirical studies which show that endogenous variations of capital do not significantly affect the variation of output and business cycle frequencies (McCallum and Nelson, 2000).

maximisation problem is given by

$$\max\ P_{Nt}C_{Nt} - \int_0^1 P_{Nt}(i)\,Y_{Nt}(i)\ \partial i \tag{15}$$

and this yields the demand function for the intermediate good

$$Y_{Nt}(i) = \left(\frac{P_{Nt}(i)}{P_{Nt}}\right)^{-\theta_{Nt}} Y_{Nt} \tag{16}$$

Production technology used for intermediate non-traded goods is described in equation 17, and an AR(1) productivity shock.

$$Y_{Nt}(i) = A_{Nt}H_{Nt}(i) \tag{17}$$

Intermediate firms set prices to maximise the present value of profits and they take the demand function of final goods firms as given. Profits are discounted at the same rate as households such that the objective function of intermediate firms is given by

$$\max E_t \sum_{\tau=t}^{\infty} \beta^{T-t}\frac{\Lambda_T}{\Lambda_t}\left[\frac{P_{N\tau}(i)}{P_{N\tau}}Y_{N\tau}(i) - \frac{W_\tau}{P_{N\tau}}H_{N\tau}(i) - \frac{\kappa}{2}\left(\frac{P_{N\tau}(j)/P_{N\tau-1}(j)}{\pi^{\varphi}_{N\tau-1}} - 1\right)^2 Y_{Nt}\right] \tag{18}$$

where $\frac{\kappa}{2}\left(\frac{P_{N\tau}(i)/P_{N\tau-1}(i)}{\pi^{\varphi}_{N-1}} - 1\right)^2$. Y_{Nt} is the quadratic cost of price adjustment which is scaled by aggregate domestic output and regulated by the parameter κ. φ regulates the extent to which current price changes are indexed to past inflation. Profits are used to pay wages and are then distributed to households such that the real distributions are given by

$$\frac{\Pi_{Nt}(i)}{P_{Nt}} = \frac{P_{Nt}(i)}{P_{Nt}}Y_{Nt}(i) - \frac{W_t}{P_{Nt}}H_{Nt}(i) \tag{19}$$

Log linearising the first order condition derived from firm maximisation gives the New Keynesian Phillips curve for non-traded goods;

$$\pi_{Nt} - \varphi\pi_{Nt-1} = \beta E_t\left[\pi_{Nt+1} - \varphi\pi_{Nt}\right] + \frac{\theta_{Nt}-1}{\kappa^*}\left[\mu_{Nt} + w_t - p_{Nt} - a_{Nt}\right] \tag{20}$$

implying

$$\pi_{Nt} = \frac{\beta}{1+\beta\varphi}E_t\left[\pi_{Nt+1}\right] + \frac{\varphi}{1+\beta\varphi}\pi_{Nt-1} + \frac{\theta_N - 1}{\kappa(1+\beta\varphi)}mc_{Nt} + \mu_{Nt} \tag{21}$$

where the markup shock μ_{Nt} is redefined as

$$\mu_{Nt} = \frac{\theta_N - 1}{\kappa(1+\beta\varphi)}\widehat{\mu_{Nt}} \tag{22}$$

and $mc_{Nt} = w_t - p_{Nt} - a_{Nt}$. The marginal cost can also be expressed as

$$mc_{Nt} = \varphi y_{Nt} - (1+\varphi) a_{Nt} + \alpha tot_t + \frac{\sigma}{1-\zeta}(c_t - \zeta c_{t-1}) \tag{23}$$

Aggregate inflation (CPI) is a weighted average of the price of traded and non-traded goods and is given by

$$\begin{aligned} \pi_t &= (1-a_1)\pi_{Tt} + a_1\pi_{Nt} \qquad (24) \\ &\Rightarrow (1-a_1)\left[(1-a_2)\pi_{Ht} + a_2\pi_{Ft}\right] + a_1\pi_{Nt} \end{aligned}$$

In the traded goods sector, inflation is the weighted average of home and foreign produced traded goods, with the proportion of each good in the consumption bundle used to determine the weight. Since monetary policy affects non-traded goods through inflation, its also affects the markup and the current account.

4.2.2 Traded Goods Sector

The structure of the traded goods sector is similar to that of non-traded goods with a perfectly competitive final goods sector and a monopolistically competitive intermediate sector. The production function used to aggregate the differentiated intermediate goods into the final good Y_{Tt} is given by;

$$Y_{Tt} = \left[\int_0^1 Y_{Tt}(j)^{\frac{\theta_{Tt}-1}{\theta_{Tt}}} \partial j\right]^{\frac{\theta_{Tt}}{\theta_{Tt}-1}} \tag{25}$$

where θ_{Tt} is the elasticity of substitution between traded intermediate goods and the gross markup is similarly defined as in the case of non-traded goods. The final traded good is either domestically consumed, C_{Ht} or exported C^*_{Ht} such that the final goods firms maximise profits according to;

$$\max\ P_{Ht}C_{Ht} + S_t\ P^*_{Ht}C^*_{Ht} - \int_0^1 P_{Tt}(j)\, Y_{Tt}(j)\ \partial j \tag{26}$$

This maximisation problem gives the demand function for intermediate goods given by

$$Y_{Tt}(j) = \left(\frac{P_{Tt}(j)}{P_{Tt}}\right)^{-\theta_{Tt}} Y_{Tt} \tag{27}$$

whilst the foreign demand for exports (home goods) is given by

$$C^*_{Ht} = \left(C^*_{Ht-1}\right)^{\Upsilon} \left[a^* Y^*_{Tt} \left(\frac{P_{Tt}}{S_t P^*_{Tt}}\right)^{-\rho_1}\right]^{1-\Upsilon} \tag{28}$$

where Υ determines the extent to which current level of exports are dependant on past exports and is a persistence parameter based on the specification in the foreign utility function. a^* regulates the share of home produced consumption goods in the overall expenditure of foreign households and Y^*_{Tt} is foreign output of the traded goods sector.

Intermediate goods firms are monopolistically competitive with each firm indexed by j. Their production function is given by

$$Y_{Tt}(j) = A_{Tt} H_{Tt}(j) \tag{29}$$

where A_{Tt} is the AR(1) aggregate productivity shock. Quadratic price adjustment is used to model price rigidity, and maximising the present value of profits with respect to own price gives the price setting rule below;

$$\left(\frac{\Pi_{Tt}}{\Pi^{\varphi}_{T\tau-1}} - 1\right)\frac{\Pi_{Tt}}{\Pi^{\varphi}_{T\tau-1}} = E_t\left\{\beta\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi_{Tt}}{\Pi^{\varphi}_{T\tau-1}} - 1\right)\frac{\Pi_{Tt+1}}{\Pi^{\varphi}_{T\tau}}\frac{Y_{Tt+1}}{Y_{Tt}}\right\} + \frac{1}{\kappa}\left[(1-\theta_{Tt}) + \theta_{Tt}\frac{W_t/P_{Tt}}{A_{Tt}}\right] \tag{30}$$

Log linearising this condition gives the New Keynesian Phillips curve

$$\pi_{Tt} = \frac{\beta}{1+\beta\varphi}E_t\left[\pi_{Tt+1}\right] + \frac{\varphi}{1+\beta\varphi}\pi_{Tt-1} + \frac{\theta_T - 1}{\kappa(1+\beta\varphi)}mc_{Tt} + \mu_{Tt} \tag{31}$$

where the markup shock μ_{Tt} is redefined as

$$\mu_{Tt} = \frac{\theta_T - 1}{\kappa(1+\beta\varphi)}\widehat{\mu_{Tt}}$$

and $mc_{Tt} = w_t - p_{Tt} - a_{Tt}$. The marginal cost can also be expressed as

$$mc_{Tt} = \varphi y_{Ht} - (1+\varphi)a_{Tt} + a_2 tot_t + \frac{\sigma}{1-\zeta}\left(c_t - \zeta c_{t-1}\right) \tag{32}$$

and shows that an increase in traded output and terms of trade increases the marginal cost of traded goods firms.

Households exhibit staggered wage setting such that the wage inflation Phillips curve is given by;

$$\pi_{wt} - \mu\pi_{wt-1} = \beta E_t\left[\pi_{wt+1}\right] - \mu\beta\pi_t + \frac{(1-\theta_w)(1-\theta_w\beta)}{\theta_w(1+\varphi\epsilon_w)}\mu_w \tag{33}$$

where π_{wt} is the inflation of the nominal wage. μ shows the degree of overall inflation indexation to nominal wage inflation whilst φ is the elasticity of labour supply. ϵ_w denotes the elasticity of substitution between different labour services and μ_w shows the difference between the marginal rate of substitution between consumption and labour, and the real wage such that;

$$\mu_t^w = \frac{\sigma}{1-\zeta}\left(c_t - \zeta c_{t-1}\right) + \varphi\left[\left(y_{Tt} - a_{Tt}\right) + y_{Nt} - a_{Nt}\right] - rw_t + \eta_t^w \tag{34}$$

where η_t^w is the wage cost push shock following an AR(1) process. The following expression gives the relationship between nominal wage inflation and real wage inflation;

$$\pi_{wt} = rw_t - rw_{t-1} + \pi_t \tag{35}$$

4.3 Current Account, Exchange Rate Dynamics and Terms of Trade

The terms of trade tot_t is defined as the the ratio of the price of the imported good to that of the home produced traded good and is included to cater for commodity price shocks given that South Africa is a commodity exporter. Equation (36) defines the terms of trade.

$$tot_t = \frac{P_{Ft}}{P_{Ht}} \tag{36}$$

Our aim is in analysing the role of the non-traded goods sector in current account dynamics and exchange rate determination, so we analyse the evolution of both the macroeconomic and microeconomic exchange rate in the model. The macroeconomic exchange rate is given by the real exchange rate Q_t defined as;

$$Q_t = \frac{S_t P_t^*}{P_t} \tag{37}$$

The difference between the real exchange rate and the terms of trade gives the marginal cost of foreign intermediate traded good firms who buy the product at $S_t P_t^*$ and sell it P_{Ft}. Following Monacelli (2005), the difference between the real exchange rate and terms of trade can also be considered to be the deviation from the law of one price, such that the loglinearised law of one price gap is defined as

$$\begin{aligned} \psi_{Ft} &= s_t + p_t^* - p_{Ft} \\ &= q_t - s_t \end{aligned} \tag{38}$$

The microeconomic exchange rate gives the relative price of the traded and non-traded goods in the domestic economy and is included to analyse the extend to which it is also affected by stochastic shocks. This exchange rate is defined as

$$Q_t^N = \frac{P_{Tt}}{P_{Nt}} \tag{39}$$

The current account is modelled as the change in net foreign assets. This embeds the net exports which are derived from the national income identity as;

$$\frac{W_t}{P_t} H_t + \frac{\Pi_t}{P_t} = \frac{C_t}{P_t} + NX_t = Y_t \tag{40}$$

where Y_t is an aggregate of traded and non traded goods output. From the national income identity, consumption can be related to output by

$$y_t = \alpha s_t + c_t + \alpha \left(c_{H,t}^* - m_t \right) \tag{41}$$

where $c_{H,t}^*$ denotes home goods which are exported and is a function of past exports, home goods and foreign output expressed as;

$$c_{H,t}^* = \Upsilon c_{H,t}^* + (1 - \Upsilon) \left(\rho_2 q_t + y_t^* \right) \tag{42}$$

Imports m_t are affected by terms of trade and consumption;

$$\begin{aligned} m_t &= tot_t + c_{F,t} \\ &\Rightarrow m_t = c_t + \left[1 - \rho_2 (1 - \alpha) \right] tot_t \end{aligned} \tag{43}$$

The balance of payments is described by the household budget constraint, combined with profits received by households such that;

$$\frac{S_t}{P_t} \left[B_t^* - r_t^* \phi_{t-1} B_{t-1}^* \right] = NX_t = C_{Ht}^* - \frac{P_{Ft}}{P_t} C_{Ft} \tag{44}$$

where NX_t gives the net exports which is the difference between exports and imports in the domestic economy. The difference between this period's asset holding and the previous period's makes the net foreign assets of the household, and consequently defines the current account. The balance of payments therefor relates the flow of assets to the flow of goods such that

$$z_t - \frac{1}{\beta} z_{t-1} = \alpha \left(c^*_{H,t} - m_t \right) \tag{45}$$

This implies that the current account ca_t can be modelled as the change in net foreign assets such that it incorporates the high levels of household debt which are characteristic of the South African economy.

$$ca_t = z_t - z_{t-1} \tag{46}$$

4.4 Foreign Economy

Foreign output of traded good firms Y^*_{Tt}, foreign inflation $\pi^*_{Tt} = \frac{P^*_{Tt}}{P^*_{Tt-1}}$,and foreign interest rates $r^*_t$are all exogenous and follow an AR(2) process such that

$$\log Y^*_{Tt} = (1 - \kappa_{1,y^*} - \kappa_{2,y^*}) \log \overline{Y^*} + \kappa_{1,y^*} \log Y^*_{Tt-1} + \kappa_{2,y^*} \log Y^*_{Tt-2} + \varepsilon_{y^*,t} \tag{47}$$

$$\log \pi^*_{Tt} = \kappa_{1,\pi^*} \log \pi^*_{t-1} + \kappa_{2,\pi^*} \log \pi^*_{t-2} + \varepsilon_{\pi^*,t} \tag{48}$$

$$\log r^*_t = (1 - \kappa_{1,r^*} - \kappa_{2,r^*}) \log \overline{r^*} + \kappa_{1,r^*} \log r^*_{t-1} + \kappa_{2,r^*} \log r^*_{t-2} + \varepsilon_{r^*,t} \tag{49}$$

where $\overline{r^*}$ is the mean of r^*_t. The structure of producers in the foreign economy is similar to that in the domestic economy. Imports in the domestic economy are obtained directly from foreign producers of traded goods who engage in monopolistic competition, such that pricing to market applies that foreign producers sell their goods in the domestic economy at the domestic price with the pricing decision defined by

$$\pi_{Ft} - \varphi^* \pi_{Ft-1} = \beta E_t \left[\pi_{Ft+1} - \varphi^* \pi_{Ft} \right] + \frac{\theta - 1}{\kappa} \left[q_t - s_t + \Psi^*_t \right] \tag{50}$$

where π_{Ft} is the inflation of the imported good and Ψ_t is the foreign exogenous cost push shock defined as

$$\log \Psi^*_t = \varepsilon_{\Psi^*_t} \tag{51}$$

4.5 Monetary Authority

To complete the characterisation of the model, we describe the monetary rules adopted by the central bank. The monetary authority uses an interest rate rule based on the Clarida, Gali and Gertler (1998) specification in which the authors demonstrate the need for a central bank to adjust interest rates in response to economic conditions. This specification is based on a Taylor rule as these rules are found to adequately explain monetary policy decisions in several countries. Following Alpanda et al. (2010) and Ortiz and Sturzenegger (2007), we assume a generalised Taylor rule (equation 52) in which the central bank targets inflation π_t, output y_t, and the exchange rate d_t.

$$\log r_t = \rho_r \log r_{t-1} + (1-\rho_r)\left(\omega_\pi \pi_{t-1} + \omega_y \frac{y_{t-1}}{\overline{y}} + \omega_d \log d_t + \log \overline{r}\right) + \varepsilon_{rt} \tag{52}$$

In this framework, $d_t = s_t - s_{t-1}$, ε_{rt} describes the monetary policy shock, and ρ_r is the degree of interest rate smoothing, which enables gradual adjustment of interest rates over time in response to inflation movements. Interest rate smoothing is incorporated to introduce history dependency of policy in the model. This is essential for forward looking models where commitment is necessary for the central bank's ability to affect the public's expectations of future interest rates (Woodford and Walsh, 2005). Clarida et al. (1998) argue that policy rules without interest rate smoothing are too restrictive to give a perception of actual interest changes in most central banks. In addition, interest rate smoothing is based on empirical studies which show that the majority of central banks adjust interest rates in small steps to help curb unintended fluctuations in economic activity.

Log linearising the Taylor rule gives equation 53 where ω_π, ω_y, and ω_d are relative weights on inflation, output, and the nominal exchange rate depreciation respectively. The nominal interest rate is conditioned on lagged output and inflation to capture data dissemination delays, but conditioned on current depreciation since data on current depreciation are normally readily available. In addition, the model implied output gap is the percentage difference between the actual output and the natural rate of output and gives an indication of productivity of the economy. Although the mandate of the SARB is to stabilise inflation, estimations of South Africa's policy reaction function show that the SARB targeted both inflation and the exchange rate in the pre-inflation targeting regime, and targeted inflation, the exchange rate and output in the inflation targeting regime. However, the weight placed on the exchange rate is much lower in the inflation targeting regime (Ellyne and Veller, 2011), so to capture this, we incorporate a very low value of ω_d.

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left[\omega_\pi \pi_{t-1} + \omega_y y_{t-1} + \omega_d d_t\right] + \varepsilon_{rt} \tag{53}$$

4.6 Equilibrium

The model equilibrium is defined where households maximise utility, final producers of traded and non-traded goods maximise profits, and intermediate producers of non-traded goods and home produced traded goods maximise the present value of profits distributed to households (equation 57) such that all markets clear. To determine this equilibrium, domestic bonds are assumed to be in net zero net supply (equation 54), total labour demanded is equal to total labour supplied to the traded and non-traded goods sectors (equation 55), total output is equated to total production (equation 56), and aggregate profits distributed to households are a sum of profits from both traded and non traded goods firms (equation 57).

$$B_t = 0 \tag{54}$$

$$H_t = \int_0^1 H_{Tt}(j)\,\partial j + \int_0^1 H_{Nt}(i)\,\partial i \tag{55}$$

$$Y_t = A_{Tt}H_{Tt} + A_{Nt}H_{Nt} \tag{56}$$

$$\Pi_t = \int_0^1 \Pi_{Tt}(j)\ \partial j + \int_0^1 \Pi_{Nt}(i)\ \partial i \tag{57}$$

With the key features of the model now fully characterised, we move on to discuss the calibration technique used. This is necessary to ensure that model is representative of South Africa.

5 Calibration

To display the characteristics of South Africa, it is important to use parameter values that match data on South Africa and similar emerging markets as closely as possible using parameter values obtained from business cycles literature on small open economies.

The rate of time preference is set at 0.01 so that the subjective discount factor β is 0.99. The intertemporal elasticity of substitution σ is set at 0.5 following Alpanda et al. (2010) and Ortiz and Sturzenegger (2007) who estimate this parameter and find it to have a posterior mean of 0.5 in South Africa. The degree of habit formation in consumption is considered to be 0.7 (e.g. Smets and Wouters, 2007; Steinbach et al., 2009). We set theinitial value of the elasticity of substitution between traded and non traded goods (ρ_1) to 1 in line with Devereux, Lane and Xu (2006). Studies on developed countries assume the elasticity is lower than this, for example Ostry and Reinhart (1992) and Lu (2009) assume an elasticity of 0.75, but given the production structure of emerging markets and developing countries, and the share of consumption of non traded goods, the elasticity is set at a higher value than developed counties. Senbeta (2011) posits an intratemporal elasticity as high as 12 in low income economies, implying the value for emerging market economies should lie in between that of developed and developing countries. The share of non-traded goods in the household's consumption bundle a_1 is set at 0.5, following Devereux et al. (2006) for Malaysia and Thailand. This value is consistent with our findings of the share of non-traded goods reported in section 3 of the paper. However, Harberger, Jenkins, Kuo and Mphahlele (2003) find an aggregate demand for non-tradeable goods of 38.6% in 2009. In addition, STATSSA (2014) reports that the manufacturing sector in South Africa shrunk by 3.4% in the third quarter of 2014. To cater for this, the parameter used for the share of non-traded goods is varied between 0.5 and 0.7 to test sensitivity. The share of imported goods in traded consumption a_2 is set at 0.3 to mimic the average share of imports in GDP from 2000 to 2013.

The degree to which prices are indexed to past domestic price inflation φ is 0.25 whilst the intratemporal elasticity of substitution between imports and domestically produced traded goods ρ_2 is set to 0.67 following Alpanda et al. (2010). Persistence of the productivity shocks, demand shocks and risk premium shock are based on estimations on South African models, whilst persistence of traded and non-traded goods productivity shock follow Hove, Touna Mama and Tchana (2015) and the parameters are set to 0.85 and 0.75 respectively. The sensitivity of the risk premium to changes in foreign bond holdings χ is set at 0.01 in line with Schmitt-Grohe and Uribe (2003) and Bergin (2006) who set a small value for this parameter, and Alpanda et al. (2010) who finds the prior density of the parameter to be in line with this value. The probability that importers cannot adjust price in any given period θ_F is set to 0.82 reflecting price stickiness in the traded goods sector. The degree of overall inflation indexation to nominal wage inflation is set at 0.78.

The interest rate smoothing parameter ρ_r is set at 0.73 following Ortiz and Sturzenegger (2007) who estimate South Africa's policy reaction function. This value is supported by Alpanda et al. (2010) who estimate this parameter and find a posterior mode of 0.72 and Liu and Zhang (2010) who find an estimate of 0.82 for China. The weight in inflation is set at 1.6 whilst weight on output is 0.59. The coefficient of exchange rate intervention is set to 0.03 to reflect the flexible exchange rate regime in South Africa. This is also in line with the value estimated by Ellyne and Veller (2011) for the inflation targeting regime in South Africa.

Based on these parameter values summarised in table (2), DYNARE is used to solve the model and generate impulse response functions and variance decompositions of the variables to shocks, with focus on the response of the variables to shocks from the traded and non traded goods sectors.

Table 2: Calibration of the Model

Parameter	Value	Description
β	0.99	Discount factor
σ	0.5	Intertemporal elasticity of substitution in consumption
ζ	0.7	Consumption habit persistence
ψ	3	Elasticity of labour supply
ρ_d	0.78	Persistence of demand shock
ρ_1	1	Elasticity of substitution between traded and non traded goods
a_1	0.5	Share of non-traded goods in the household's consumption bundle
a_2	0.3	Share of imported goods in traded consumption
ρ_2	0.67	Intratemporal elasticity of substitution between imports and home traded goods
χ	0.01	Sensitivity of risk premium to changes in foreign debt
ρ_Φ	0.92	Persistence of risk premium shock
θ_{Tt}	7	Elasticity of substitution between traded intermediate goods
θ_w	0.8	Probability that domestic firms cannot adjust prices in any given period
ρ_{aT}	0.85	Persistence of traded goods productivity shock
φ	0.25	Degree to which prices are indexed to past domestic price inflation
θ_{Nt}	7	Elasticity of substitution between non traded intermediate goods
ρ_{aN}	0.74	Persistence of non traded goods productivity shock
μ	0.78	Degree of overall inflation indexation to nominal wage
ϵ_w	1	Elasticity of substitution between different labour services
ρ_{tot}	0.9	Persistence of terms of trade shock
ρ_r	0.73	Interest rate smoothing parameter
ω_π	1.6	Relative weight on inflation
ω_y	0.59	Relative weight on output
ω_d	0.03	Relative weight on nominal exchange rate depreciation

Table 3: Summary Statistics

	Model Std Deviations	Data Std Deviations	ca Model Correlations	ca Data Correlations
y	0.7776	0.2189	0.1442	0.8263
rr	0.5429	4.4459	0.4510	0.3029
rer	15.9394	0.1459	-0.0284	-0.4325
ca	1.1090	3.4403	1.0000	1.0000

6 Results

To analyse the role of the non-traded goods sector in the economy, the model is simulated and the impact of technology shocks from the traded and non-traded goods sectors is analysed on the current account (ca) , real exchange rate (rer), output (y) and interest rates (rr). Whilst the focus of the study is mainly on the current account and exchange rate, we analyse the response of output to shocks to infer the impact of these shocks on growth, and the response of the interest rate to analyse how these shocks affect monetary policy. It is also necessary to analyse the impact of monetary and risk premium shocks on variables to determine whether the findings of this dual sector model differ from findings of single sector models.

Simulating the model and analysing the correlation coefficients shows that most of the theoretical relationships between the variables hold. The current account is positively correlated to output showing that an increase in output improves the current account position. The positive correlation between the current account and real interest rate suggests that an increase in the real interest rate also leads to current account improvement. Since investment is assumed to be fixed in the model, the interest rate channel could be explained by a dominant substitution effect where private saving increase and consumption reduces, thereby improving the current account. The results show a negative correlation between the current account and real exchange rate, suggesting that an exchange rate depreciation is accompanied by a current account deficit which worsens, which contradicts theoretical predictions, but is consistent with the correlations from the data. The correlation coefficients generated from the model are a close fit to coefficients generated from quarterly time series data from 1985 to 2012, with the exception of the correlation coefficient of output which is much larger with data. Table 3 gives the model's summary statistics and those obtained from data.

As in the case of VAR models, we use the impulse response functions and variance decompositions to analyse the impact of shocks on variables of interest, with the results generated with values of $\rho_1 = 1$, $\sigma = 0.5$, and $a_1 = 0.5$.

6.1 Impulse Response Functions

The impulse response functions show the total response of variables of interest to exogenous shocks to traded and non-traded goods productivity shocks, a monetary shock and a UIP shock[7]. This helps in evaluating the model's fit by analysing its ability to match stylised facts generated from the data. It also enables a comparison of the model's predictions about the current account to predictions from models where all goods are assumed to be tradeable. All impulse responses are in response to 100 basis points on the innovation.

Analysing the response of the current account to shocks (figure 4), an increase in traded goods productivity worsens the current account deficit by 65 basis points and the shock is persistent for 6 quarters, whilst an increase in non-traded goods productivity improves the current account to a surplus by 65 basis points[8]. The improvement in the current account lasts for 3 quarters before a deficit is experienced and the shock is persistent for almost 16 quarters. The stylised facts suggest that a shock to output moves the current account to a surplus in the first quarter with a deficit experienced by the second quarter which gradually declines. Results generated by this model demonstrate that the non-traded goods sector plays a larger role in generating the initial current account surplus than the traded goods sector. A possible explanation for this is that an increase in non-traded productivity encourages consumption of the domestically produced equivalent of imported goods, and induces a current account surplus through the trade balance channel through a reduces import requirement. This suggests that in South Africa, given the high levels of consumption, the consumption path may play a great role in the generation of current account dynamics. The results are in line with other findings in literature such as Glick and Rogoff (1995) who find that the current account responds negatively to productivity shocks in a single sector model with traded goods. Iscan (2000) extends the Glick and Rogoff (1995) single sector model to include non-traded goods, and find that inclusion of the non-traded goods sector magnifies the response of the current account to country specific productivity shocks, a result confirmed by this study.

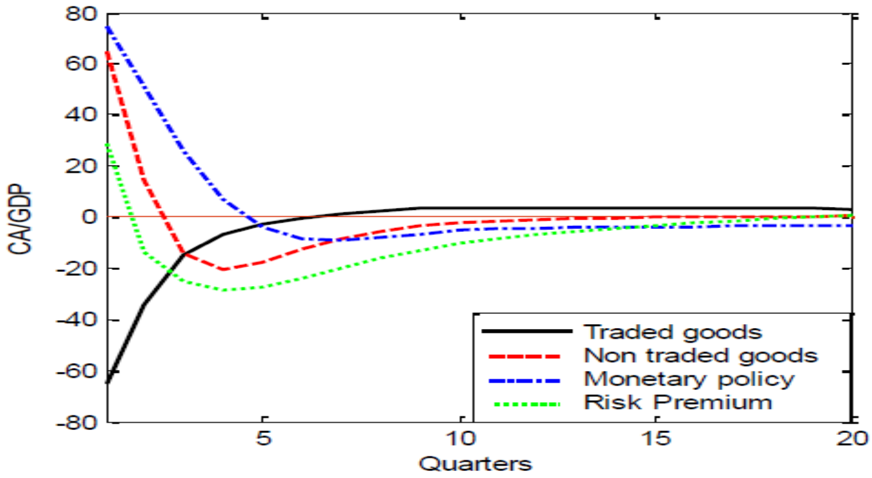
A 100 basis points decrease in the risk premium improves the current account position. The current account moves to a surplus by about 29 basis points, with the shock persistent for about 16 quarters. This could be explained by the relationship between the risk premium and the levels of debt in the form of short term capital flows which finance the current

[7] Other shocks are included in the model to include rigidities specific to the South African Economy such as cost push shocks, foreign shocks and a terms of trade shock. However, these shocks depart from the main focus of the paper and their contribution to variation in the variables of interest is negligible hence their interpretation is left out.

[8] Since 100 basis points are equal to 1 percentage point, a response of 65 basis points on the current account balance would be a change from a surplus of say 5% of GDP to 5.65% of GDP

account deficit, and increase the risk premium of the country. A reduction in the amount of debt reduces the available financing for the deficit and forces the current account to adjust towards a surplus. An innovation in the Taylor rule also moves the current account to a surplus by 75 basis points, with the shock being persistent for about 16 quarters. This suggests that monetary policy may have a stabilising role to play in current account management in emerging markets, a result which departs from models of developed countries (e.g. Ferrero et al., 2008). These results are consistent with stylised facts which show that a monetary shock generated through the interest rate moves the current account to a surplus, provided the domestic interest rate is relatively lower than the foreign interest rate. This emphasises the possible role that monetary policy can play in current account management in a dual-sector model with non-traded goods as in Lu (2009).

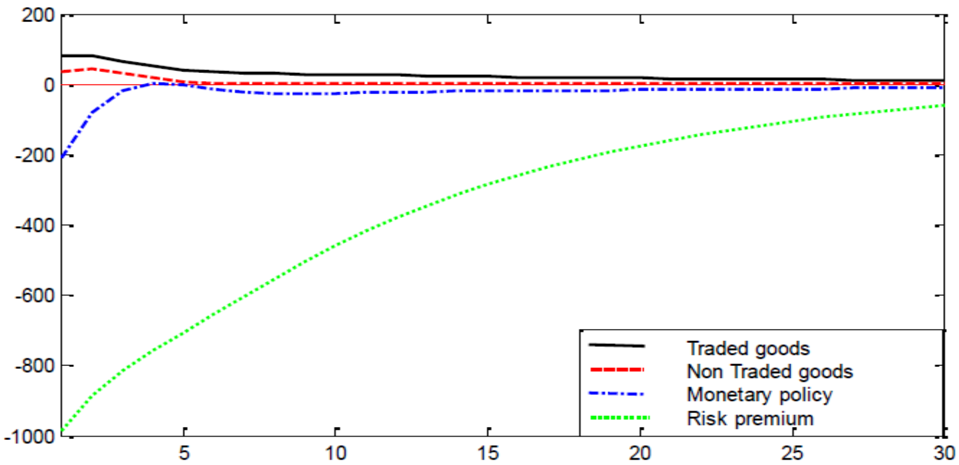
Figure 4: Response of current account to orthogonalised shocks



It is necessary to analyse the response of the response of the exchange rate to shocks, since the current account and exchange rate are often jointly determined in structural models, and we do so in two phases. First we analyse the response of the macroeconomic exchange rate (the relative price of foreign goods to domestic goods) in figure 5, then we analyse the microeconomic exchange rate (the relative price of tradeables to non-tradeables in the domestic economy) in figure 6. This facilitates in making inferences about how shocks affect the relative price of traded goods in the domestic economy, both with regards to foreign prices and non-traded good prices. From figure 5, a positive traded goods productivity shock induces an exchange rate depreciation by about 82 basis points, which lasts for about 30 quarters. An increase in non-traded goods productivity also induces an exchange rate depreciation by 35 basis points. However, unlike in the traded goods sector, the depreciation from an increase in non-traded goods productivity is smaller and quickly dies out after 6 quarters. From the stylised facts in the data, an output shock leads to a depreciation of the exchange rate as well. On the other hand, a positive monetary shock depreciates the exchange rate by about 208 basis points (roughly 2 percentage points), whilst a risk premium shock causes the exchange rate to appreciate substantially as in Bergin (2006). The largest response in the exchange rate is generated by risk premium shocks, where a decrease in the risk premium appreciates the exchange rate. This may be because the risk premium is closely related to volatile capital flows in the economy, and this filters to volatility in the exchange rate. It is no surprise that traded goods generate more volatility in the exchange rate as compared to non-traded goods, given the relation between exports, imports, and the exchange rate.

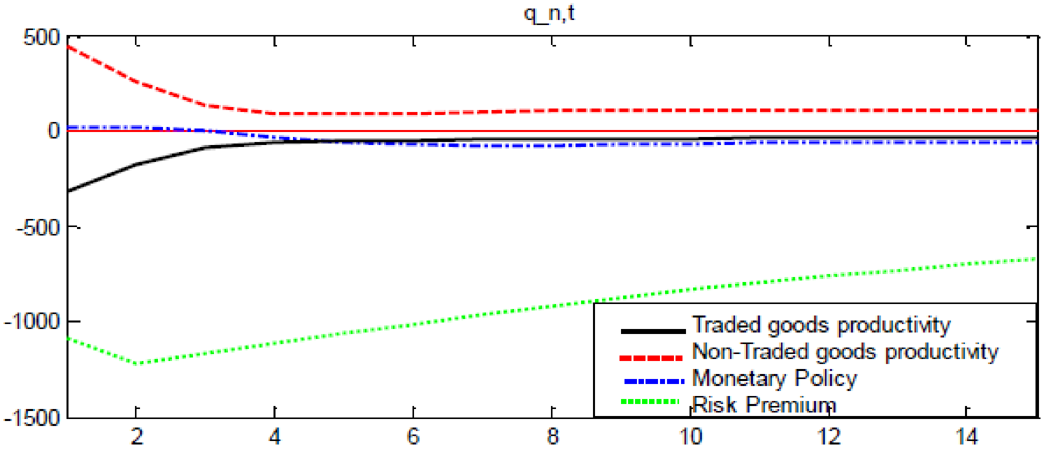
The microeconomic exchange rate is affected by shocks in a similar manner, i.e. it depreciates in response to traded and non-traded goods productivity shocks and appreciates in response to a reduction in the risk premium. Whilst the macroeconomic exchange rate depreciated in response to a monetary shock, the microeconomic exchange rate appreciates. However, the response of the microeconomic exchange rate is much larger, suggesting that the relative price between tradeables and non tradeables is affected more by shocks than by the relative price between domestic and foreign goods.

Figure 5: Response of real exchange rate (macroeconomic) to orthogonalised shocks



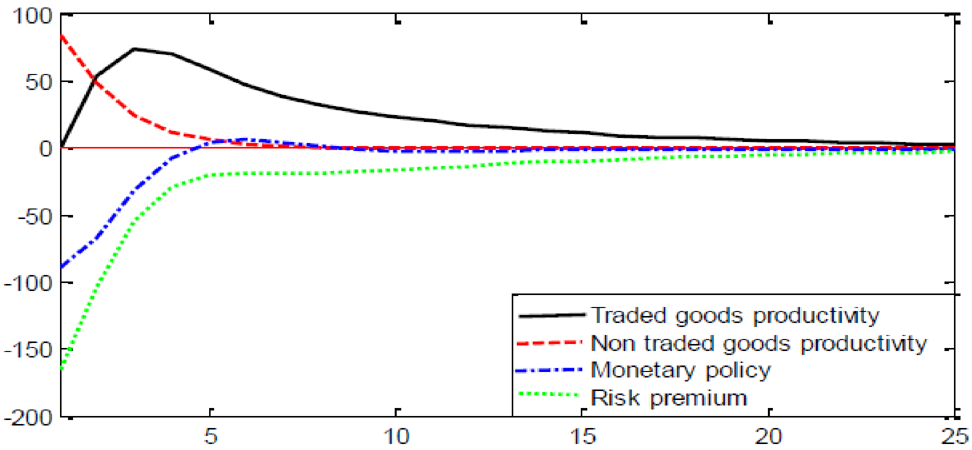
Moving on to the response of output shocks (figure 7), a traded goods productivity shock has a lagged effect on output, with the peak in the increase in output of 74 basis points only experienced after 3 quarters and lasting for about 20 quarters. On the other hand, a non-traded goods productivity shock causes an immediate increase in output of 84 basis points, though the impact of the shock only lasts for 6 quarters. An increase in the monetary policy shock causes a decline in output of 88 basis points. This could be explained by a rise in interest rates causing a decline in borrowing and consequently a fall in consumption. The result reflects consumption driven GDP in South Africa which is based on households accumulating debt, and matches the stylised fact established in the data and reflects the high levels of consumption against debt. This result is similar to other studies on the South African economy such as (e.g. Alpanda et al., 2010; Steinbach et al., 2009). However, the

Figure 6: Response of real exchange rate (microeconomic) to orthogonalised shocks



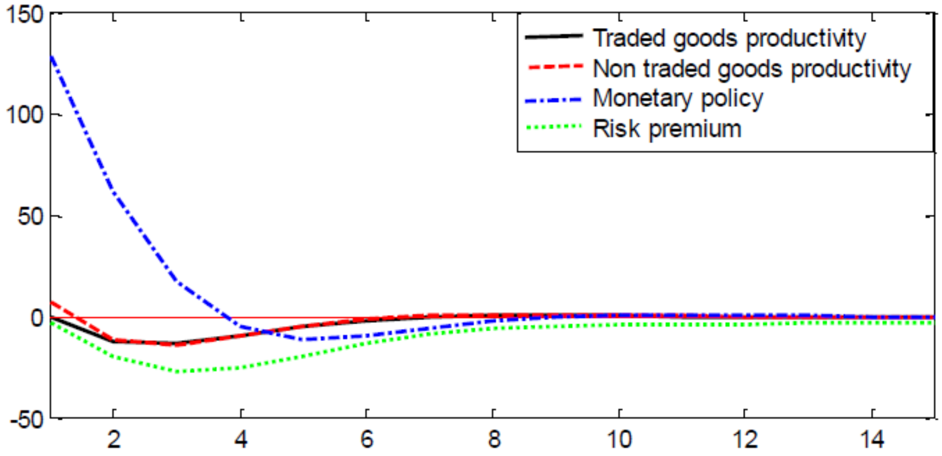
response of output to monetary shock is slightly less when non-traded goods are included in the model. A decline in the risk premium also causes a decline in output. This is also explained through the consumption path financed by debt and liquid short-term capital flows. A lowering of the debt position improves the risk premium, but lowers consumption and output through reduced borrowing by households. The inclusion of non-traded goods doubles the response of output to a decrease in the risk premium shock on impact when compared to Alpanda et al. (2010) and Steinbach et al. (2009). Risk premium shocks also cause a reduction in output in advanced economies, (e.g. Bergin, 2006), but the effect is larger in emerging markets, more so with the inclusion of the non-traded goods sector.

Figure 7: Response of output to orthogonalised shocks



The interest rate responds mainly to monetary policy shocks (figure 8). This is explained by the use of interest rates as a policy tool in the inflation targeting framework. At the onset of a positive monetary shock, the interest rate shoots up by 128 basis points with the increase lasting approximately 4 quarters. The response is stronger to shocks in non-traded goods productivity as opposed to traded goods productivity, with a positive non-traded goods productivity shock increasing interest rates by 8 basis points before the rate falls, whilst, the interest rate only falls with a lag of 2 quarters in response to traded goods productivity shocks. A reduction in the risk premium shock also reduces interest rates with a lagged effect, and there is no response to the shock on impact. This differs with studies that do not include the non-traded goods sector, where the interest rate is reduced by a risk premium shock on impact, so the inclusion of non-traded goods dampens the effect of the risk premium shock on interest rates.

Figure 8: Response of real interest rate to orthogonalised shocks



Overall, the IRFs show that the current account, output and interest rate are more affected by non-traded goods productivity shocks as opposed to traded goods productivity shocks, whilst the exchange rate is mostly affected by the risk premium and traded goods productivity shocks. The ability of the model's IRFs to match stylised facts further reflects the importance of the non traded goods sector in the South African economy, particularly when modelling the current account.

6.2 Forecast Error Variance Decompositions

It is important to understand the contribution that each of these innovations actually makes to variation in the variables, and to do this, we use the variance decomposition analysis which helps in analysing the importance of each shock in shaping macroeconomic dynamics.

The current account is more affected by shocks to both traded goods and non traded goods, with non traded goods productivity shocks accounting for half the variation in the current account, even at longer horizons. The contribution of non traded goods productivity shocks is still substantial, over 40%, with a maximum variation of 49% in the second and third periods. This result departs from the stylised facts established when all goods are assumed to be traded, in which GDP shocks account for at most 7% of variation in the current account. Bergin (2006), in a single sector model, finds that technology shocks account for 24% of variation in the current account in the first period, and 32% by the 20th period, while interest rate parity shocks account for as much as 64% of variation in the current account in the first period, and 36% by the 20th period. The inclusion of non-traded goods in this model has the effect of attributing a substantial amount of variation in the current account to technology shocks, particularly non-traded goods technology, whist the impact of the risk premium on the current account is substantially reduced. Monetary policy shocks however only account for a small proportion of variation in the current account, a result which is consistent with the stylised facts established from the data. Risk premium shocks also account for very little variation in the current account, a significant difference from the United States economy modelled by Bergin (2006). This variation in results demonstrates the need for current account models tailored to the circumstances of emerging markets.

At most 85% of variation in the exchange rate is explained by risk premium shocks, with the contribution increasing at larger horizons. This result is similar to Alpanda et al. (2010) and could be explained by the volatility of short term capital flows which has immediate effects on the exchange rate. The results are however in contradiction to Bergin (2006), suggesting that exchange rate dynamics in advanced and emerging economies may differ, with exchange rate volatility in emerging economies mostly explained by UIP and the risk premium. Monetary policy shocks account for very little variation in the exchange rate, a result which is not surprising in South Africa, considering the SARB mandate to maintain a flexible exchange rate. However, the inclusion of non traded goods reduces the role of monetary policy in exchange rate dynamics as compared to Alpanda et al. (2010)'s single sector model. Another feature to note is that in a single sector traded good model of South Africa, almost all the variation in the exchange rate is explained by deviations from UIP, but the introduction of non traded goods attributes some exchange rate variation to productivity shocks as well.

The real interest rate is largely affected by monetary shocks in the first period (71%). This is because the nominal interest rate is the tool used for monetary policy intervention in the inflation targeting framework. In the first period, non-traded goods productivity shocks account for 17% of the variation in interest rates, whilst traded goods productivity shocks account for almost non of the variation in interest rates. The contribution of monetary policy shocks to real interest rate variation decreases at longer horizons to about 17% after 20 periods, whilst the contribution of non-traded goods productivity shocks increases to 37% after 20 periods. Traded goods productivity shocks also increase in contribution to variation in the real interest rate, with a contribution of 28% after 20 periods. This suggests that traded goods productivity shocks have a lagged effect on the real interest rate, but are still outweighed by non traded goods productivity shocks. Risk premium shocks account for 6% of variation in the interest rate at most, a result which is similar to Bergin (2006).

The decomposition of the variation of output shows that output is greatly affected by non-traded goods productivity shocks at shorter horizons, but affected more by traded goods productivity shocks at longer horizons. Non-traded goods productivity shocks account for 84% of variation in output in the first period, with the impact declining to 30% by the 20th period. Traded good productivity shocks affect the variation in output with a lagged effect, with a contribution of 18.8% in the second period. By the fourth period, traded goods productivity shocks account for half the variation in output, a substantial amount more than the non-traded goods productivity shocks. Risk premium shocks also account for a significant proportion of the variation in output, with a contribution of 13% in the first period, and 6% after 20 periods, whilst monetary policy shocks account for almost non of the variation in output.

A dual sector economy with non traded goods reveals that variation in the current account is mostly due to traded and non traded goods productivity shocks, with the risk premium explaining very little variation in the current account. The exchange rate is largely explained by risk premium shocks whilst non traded goods account for a significant proportion of variation in output and interest rates as well. This demonstrates the significance of the non traded goods sector in determining current account movements and movements in monetary variables such as the interest rate. The result that monetary policy shocks account for very little of the variation in the current account (1%) supports the findings by Lu (2012), Lu (2009) and Bergin (2006) who suggest that there are small gains from monetary policy intervention in current account management.

With an understanding of the effect and contribution of each of the shocks to the evolution of macroeconomic variables, we now analyse how these results vary within different ranges of the parameters. This is useful for examining the sensitivity of the model to the chosen parameter values, and helps in ensuring the reliability of the results.

Table 4: Baseline Model Forecast Error Variance Decomposition

Shocks	Traded Goods	Non traded goods	Monetary	Risk Premium (UIP)
A. 1 quarter ahead forecast error variance decomposition (in%)				
Current Account	44.74	49.24	0.81	0.38
Exchange rate	12.34	2.59	1.13	81.13
Real Interest rate	0.09	17.02	71.16	0.16
Output	0.00	84.32	1.17	13.14
B. 2 quarter ahead forecast error variance decomposition (in%)				
Current Account	48.91	44.21	1.02	0.40
Exchange rate	13.15	3.48	0.70	79.48
Real Interest rate	21.21	30.01	39.14	2.59
Output	18.80	67.99	1.10	11.06
C. 3 quarter ahead forecast error variance decomposition (in%)				
Current Account	48.57	44.27	1.06	0.63
Exchange rate	12.87	3.36	0.52	79.91
Real Interest rate	27.64	38.10	24.19	4.34
Output	38.38	51.38	0.85	8.50
D. 4 quarter ahead forecast error variance decomposition (in%)				
Current Account	46.65	46.14	1.01	0.90
Exchange rate	12.22	2.97	0.42	81.08
Real Interest rate	29.00	39.02	19.83	5.58
Output	49.30	42.21	0.69	7.03
E. 12 quarter ahead forecast error variance decomposition (in%)				
Current Account	43.94	48.16	0.98	1.66
Exchange rate	10.04	1.80	0.27	85.37
Real Interest rate	27.88	36.83	19.95	7.13
Output	62.81	30.72	0.51	5.38
F. 20 quarter ahead forecast error variance decomposition (in%)				
Current Account	44.26	47.81	0.99	1.68
Exchange rate	10.28	1.65	0.25	85.39
Real Interest rate	27.83	36.74	17.91	7.29
Output	63.55	30.05	0.5	5.33

6.3 Sensitivity Analysis

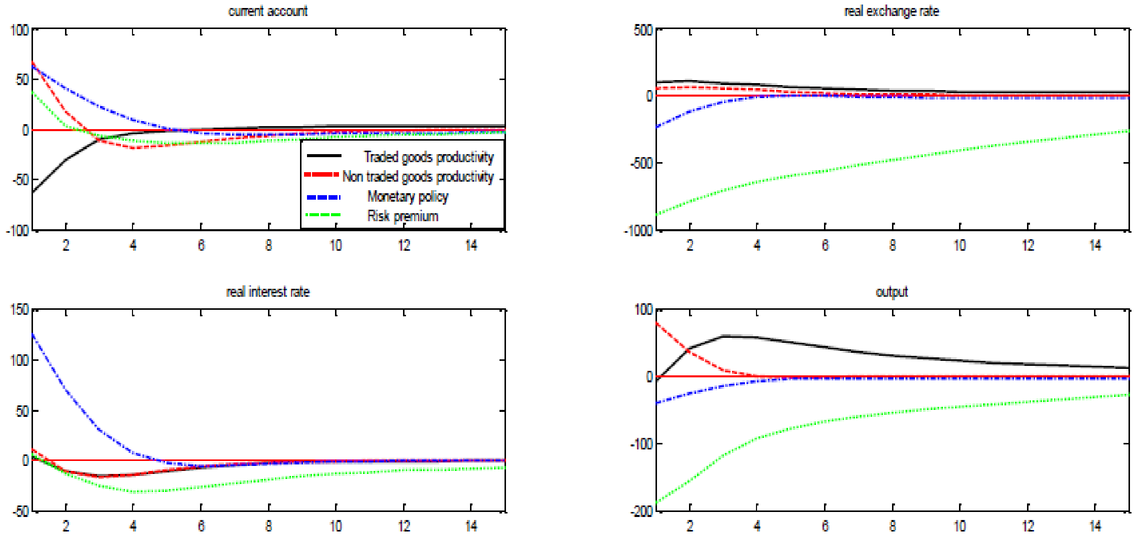
We have so far shown that the non-traded goods sector plays a significant role in shaping the dynamics of the current account and monetary variables in the South African economy. The results match stylised facts generated from quarterly data on South Africa, and show some departures form single sector models with traded goods. To further analyse the role played by the non traded goods sector in shaping ,macroeconomic fundamentals, this section analyses the sensitivity of the above results to changes in the intertemporal elasticity of substitution in consumption σ, the intratemporal elasticity of substitution between traded and non traded goods ρ_1, and the share of non traded goods in the household's consumption bundle a_1. ρ_1 and a_1 are the key parameters that govern household consumption behaviour with regards to traded and non-traded goods, and sensitivity of the results to changes in these parameters sheds light on current account and exchange rate dynamics with regards to non-traded goods in a dual sector economy model.

A useful starting point is to consider changes in the intertemporal elasticity of substitution in consumption. The value of σ is changed from $\sigma = 0.5$ to $\sigma = 2$ and 0.2. A high elasticity shows that consumption is not very costly to consumers and as a result if the real interest rate is high, consumers will save a large portion of their income and consume less. The results for the different values of σ show that the current account is pushed into deficit by positive traded goods productivity shocks, and surplus by non-traded goods productivity shocks. The response of the current account to monetary shocks increases, whilst the response to risk premium shock decreases. The decline in output in response to a monetary shock also worsens when the intertemporal elasticity of consumption is larger, whilst exchange rate and interest rate responses remain unchanged (see figure 9). The contribution of shocks to variation in the current account, exchange rate, and interest rate is also similarly distributed, though with a greater proportion of variation in the current account attributed to non-traded goods productivity shocks, and exchange rate variation slightly explained less by risk premium shocks. This result is in contradiction of the notion that the sign of the current account is determined by whether $\frac{1}{\sigma}$ is greater or smaller than ρ, posited in Lu (2009) and Obstfeld and Rogoff (1995), since the sign of the current account remains the same in this model, regardless of the relationship between $\frac{1}{\sigma}$ and ρ[9]. Similar results holds at higher and lower values of σ, reflecting that the rate of consumption smoothing in South Africa may not necessarily play a large part in the evolution of the current account, especially given the growing consumption levels of South African households supported by increasing levels of household debt. The only change in results from the baseline scenario is that higher values of the intertemporal elasticity cause a larger response of the current account to non-traded

[9]The sign of the current account refers to a deficit or surplus position. A positive sign implies a surplus whilst a negative sign implies a deficit.

goods productivity shocks.

Figure 9: Response of variables to orthogonalised shocks: $\sigma = 2$



In analysing sensitivity to changes in the intratemporal elasticity of substitution between traded and non traded goods, the value of ρ_1 is also varied. When $\rho_1 = 2$, a positive traded goods productivity shock worsens the current account balance by 110 basis points, compared to 65 basis points in the case when $\rho_1 = 1$. The impact of the shock dies out two periods quicker when $\rho_1 = 2$. A non traded goods productivity shock also increases the current account surplus by 130 basis points, compared to 65 basis points with a lower elasticity of substitution. A positive monetary policy shock increases the current account surplus as well by 94 basis points with a higher value of ρ_1,compared to 75 basis points in the baseline scenario. A decrease in risk premium now shifts from inducing a current account surplus to induce a current account deficit when the elasticity of substitution between traded and non traded goods is higher. Sensitivity is also tested with values of $\rho_1 = 5$ and $\rho_1 = 0.5$. When the elasticity of substitution between traded and non traded goods is high, the current account deficit is worsened more by traded goods productivity shocks. Likewise, the higher the elasticity of substitution between traded and non traded goods, the bigger the current account surplus generated by non traded goods productivity shocks. However, the contribution of non traded goods productivity shocks still continues to outweigh that of traded goods productivity shocks, particularly at higher values of ρ_1. A positive monetary shock generates a bigger current account surplus when the elasticity of substitution between traded and non traded goods is higher. This suggests that monetary policy may induce a bigger response in the current account when traded and non traded goods are more easily substituted. A decrease in the risk premium worsens the current account position the bigger the value of the elasticity of substitution between traded and non traded goods. In addition, all shocks are less persistent with a larger value of ρ_1.

A traded goods productivity shock depreciates the exchange rate less when the elasticity of substitution is higher, with a 100 basis point depreciation when $\rho_1 = 0.5$ and a depreciation of 8 basis points when $\rho_1 = 2$. The depreciation in response to a non-traded goods productivity shock is also lower for higher elasticities of substitution, with a depreciation of 40 basis points when $\rho_1 = 0.5$ and 22 basis points when $\rho_1 = 2$. The appreciation of the exchange rate in response to monetary shocks is magnified with a higher elasticity of substitution, and the appreciation in response to a decline in the risk premium is less when the elasticity of substitution is higher.

The effect of a higher elasticity of substitution is robust across output and interest rates as well. When the elasticity of substitution between traded and non-traded goods is high, the interest rate is reduced more by traded goods productivity shocks and increased more by non-traded goods productivity shocks. The interest rate is only slightly less affected by monetary policy shocks and the decline in interest rates from a decline in risk premium also reduces. A higher value of ρ_1 increases the contribution of non-traded goods productivity shocks to variation in the current account, with non-traded goods productivity shocks accounting for as much as 62 basis points of variation in the current account when $\rho_1 = 5$. The effect of the risk premium on current account movements also increases, but only to as much as a 5 basis points contribution, which is substantially less than the contribution of risk premium shocks when all goods are assumed to be tradeable (64 basis points in the first period and 34 basis points after 20 periods in Bergin (2006). The contribution of monetary shocks remains small, whilst that of traded goods productivity shocks decreases with the ease of substitutability between traded and non-traded goods.

The exchange rate is still largely affected by risk premium shocks, especially at larger horizons, but an increase in the elasticity of substitution between traded and non-traded goods reduces the contribution of the risk premium, whilst substantially increasing the contribution of traded goods productivity shocks and slightly increasing the contribution of non-traded goods productivity shocks. Increasing the elasticity of substitution between traded and non-traded goods also implies that the interest rate and output are more affected by monetary policy shocks and non-traded goods productivity shocks, whilst less affected by traded goods productivity shocks. Hence in this case, the intratemporal elasticity determines the magnitude of the current account deficit or surplus generated by a non traded goods productivity shock.

Considering that the consumption of non-traded goods is high in emerging markets and low income economies, the sensitivity of the results to the share of non-traded goods in the consumption bundle (a_1) is also analysed. Increasing the share of non traded goods in the household's consumption bundle reduces the current account deficit generated by a positive traded goods productivity shock. The exchange rate depreciates less, whilst the real interest rate increases and output increases in response to a positive traded goods productivity shock when the household consumes more non-traded goods. In response to a non traded goods productivity shock, the current account balance worsens, the exchange rate depreciates more, interest rates decrease and the increase in output is less as the share of non traded goods consumed increases. A monetary shock still generates a current account surplus, though the surplus is smaller with more non-traded goods consumed. The exchange rate appreciates, and output falls more in response to a monetary shock. However, regardless of the share of non-traded goods in the consumption bundle, the response of interest rates to monetary shocks remains the same. Whilst small values of a_1 generate a current account deficit in response to a reduction in risk premium, high enough values of a_1 generate a current account surplus. The exchange rate appreciates more when the share of non-traded goods consumed is high and the risk premium reduces, whilst real interest rates fall and output falls more.

Whilst non traded goods productivity shocks generate a current account surplus at all times, the surplus is greater with bigger values of ρ_1, and smaller with bigger values of a_1. This suggests that an increase in the share of non-traded goods consumed may crowd out investment in the traded goods sector and reduce exports, leading to a smaller current account surplus.

As a result, in a dual sector economy with non-traded goods, dynamics of the current account are not shaped by the intertemporal elasticity of substitution as in a traded goods framework, but rather, the current account and macroeconomic variables are affected by the degree to which traded and non traded goods can be substituted, and by the share of non-traded goods in the consumption bundle. The greater the ease of substitutability between trade and non-traded goods, the greater the role that non-traded goods take in shaping macroeconomic fundamentals. Variance decomposition results for $\rho_1 = 2$ are in table 6, whilst results for $\rho_1 = 5$ are in the appendix.

Table 5: Forecast Error Variance Decomposition Sensitivity Analysis

Shocks	Traded Goods	Non traded goods	Monetary	Risk Premium (UIP)
$\rho_1 = 2$				
A. 1 quarter ahead forecast error variance decomposition (in%)				
Current Account	37.15	57.99	0.38	0.16
Exchange rate	17.02	1.34	1.80	76.46
Real Interest rate	8.12	47.09	36.42	0.00
Output	5.9	86.03	0.35	5.68
B. 4 quarter ahead forecast error variance decomposition (in%)				
Current Account	35.77	56.45	0.60	2.37
Exchange rate	14.60	3.90	0.75	76.85
Real Interest rate	38.88	32.60	16.78	4.92
Output	37.37	56.12	0.32	4.84
C. 12 quarter ahead forecast error variance decomposition (in%)				
Current Account	33.37	57.09	0.57	4.31
Exchange rate	10.88	2.90	0.51	82.69
Real Interest rate	35.93	32.58	15.04	7.16
Output	49.37	45.22	0.26	3.98
C. 20 quarter ahead forecast error variance decomposition (in%)				
Current Account	33.63	56.77	0.58	4.32
Exchange rate	10.75	2.79	0.50	82.69
Real Interest rate	35.86	32.52	15.01	7.16
Output	50.05	44.61	0.25	3.98

Table 6: Forecast Error Variance Decomposition Sensitivity Analysis

Shocks	Traded Goods	Non traded goods	Monetary	Risk Premium (UIP)
$\rho_1 = 5$				
A. 1 quarter ahead forecast error variance decomposition (in%)				
Current Account	32.84	62.83	0.15	0.38
Exchange rate	32.76	0.75	2.84	58.83
Real Interest rate	21.17	66.10	8.15	0.00
Output	16.63	79.01	0.05	1.73
B. 4 quarter ahead forecast error variance decomposition (in%)				
Current Account	31.06	62.20	0.33	2.20
Exchange rate	24.46	5.88	1.51	63.17
Real Interest rate	39.34	46.22	6.94	2.15
Output	29.02	66.66	0.06	2.04
C. 12 quarter ahead forecast error variance decomposition (in%)				
Current Account	29.66	62.10	0.32	3.82
Exchange rate	18.03	6.81	1.14	69.30
Real Interest rate	36.69	46.98	6.36	3.86
Output	34.79	61.17	0.05	1.92
C. 20 quarter ahead forecast error variance decomposition (in%)				
Current Account	29.83	61.80	0.33	3.87
Exchange rate	17.61	6.74	1.13	69.57
Real Interest rate	36.65	46.93	6.36	3.91
Output	35.13	60.85	0.05	1.91

7 Conclusion

The rate of consumption of non-traded good is high in emerging markets, posing the hypothesis that shocks from the non-traded goods sector together with the traded goods sector influence the dynamics of the current account and exchange rate. We investigate this hypothesis and contribute to literature by developing a model of the current account that includes both traded and non-traded goods. We exploit the model to analyse the response of the current account and exchange rate to shocks in this dual sector setting, and the importance of shocks from the non-traded goods sector in determining the current account and macroeconomic variables compared to those from the traded goods sector.

The model is calibrated to South Africa and shows that non-traded goods play a significant role in the determination of the current account, with half the variation in the current account explained by non-traded goods productivity shocks. This result particularly holds if the share of non-traded goods in the consumption bundle is large and households are able to substitute between traded and non-traded goods with ease. Whilst studies that assume that all goods are tradeable attribute a large proportion of variation in the current account to the risk premium, a dual sector framework shows that variation in the current account is mostly due to productivity shocks in emerging markets. A large proportion of variation in the exchange rate in single sector models is due to risk premium shocks (see Alpanda et al., 2010), but the contribution of these shocks decreases with the introduction of non-traded goods in the model. Our model is able to replicate stylised facts from data, suggesting it is a good fit. Also of interest is that our results provide a departure from other current account models of developed countries such as Bergin (2006) and Lu (2009), suggesting the importance of the non-traded goods sector in emerging markets. This suggests that the non-traded goods sector has a role to play towards current account management, and policy targeted at current account sustainability should also consider productivity and structural rigidities in the non-traded goods sector.

Future research should estimate this model to analyse the model properties with data, as well as extend the model to analyse other emerging markets with similar characteristics.

References

Alpanda, S., Kotze, K. and Woglom, G. (2010). The role of the exchange rate in a New Keynesian DSGE model for the South African economy, *South African Journal of Economics* **78**(2): 170–191.

Batini, N., Harrison, R. and Millard, S. P. (2003). Monetary policy rules for an open economy, *Journal of Economic Dynamics and Control* **27**(11): 2059–2094.

Benigno, G. and Thoenissen, C. (2008). Consumption and real exchange rates with incomplete markets and non-traded goods, *Journal of International Money and Finance* **27**(6): 926–948.

Bergin, P. R. (2006). How well can the new open economy macroeconomics explain the exchange rate and current account?, *Journal of International Money and Finance* **25**(5): 675–701.

Bergin, P. R. and Sheffrin, S. M. (2000). Interest rates, exchange rates and present value models of the current account, *The Economic Journal* **110**(463): 535–558.

Bussière, M., Fratzscher, M. and Müller, G. J. (2010). Productivity shocks, budget deficits and the current account, *Journal of International Money and Finance* **29**(8): 1562 – 1579.

Clarida, R., Gali, J. and Gertler, M. (1998). Monetary policy rules and macroeconomic stability: Evidence and some theory, *National Bureau of Economic Research* .

Corsetti, G., Dedola, L. and Viani, F. (2011). Traded and nontraded goods prices, and international risk sharing: An empirical investigation, *NBER International Seminar on Macroeconomics 2011*, University of Chicago Press, pp. 403–466.

Devereux, M. B., Lane, P. R. and Xu, J. (2006). Exchange rates and monetary policy in emerging market economies, *The Economic Journal* **116**(511): 478–506.

Dotsey, M. and Duarte, M. (2008). Non-traded goods, market segmentation, and exchange rates, *Journal of Monetary Economics* **55**(6): 1129–1142.

Ellyne, M. and Veller, C. (2011). What is the SARB's inflation targeting policy, and is it appropriate?, *University of Cape Town* .

Fedderke, J. (2012). The cost of rigidity: The case of the South African labor market, *Comparative Economic Studies* **54**(4): 809–842.

Ferrero, A., Gertler, M. and Svensson, L. E. (2008). Current account dynamics and monetary policy, *National Bureau of Economic Research* .

Gali, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy, *The Review of Economic Studies* **72**(3): 707–734.

Ghironi, F. and Melitz, M. J. (2004). International trade and macroeconomic dynamics with heterogeneous firms, *National Bureau of Economic Research* .

Glick, R. and Rogoff, K. (1995). Global versus country-specific productivity shocks and the current account, *Journal of Monetary Economics* **35**(1): 159 – 192.

Harberger, A. C., Jenkins, G. P., Kuo, C.-Y. and Mphahlele, M. B. (2003). The economic cost of foreign exchange for South Africa, *South African Journal of Economics* **71**(2): 155–169.

Hau, H. (2000). Exchange rate determination: The role of factor price rigidities and non-tradeables, *Journal of International Economics* **50**(2): 421–447.

Herz, B. and Hohberger, S. (2013). Fiscal policy, monetary regimes and current account dynamics, *Review of International Economics* **21**(1): 118–136.

Hove, S., Touna Mama, A. and Tchana, F. T. (2015). Monetary policy and commodity terms of trade shocks in emerging market economies, *Economic Modelling* **49**: 53–71.

Iscan, T. B. (2000). The terms of trade, productivity growth and the current account, *Journal of Monetary Economics* **45**(3): 587 – 611.

Justiniano, A. and Preston, B. (2010). Monetary policy and uncertainty in an empirical small open-economy model, *Journal of Applied Econometrics* **25**(1): 93–128.

Lewis, K. K. (1994). Puzzles in international financial markets, *Handbook of International Economics* **3**: 1913–1971.

Liu, G. D., Gupta, R. and Schaling, E. (2009). A New Keynesian DSGE model for forecasting the South African economy, *Journal of Forecasting* **28**(5): 387–404.

Liu, L. and Zhang, W. (2010). A New Keynesian model for analysing monetary policy in Mainland China, *Journal of Asian Economics* **21**(6): 540 – 551.

Lombardo, G. (2002). Price rigidity, the mark–up, and the dynamics of the current account, *Canadian Journal of Economics/Revue Canadienne de'conomique* **35**(3): 531–555.

Lu, M. (2009). Current account dynamics and optimal monetary policy in a small-open economy, *International Journal of Monetary Economics and Finance* **2**(2): 166–193.

Lu, M. (2012). Current account dynamics and optimal monetary policy in a two–country economy, *International Journal of Monetary Economics and Finance* **5**(2): 299–324.

McCallum, B. T. and Nelson, E. (2000). An optimizing IS-LM specification for monetary policy and business cycle analysis, *National Bureau of Economic Research* .

Milesi-Ferretti, M. G.-M. and Blanchard, O. J. (2009). *Global Imbalances: In Midstream?*, International Monetary Fund.

Monacelli, T. (2005). Monetary policy in a low pass-through environment, *Journal of Money, Credit and Banking* **37**(6): pp. 1047–1066.

Obstfeld, M. (2012). Does the current account still matter?, *Technical report*, National Bureau of Economic Research.

Obstfeld, M. and Rogoff, K. (1995). The Intertemporal Approach to the Current Account, *Handbook of International Economics* **3**: 1731–99.

Obstfeld, M. and Rogoff, K. (1996). Exchange rate dynamics redux, *Technical report*, National Bureau of Economic Research.

Obstfeld, M. and Rogoff, K. S. (2009). *Global imbalances and the financial crisis: Products of common causes*, Centre for Economic Policy Research London.

Ortiz, A. and Sturzenegger, F. (2007). Estimating sarb's policy reaction rule, *South African Journal of Economics* **75**(4): 659–680.

Ostry, J. D. and Reinhart, C. M. (1992). Private saving and terms of trade shocks: Evidence from developing countries, *Staff Papers-International Monetary Fund* pp. 495–517.

Rabanal, P. and Tuesta, V. (2013). Non-tradable goods and the real exchange rate, *Open Economies Review* **24**(3): 495–535.

Rodrik, D. (2008). Understanding South Africa's economic puzzles, *Economics of Transition* **16**(4): 769–797.

SARB (2014). South african reserve bank, *Technical report*, https://www.resbank.co.za.

Schmitt-Grohe, S. and Uribe, M. (2003). Closing small open economy models, *Journal of International Economics* **61**(1): 163–185.

Senbeta, S. R. (2011). *A Small Open Economy New Keynesian DSGE model for a foreign exchange constrained economy*, University of Antwerp.

Smets, F. and Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach, *ECB Working Paper* .

STATSSA (2014). Statistics South Africa, *Technical report*, www.statssa.gov.za.

Steinbach, M., Mathuloe, P. and Smit, B. (2009). An open economy New Keynesian DSGE model of the South African economy, *South African Journal of Economics* **77**(2): 207–227.

Woodford, M. and Walsh, C. E. (2005). Interest and prices: Foundations of a theory of monetary policy, *Cambridge University Press* .

Yamamoto, S. (2013). Structural change in the external balances response to macroeconomic policies: Perspective from a two-sector New Open Economy Macroeconomic Model, *Review of International Economics* **21**(5): 1021–1031.

A Appendix

A.1 Extended Model

1. Exogenous AR(1) demand shock

$$\log \Theta_t^d = \rho_d \log \Theta_{t-1}^d + \varepsilon_{\Theta,t}^d \tag{58}$$

2. Price index for traded goods

$$P_{Tt} \;=\; \left[a_2 P_{Ft}^{1-\rho_2} + (1-a_2)\, P_{Ht}^{.1-\rho_2}\right]^{\frac{1}{1-\rho_2}} \tag{59}$$

3. Domestic traded goods demand

$$C_{Ht} = (1-a_2)\left(\frac{P_{Ht}}{P_{Tt}}\right)^{-\rho_2} C_{Tt} \tag{60}$$

4. Domestic non-traded goods demand

$$C_{Ft} = a_2\left(\frac{P_{Ft}}{P_{Tt}}\right)^{-\rho_2} C_{Tt} \tag{61}$$

5. Loglinearised aggregate consumption

$$c_t = a_1 c_{Nt} + (1-a_1)c_{Tt} \tag{62}$$

6. Loglinearised traded goods consumption

$$c_{Tt} = a_2 c_{Ft} + (1-a_2)c_{Ht} \tag{63}$$

7. Loglinearised aggregate price index

$$p_t = a_1 p_{Nt} + (1 - \alpha_1) p_{Tt} \tag{64}$$

8. Loglinearised traded goods price index

$$p_{Tt} = a_2 p_{Ft} + (1 - a_2) p_{Ht} \tag{65}$$

9. Log linearisation of the demand function for non tradeables

$$c_{Nt} = -\rho_1 (p_{Nt} - p_t) + c_t \tag{66}$$

10. Log linearisation of the demand function for domestically produced tradeables

$$c_{Ht} = -\rho_2 (p_{Ht} - p_{Tt}) + c_{Tt} \tag{67}$$

11. Log linearisation of the demand function for imported tradeables

$$c_{Ft} = -\rho_2 (p_{Ft} - p_{Tt}) + c_{Tt} \tag{68}$$

12. Loglinearised Euler, where $r_t - E_t [\pi_{t+1}]$ is the ex-ante real interest rate

$$c_t \approx \frac{1}{1+\zeta} E_t c_{t+1} + \frac{\zeta}{1+\zeta} c_{t-1} - \frac{1-\zeta}{\sigma(1+\zeta)} \left(r_t - E_t [\pi_{t+1}] \right) + \widetilde{\Theta}_t^{d} {}^{10} \tag{69}$$

13. demand shock

$$\widetilde{\Theta}_t^d = \frac{(1-\rho_d)(1-\zeta)}{\sigma(1+\zeta)} \widehat{\Theta}_t^d \tag{70}$$

14. Risk premium factor

$$\phi_t = \exp \left(\Phi_t - \chi Z_t \right) \tag{71}$$

15. Final non traded goods production markup

$$\log \mu_{Nt} = \log \overline{\mu} + \varepsilon_{\mu N,t} \tag{72}$$

[10] where variables with $\sim$ represent a level deviation from the steady state instead of a percentage deviation as the variables can be negative.

16. Intermediate non traded goods productivity shock

$$\log a_{Nt} = \rho_{a_N} \log a_{Nt-1} + \varepsilon_{a_{Nt}} \tag{73}$$

17. Intermediate traded goods productivity shock

$$\log a_{Tt} = \rho_{a_T} \log a_{Tt-1} + \varepsilon_{a_T} \tag{74}$$

18. Log Linearised Terms of trade

$$tot_t = p_{Ft} - p_{Ht} + \mu_{tot,t} \tag{75}$$

lagging this

$$tot_t - tot_{t-1} = \pi_{Ft} - \pi_t \tag{76}$$

19. AR(1) TOT shock

$$\mu_{tot,t} = \rho_{tot,t} * \mu_{tot,t-1} + \varepsilon_{tot,t} \tag{77}$$

20. Log Lineraised macroeconomic real exchange rate

$$q_t = s_t + p_t^* - p_t \tag{78}$$

lagging this

$$q_t - q_{t-1} = d_t + \pi_t^* - \pi_t \tag{79}$$

21. Law of one price gap

$$s_t + p_t^* = \psi_t - p_{Ft} \tag{80}$$

22. Log Lineraised microeconomic real exchange rate

$$q_t^N = p_{Tt} - p_{Nt} \tag{81}$$

lagging this

$$q_t^N - q_{t-1}^N = \pi_{Tt} - \pi_{Nt} \tag{82}$$

23. Imports inflation

$$\pi_{Ft} = \frac{\beta}{1+\beta\varphi^*} E_t\left[\pi_{Ft+1}\right] + \frac{\varphi^*}{1+\beta\varphi^*}\pi_{Ft-1} + \frac{\theta_F - 1}{\kappa^*\left(1+\beta\varphi^*\right)}\psi_{Ft} + \Psi_t^*$$

24. Foreign cost push shock

$$\Psi_t^* = \frac{\theta_F - 1}{\kappa\left(1+\beta\varphi^*\right)}\widehat{\Psi_t^*}$$

25. Deviations from the law of one price

$$\psi_{Ft} - \psi_{Ft-1} = d_t + \pi_{Tt} - \pi_{Ft}$$

A.2 Sensitivity Analysis Figures

Figure 10: Response of variables to orthogonalised shocks when $\rho_1 = 2$

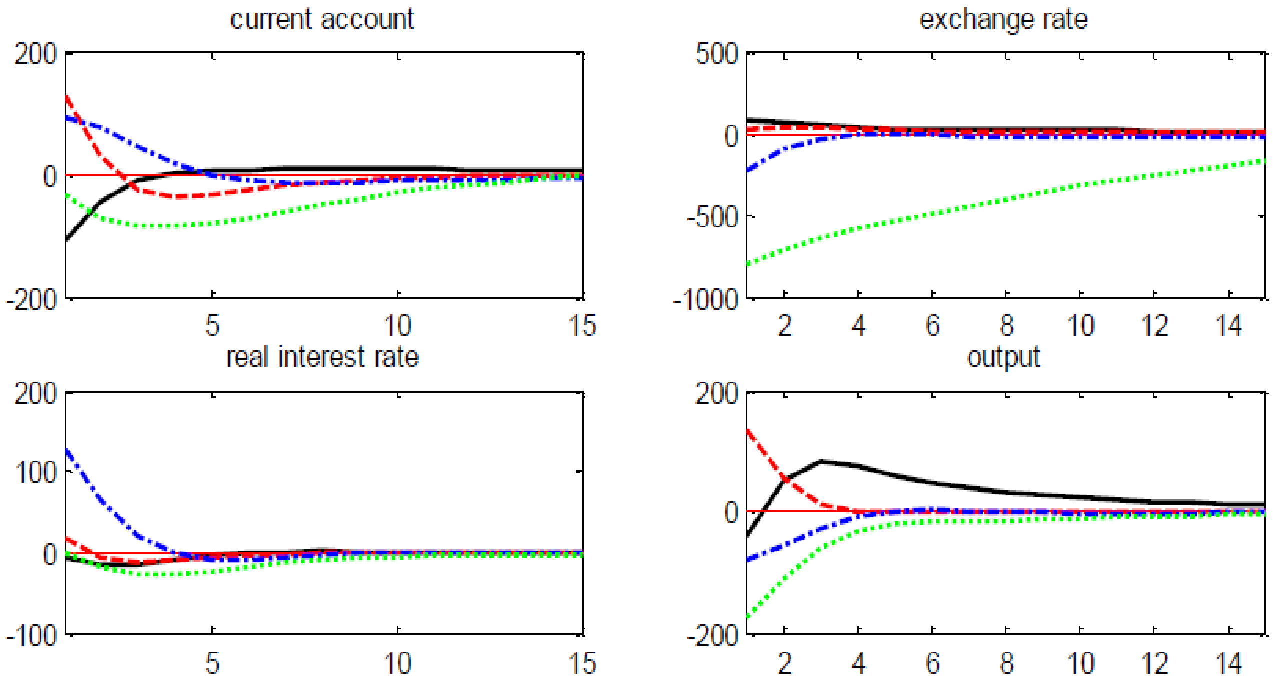


Figure 11: Sensitivity to traded goods productivity shock when a_1 varies

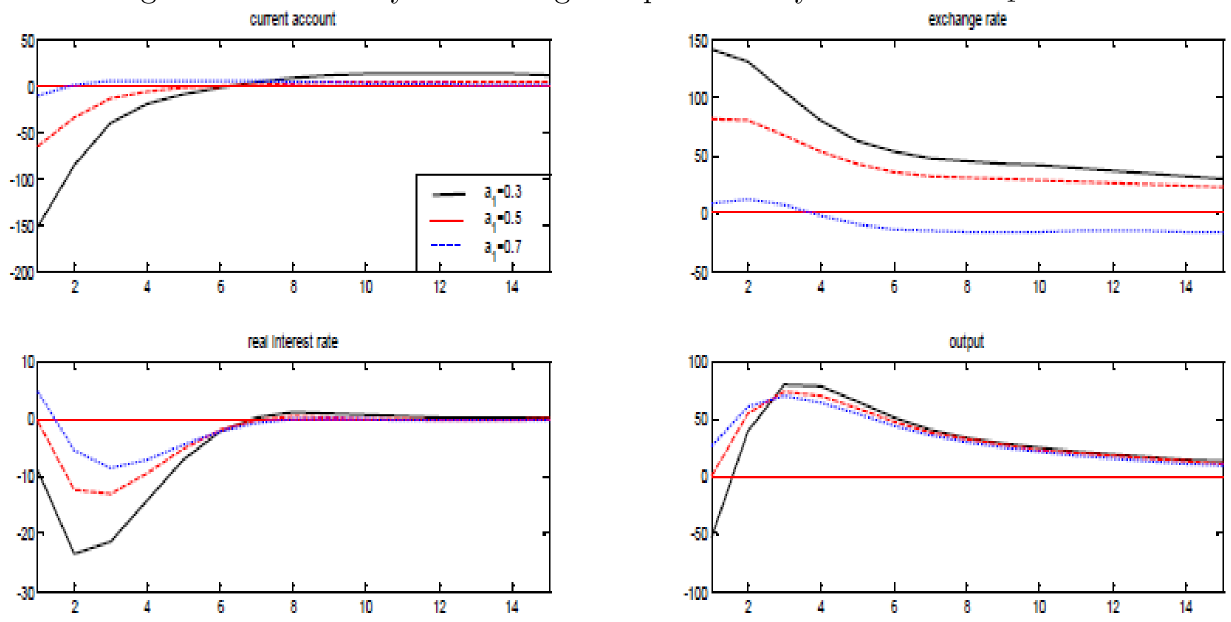


Figure 12: Sensitivity to non-traded goods productivity shock when a_1 varies