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Chapter 1

The ongoing global financial crisis and the attendant economic meltdown have placed on the centre stage the interaction of internal and external factors in shaping macroeconomic developments in the context of emerging and low-income countries. In this paper, I construct a medium-scale open economy Dynamic Stochastic General Equilibrium (DSGE) model to study business cycle fluctuations under money growth rule. The model features several nominal and real distortions including habit formation in consumption, price rigidity, deviation from purchasing power parity, and imperfect capital mobility. I also distinguish between liquidity constrained and Ricardian households. The model parameters are calibrated for the Ethiopian economy based on data covering the period 2000.1-2013.4. The main result suggests that the model economy with money growth rule is substanially less powerful or more muted for the amplification and transmission of exogenous shocks originating from governemnt spending programmes, monetary policy, technological progress, and exchange rate movements.

Key words: low-income country, terms of trade, exchange rate, fiscal policy, liquidity-constrained consumers

Chapter 2

In the last few years, macroeconomic modeling has emphasized the role of credit market frictions in magnifying and transmitting nominal and real disturbances and their implication for macro-prudential policy design. In this chapter, I construct a modest New Keynesian general equilibrium model with active banking sector. In this set-up, the financial sector interacts with the real side of the economy via firm balance sheet and bank capital conditions and their impact on investment and production decisions. I rely on the financial accelerator mechanism due to Bernanke et al. (1999) and combine it with a bank capital channel as demonstrated by Aguiar and Drumond (2007). The resulting model is calibrated from the perspective of a low income economy reflecting the existence of relatively high investment adjustment cost, strong fiscal dominance, and underdeveloped financial and capital markets where the central bank uses money growth in stabilizing the national economy. I focus on the

behaviour of small and micro enterprises which employed more than 10 million citizens in Ethiopia between 2011 and 2015 alone. These enterprises have limited net worth and cannot post collateral when applying for credit in the financial market. Moreover, they have no dollarized debt and this obviates the need for analyzing the impact of changes in the exchange rate and the terms of trade. As a result, I study the response of selected endogenous variables to shocks stemming from the fiscal authority, the monetary policy process, and technological progress. The findings are broadly consistent with previous studies that demonstrated stronger role for credit market imperfections in amplifying and propagating monetary policy shocks. Moreover, we also compare the trajectory of the model economy under alternative monetary policy instruments. The results suggest that overall the model with money growth rule generates slightly higher volatility in output and inflation than the one with interest rate rule.

Key words: firm net worth, bank equity, monetary policy transmission, macro-prudential regulation, business cycle

Chapter 3

This paper employs recursive structural vector auto-regression (SVAR) to study exchange rate pass-through into domestic consumer price inflation in Ethiopia. The study utilizes quarterly data spanning out the period from 1997.3 to 2011.4. Innovation accounting from the resulting SVAR was performed to trace out the impact of a one-time unit shock in one variable on the trajectory of other variables over time. The impulse response function analysis indicates that nominal effective exchange rate plays an important but short-lived role in affecting consumer price developments in Ethiopia. In particular, a unit change in the trade weighted exchange rate (appreciation) caused the consumer price inflation to fall by about 0.01 after four quarters (or an accumulated response of about 0.11 after 14 quarters). As a result, exchange rate pass-through into domestic prices in Ethiopia is incomplete and inconsequential. The forecast error variance decomposition exercise shows own shock explains about 63 percent of the forecast error variability of inflation followed by world oil price (20 percent) and exchange rate (13 percent). Monetary aggregate has trivial effect for all horizons considered.

Keywords: Exchange rate pass-through, consumer price inflation, Structural vector-autoregression, Impulse response function, forecast error variance decomposition.

CHAPTER 1

"A Small Open DSGE Model for Ethiopia with Incomplete Capital Market and Money Growth Rule"

1. Introduction

Notwithstanding the uncertainty surrounding the propagation mechanism, central banks in most economies strive to maintain rapid growth, stable prices, and low unemployment. These goals are often competing and incompatible. To support growth, monetary authorities would need to lower interest rates[1]. However, arresting inflation would need raising rates by some margin. Changes in interest rates affect economic decisions mainly via their effects on aggregated demand. Lower rates spur aggregate demand by inducing households and businesses to increase consumption and investment spending. Subject to the productive capacity of the economy, increased demand can generate higher inflation and real growth. While an expanding economy is good news, the attendant price hike can be potentially destabilizing. Balancing these competing goals requires better understanding of how central bank policies work and the mechanisms through which the effects of such policies are propagated across the broader economy.

Normally macroeconomists have relied on a-theoretical reduced and structural time series models to evaluate fiscal and monetary policy transmission in developing and advanced economies. However, these models were under constant assault from rational expectation adherents that such modeling frameworks were not suitable for coherent policy analysis, as the underlying parameters are sensitive to changes in policy actions. According to Lucas (1976) the structure of an econometric model embeds optimal choices made by economic agents, and that optimal decision rules change fundamentally in line with changes in the structure of series relevant to the agent, and consequently any change in policy will

[1] It is true that monetary policy loses traction when the interest rate is up against the zero lower bound (ZLB) or when the economy is caught in a liquidity trap. When the ZLB is a real constraint, central banks find it hard to fight recession as rates cannot be lowered below zero.

systematically modify the structure of econometric models.[2] As a result, the quest for evaluating the implications of alternative policy options is severely constrained by the fact that the structures of such models are subject to changes in tandem with public expectations of policy actions.

The promising proposition to accommodate such criticism was to find ways in which macroeconomic models accounted for human behavior. This has come to be known as the micro foundation approach in the business cycle literature and has been vitally influenced by the contribution of Kydland and Prescott (1982). These models feature forward-looking autonomous agents interacting in competitive markets and forming expectations about the future (Rebelo, 2005). In this setting, the co-movement of several aggregate variables—production, hours worked, wages, total factor productivity, investment and consumption spending--are explained with a single exogenous shock arising from technological progress (Nakamura, 2006).[3]

These real business cycle (RBC) models—as they have come to be known in mainstream macro—have numerous vulnerabilities. First, their emphasis on real shocks, such as technology, as the only driving force of economic fluctuations ignores the role of nominal distortions and frictions in the macroeconomic adjustment process. Moreover, in such models, there is no room for central bank activism nor can the government influence aggregate economic outcomes via discretionary taxation and spending measures. In the world of RBC models, unemployment and recession are optimal rational responses to correct extravagant engagements or productivity changes, thus obviating the need for counter-cyclical fine-tuning through monetary and fiscal intervention. And finally the assumption of fully flexible wages and prices implies an economy operating at full employment and joblessness to be a conscious choice in the continuum of consumption-leisure trade-off.

[2] Lucas also remarks that this conclusion is of occasional significance as far as coherent forecasting or tracking ability of econometric models is concerned. The critique is of fundamental consequence for issues involving the assessment of policy actions.

[3] See, for instance, Smets and Wouters (2003) for further details. In this paper, the authors go well beyond the RBC tradition by considering additional shocks as the source of macroeconomic instability.

Subsequent works in macroeconomics have mainly focused on rectifying the apparent shortcomings of RBC models in an attempt to make them adaptable to reality where business booms and busts are generated by a wide range of real as well as nominal frictions. The new generation frameworks—called dynamic stochastic general equilibrium (DSGE) models—feature wage/price rigidity, habit formation in consumption preference, adjustment costs in investment, variable capital utilization, moral hazard in credit markets, the role of net worth and balance sheet effects of liability dollarization for firms, households, banks and governments.[4] DSGE models are now powerful instruments as a coherent methodological framework for policy discussion and analysis purposes. In theory, they can help to detect sources of economic fluctuations, provide clues in identifying structural changes, predict the effects of policy measures, and enable us to conduct counterfactual exercises. They also permit to form a link between the structural characteristics of economy and reduced form parameters, a task which was not possible with large scale macroeconomic models (Tovar, 2009).[5]

In this paper I develop a small open economy DSGE model for Ethiopia which heavily draws on the works of Gali and Monacelli (2005); Adam et al. (2006); Devereux et al. (2006); Liu (2006); Gali et al. (2007); Peiris and Saxegaard (2008); Berg et al. (2010); Alpanda et al. (2011); Herz and Hohberger (2012); Shen and Yang (2012); and McManus (2013), among others. DSGE models boast several attractive features that facilitate macroeconomic scenario analysis and forecasting. They are structural and each equation in the system embeds economic interpretation. Policy actions and their propagation channel can be clearly identified

[4] See Bernanke, Gertler, and Gilchrist (1999); Smets and Wouters (2003); Christiano, Eichenbaum, and Evans (2005); Devereux, Lane, and Xu (2006); Peiris and Saxegaard (2008); Berg, Mirzoev, Portillo, and Zanna (2010); among others, for a variety of nominal and real distortions relevant in the context of rich, emerging, and low-income countries.

[5] There are, of course, criticisms against DSGE models too. Joseph Stiglitz (2014), for instance, raises so many problems with standard DSGE models, most of which (e.g. the absence of financial frictions, Ricardian equivalence, monitoring costs arising from the presence of private information in credit markets, flexible prices/wages, etc.) have been addressed progressively over time. But worth mentioning are the identical nature of agents and the total disregard for the distributional consequences of the price mechanism in contemporaneous New Keynesian general equilibrium models. Inequality matters. People differ in their attitudes towards risk, for instance. Such issues need to be acknowledged and normative judgments should step in to fill gaps in current general equilibrium models.

thereby enabling a discussion on the implications of alternative policy choices. They are also microfounded in the sense that they explicitly stem from the inter-temporal maximizing behavior of businesses and individuals in the economy. They thus depict the choices of decision makers in terms of structural parameters that do not normally change in response to changes in economic policy, thereby validating the analysis of alternative policy actions (Peiris and Saxegaard, 2008). DSGE frameworks are also better suited for policy analysis purposes than traditional econometric methods that should be less useful in a situation where the economy has forward-looking behavior and is characterized by a high degree of simultaneity, and when time series data are short and subject to structural break (Berg et al., 2006).

The key features of this study are threefold. First, I distinguish between Ricardian and non-Ricardian households as in Gali et al. (2007). The former are optimizing consumers that engage in inter-temporal maximization of the present discounted streams of future expected lifetime utility. They have access to local (and possibly international) equity and bond markets and smooth consumption habit over time. The latter group are sometimes called liquidity constrained, rule-of-thumb or hand-to-mouth households. They have neither assets nor liabilities and their consumption-leisure choices are subject to disposable income in each period. Some of the justifications for the existence of these subsistence agents include shortsightedness, limited access to capital markets, fear of saving, ignorance of inter-temporal trading opportunities, among others (Gali et al., 2007).

In response to an insightful appeal by Mankiw (2000), this distinction has been found important to generate positive response of consumption to government spending shocks;[6] before that Ricardian equivalence was an article of faith in most standard RBC/DSGE models. Many did not bother to incorporate a fiscal sector, and when they did, they usually assumed that rational agents neutralize government efforts. If the government increases spending to galvanize growth, rational forward-looking consumers would retrench current consumption and raise their savings to meet future tax obligations. This was mainly due to the supposed negative wealth effect of public sector programmes on private consumption.

[6] See, among others, Linnemann and Schabert (2000); Bouakez and Rebei (2003); Linnemann (2005); Furlanetto (2006); Gali et al. (2007); and Forni et al. (2009) for further information on the interaction between private sector spending and public consumption.

Recently, many studies have attempted to generate positive response of private spending to government purchases of goods and services. There are four approaches in the literature: a complementarity between private and government consumption in the utility function; a utility specification that is non-additively separable in consumption and labour supply; the inclusion of government spending in the production technology; and the introduction of hand-to-mouth households in the model (the approach that I adopt in this specific study).

Next, I focus on aspects of the conduct of monetary policy in developing countries. The standard practice in New Keynesian modeling relies on a simple feedback rule in which the monetary regime adjusts the short-term nominal interest rate in reaction to the departure of endogenous variables from their target values. Despite its usefulness for thinking about the art of central banking in mature economies, the application of this approach to developing countries has been severely criticized in view of the structural disparities in the financial systems between poor and advanced economies. Mishra et al. (2010) observe that the traditional propagation conduits for monetary policy (interest rate, asset price, etc.) are constrained in their function in low income countries. The reasons include weak institutional arrangements, poor contractual enforcement, primitive and illiquid secondary markets for government securities and inter-bank reserves, limited central bank independence, frequent interference in the foreign exchange markets, heightened concentration and limited competition in the banking sector, and the resulting high cost of advancing loans to private businesses. In light of these problems, I follow Berg et al. (2010), O'Connell (2011) and Shen and Yang (2012)[7] to develop a monetary policy framework consistent with the experiences of low income countries like Ethiopia. We consider a hybrid set-up whereby the central bank regulates the growth rate of the quantity of monetary aggregates and intervenes in the foreign exchange markets while attempting to keep in line the trajectory of the consumer price inflation.

Third, I delve into the home economy's relationship with the rest of the world. A fundamental equation in small open economy DSGE frameworks is the uncovered interest rate parity (UIP) condition. In its simplest specification, the UIP reflects that the nominal interest rate

[7] In its original version, this kind of rule was designed to evaluate alternative monetary policy rules for managing scaled-up aid money in low-income countries. I am not particularly interested in analyzing the welfare effects of aid utilization and assume that all aid is fully absorbed.

differential between the domestic and the foreign economies equals the expected movements in the nominal exchange rate. This condition is critical in a small open economy setting for both the exchange rate and other macro aggregates as it facilitates internal transmission of exchange rate changes working via variable relative prices (Adolfson et al., 2005). The standard UIP relationship, however, holds under perfect capital mobility and international risk sharing with complete asset markets. This stands in stark contrast with the prevailing objective reality in developing countries that are characterized by numerous legal restrictions and inherent structural deficiencies that operate against the free mobility of capital into and out of these economies. To account for this imperfection, I allow for deviation from the common UIP rule such that domestic agents face a borrowing risk premium that depends on the net foreign asset position of the economy. As a result, when the domestic economy is a net creditor, it confronts a reduced lending rate in global capital markets and as a net debtor it pays higher than the world interest rate.

In recent times, open economy versions have become quite popular. Interaction with the rest of the world should force monetary policy to deviate from the desired objectives achievable in flexible equilibrium outcomes implied for autarky. Monacelli (2013) points out a couple of circumstances in which opening up the economy to trade shatters the theoretical relationship suggested by the 'divine coincidence' emphasized in closed economy settings. First, monetary authorities can capitalize on changes in the terms of trade and the exchange rate as critical margins to facilitate/improve the domestic markup stabilization instruments. Second, domestic price stability can be disturbed by exogenous cost-push shocks that arise from movements in international prices of imported consumption goods as well as imported factors of production. Such external developments can have significant bearing on central bank actions that should contrast with the classical objectives of domestic price stabilization.

In this paper, I develop a simplified two-country small open economy DSGE model for Ethiopia in which the external sector is exogenously given. The model incorporates capital market imperfection by modifying the standard uncovered interest rate parity rule that allows for time varying risk premium driven by changes in the net foreign asset position of the economy. Calvo-style nominal rigidity governs the price setting behaviour of firms engaged in domestic production and import retailing. Money growth rate and fiscal policy feedback rules are considered to evaluate the effectiveness of monetary and fiscal stabilization policies at business cycle frequencies.

The results suggest that the open economy setting reveals stronger transmission mechanism for monetary policy shocks while autarky is more effective (from the view point of the policy maker) in propagating shocks emanating from the fiscal authority. Another key result from the simulation exercise suggests that the model economy with money growth rule is substanially less powerful for the amplification and transmission of exogenous shocks originating from governemnt spending programmes, monetary policy, technological progress, and exchange rate movements.

The rest of the paper is structured as follows: the next section briefly outlines the monetary history and monetary policy practice in Ethiopia in the past four decades. Section 3 presents the model set up for the small open dynamic stochastic general equilibrium model that will be used in the simulation exercise later on. The empirical analysis and discussion of results occur in section four followed by concluding remarks in section five.

2 Monetary Policy in Ethiopia

Throughout the Derg period (1974-1991), central banking, like anything else in public life, was overwhelmingly influenced by the communist government's political choices[8]. State owned enterprises and cooperatives were accorded preferential treatment over private businesses. Collectivist organizations generally enjoyed lower borrowing rates and relatively higher returns on their saving deposits. Both lending and borrowing rates were repressed, discouraging saving and capital accumulation. The exchange rate remained pegged to the dollar and did not reflect underlying economic fundamentals. It was in the post-1991 period that the NBE gained measurable independence.

[8] For instance, the borrowing rates on private loans were between 7-10% per annum, while state owned enterprises and cooperatives were charged 4.5-8% and 4.5-6%, respectively. Similarly, rates payable on private deposits were capped at 5% and saving deposits over 100,000 birr did not earn beyond 2%. The government had also imposed an upper limit on private investment which was tagged at 500,000 birr. Moreover, the artificially overvalued birr (fixed at 2.07/dollar) along with the repressive and discriminatory interest rate policy of the central bank drove a substantial fraction of the economy underground.

The NBE today has numerous instruments to rely on in order to achieve its short-term objectives and long-term goals. The most important ones are:

Open Market Operation: the central bank of Ethiopia engages in periodic purchases and sales of debt securities issued by the government. The purpose is to improve the efficiency of financial intermediation by regulating the optimal amount of liquidity in the banking system and in the broader economy. It is a highly flexible instrument as the monetary authorities can easily and immediately reverse their action (i.e. it can be complemented by repo agreements in the inter-bank market) in the event that actual outcomes deviate from target. However, the effectiveness of such policy instrument is somewhat unclear as its practice by the NBE is mainly aimed at catering to the government's fiscal concerns by monetizing stated budget deficits. In other words, money supply management through open market operation has been secondary to fiscal policy objectives. There is a lot of room for the government to ensure monetary policy independence. Moreover, secondary bond markets are currently non-existent in Ethiopia and even if there was one, it would rather not be attractive to investors until the NBE restores confidence in its ability to stabilize prices.

Reserve Requirements: In many countries, commercial banks are required to withhold a fraction of certain deposits in the form of cash and/or reserve money at the central bank. By setting a minimum reserve requirement ratio, the central bank can have some leverage on the amount of credit supplied to the private sector. According to NBE directive issued in 2013[9], any commercial bank operating in Ethiopia is subject to maintain 5% of all birr and foreign currency liabilities received in the form of demand, time and saving deposits.

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[9] The 6th replacement reserve requirement directive No.SBB/55/3013 instructs each commercial bank to open and maintain two separate accounts one for reserve management and the other for payment and clearance purposes. The same directive allows banks to exclude cash receivables (money in the process of collection) and the reserve amount is calculated on the net deposit mobilized. The reserve requirement ratio set by the NBE has been in the range of 5-15% for most of the period since 1994. But exceptional developments have been confronted with exceptional responses. In 2008, for example, when annual inflation reached an all time high of about 40%, successive replacement directives had brought the requirement ratio in the range of 20-25%.

A Standing Credit Facility: when a commercial bank exhausts all other alternative sources of funding to cover its short-term financing needs, it can fall back on special financing facilities arranged by the NBE. The NBE provides short-term liquidity to troubled intermediaries that cannot be served by prevailing inter-bank money market arrangements. The interest rate charged by the central bank is linked to short-term market interest rates. Such central bank assistance in clearing and settling short-term transactions of financially constrained banks makes access to NBE's resources more predictable and transparent (NBE, 2009).

The monetary policy framework of the NBE (2009) outlines numerous other potential instruments including the setting of floor deposit rates, direct borrowing and lending in the inter-bank market, the use of selected credit control and moral suasion. It also actively monitors the risk-weighted capitalization[10] of commercial banks that is an indirect way of ensuring their long-term solvency and capacity to weather large, sudden adverse shocks with ripple effects.

3 Model

3.1 Households: Consumption Sector

Infinitely lived forward-looking representative households inhabit the economy on the interval [0.1]. The fraction λ of the households are liquidity constrained in the sense that they live from paycheck to paycheck. They do not participate in asset markets and consume their entire labour income every period. Changes in economic policies (such as taxation) have limited effect on the consumption and saving decisions of these hand-to-mouth families. The remaining fraction (1- λ) of households are standard rational, forward-looking agents and they

[10] As of 2013, commercial banks in Ethiopia are bound to maintain 8% risk-weighted capital level. This is sufficient given the sector's cautious track record of credit administration and limited engagement in potentially risky credit deals. Recently, however, the state owned commercial bank of Ethiopia (CBE), the biggest commercial bank in the country, has been displaying massive appetite in financing state-sponsored mortgage programmes. As witnessed in the recent global sub-prime mortgage crisis, the collapse of the housing sector can have far-reaching consequences for the real economy and it appears that the NBE should deploy innovative regulatory instruments to avoid contagion from large and simultaneous defaults in the housing market.

take into account the effect of policy changes on their activities. They invest in domestic and foreign stocks and government securities. As a result, their income and consumption profiles are affected by internal and external shocks that hit the economy.

Denoting the consumption of the savers by C_t^r (r for Ricardian) and their labour supply by N_t^r, the utility maximization problem is given by the argument:

$$E_t \sum_{t=0}^{\infty} \beta^t \{U(\mathrm{C}_t^r, \mathrm{H}_t) - V(N_t^r)\} \tag{1}$$

$$U(\mathrm{C}_t^r, \mathrm{H}_t) = \frac{(C_t^r - H_t)^{1-\sigma}}{1-\sigma} \quad \text{and} \quad V(N_t^r) = \frac{(N_t^r)^{1+\varphi}}{1+\varphi} \tag{2}$$

where β is the subjective discount rate, σ is the intertemporal inverse elasticity of substitution, φ is the inverse elasticity of labour supply; $H = hC_{t-1}^r$ $[\mathrm{h} \in (0,1)]$ captures habit formation in Ricardian household consumption. The composition of the consumption bundle C_t is assumed to be identical for both groups of households and is represented by an index of home produced and imported bundles:

$$C_t \equiv \left((1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{3}$$

where $\alpha \in [0,1]$ is a measure of the degree of openness of the economy (often approximated by the import content in gross domestic product); $\eta > 0$ is the elasticity of substitution between home produced and foreign goods. Assuming that both households access the same aggregate consumption indices of domestically produced ($C_{H,t}$) and imported goods ($C_{\mathrm{F},t}$), so-called Dixit-Stiglitz aggregator yields:

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t(i)}^{\frac{\varepsilon-1}{\varepsilon}} di \right) \quad \text{and} \quad C_{F,t} \equiv \left(\int_0^1 C_{\mathrm{F},t(i)}^{\frac{\varepsilon-1}{\varepsilon}} di \right) \tag{4}$$

where $\varepsilon > 0$ is the elasticity of substitution among varieties produced in the domestic and foreign economy and is assumed to be the same between the two countries. The following budget constraint completes the utility maximization problem of the representative saving household:

$$\int_0^\infty \{P_{H,t}(i)C_{H,t}(i)+P_{F,t}(i)C_{F,t}(\mathrm{i})\}di+D_t \le D_{t-1}+W_tN_t \tag{5}$$

Which holds for $t=1,2,...,\infty$, where $\mathrm{P}_{H,t}(i)$ and $\mathrm{P}_{\mathrm{F},t}(i)$ indicate the prices of individual good i produced in the home and foreign country, respectively; D_t is the portfolio investment made in the previous period, and W_t is the hourly nominal wage rate which is the same across both categories of households.

Given the constant elasticity of substitution (CES) aggregator for ($C_{H,t}$) and ($C_{F,t}$) in equation (4), the optimal allocation for good i in the domestic and foreign sectors is represented by the following demand functions:

$$C_{H,t}(i)=\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon}C_{H,t} \qquad \text{and} \qquad C_{F,t}(i)=\left(\frac{P_{\mathrm{F},t}(i)}{P_{\mathrm{F},t}}\right)^{-\varepsilon}C_{F,t} \tag{6}$$

where $\mathrm{P}_{\mathrm{H},t}$ and $\mathrm{P}_{\mathrm{F},t}$ are the price indices of home produced and imported goods, respectively. Moreover, assuming symmetry across all i goods, the optimal allocation of expenditure between domestic and imported goods is given by:

$$C_{H,t}=(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}C_t \qquad \text{and} \qquad C_{F,t}=\alpha\left(\frac{P_{\mathrm{F},t}}{P_t}\right)^{-\eta}C_t \tag{7}$$

Where $P_t=\{(1-\alpha)P_{H,t}^{1-\eta}+\alpha P_{F,t}^{1-\eta}\}^{\frac{1}{1-\eta}}$ is the overall consumer price index (CPI). It follows that the typical domestic household maintains total consumption expenditure equal to $P_{H,t}C_{H,t}+P_{F,t}C_{F,t}=P_tC_t$. Moreover, as Ricardian households can access both domestic and foreign bond markets, the modified form of the inter-temporal budget constraint given in equation (5) can conveniently be expressed as:

$$P_tC_t^r+B_t+\varepsilon_tNFA_t=W_tN_t^r+(1+i_{t-1})B_{t-1}+(1+i_{t-1}^*)\Omega_t(NFA_t)\varepsilon_{t-1}NFA_{t-1}+T_t \tag{8}$$

The left hand side displays the one-period expenditure on composite consumption goods, domestic bond (B_t), foreign currency-denominated bond holdings (NFA_t) while ε_t denotes the nominal exchange rate in units of domestic currency per unit of foreign currency. The right hand side records the income accruing to the household at the beginning of the period, with wage earning, $W_t N_t^r$, gross rate of return on domestic bond investment, $1+i_{t-1}$, and gross rate of return on foreign bond holding, $1+i_{t-1}^*$. T_t is lump-sum tax/transfer payment to/ from the government. Finally, Ω_t captures the premium on the foreign investment position of the household and is defined as[11]:

$$\Omega_t = \exp(v_t^{risk} - \chi NFA_t) \qquad (9)$$

The parameter χ is an elasticity term that is negatively correlated with the net foreign asset position of the economy while $NFA_t \equiv \frac{e_{t-1} NFA_{t-1}}{P_{t-1}}$ denotes the real aggregate net foreign asset (NFA) position of the concerned economy and v_t^{risk} is the shock to the risk premium. The expression $\Omega_t(NFA_t)$ reflects the costs to domestic households associated with uncertainty and adverse exchange rate movements in international capital markets. The implication is that as net creditors, households will receive lower return than the foreign interest rate; and as net borrowers, they will pay a premium over and above the prevailing foreign interest rate.

The autonomous household choices over the optimal amount of consumption and labour supply in each period give rise to the following set of first order conditions (FOCs) of the household utility optimization problem:

$$(C_t^r - hC_{t-1}^r)^{-\sigma} \frac{W_t}{P_t} = (N_t^r)^{\varphi} \qquad (10)$$

[11] See Schmitt-Uribe (2005), Alpanda et. al. (2009), Herz and Hohberger (2012) , among others, on the definition and derivation of the foreign risk premium embedded in the imperfect capital market version of the uncovered interest rate parity (UIP) relationship.

$$\beta E_t\left\{\frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}^r - hC_t^r}{C_t^r - hC_{t-1}^r}\right)^{-\sigma} = \frac{1}{1+i_t}\right. \tag{11}$$

$$\beta E_t\left\{\left(\frac{P_t}{P_{t+1}}\right)\left(\frac{\varepsilon_{t+1}}{\varepsilon_t}\right)\left(\frac{C_{t+1}^r - hC_t^r}{C_t^r - hC_{t-1}^r}\right)^{-\sigma}\right\} = \frac{1}{(1+i_t^*)\Omega(NFA_t)}.$$

(12)

Log-linearizing equations (6), (10) and (11) we get:

$$c_{H,t} = -(1-\alpha)\{\eta(\mathrm{p}_{H,t} - p_t) + c_t\} \tag{13}$$

$$c_{F,t} = -\alpha\{\eta(\mathrm{p}_{\mathrm{F},t} - p_t) + c_t\} \tag{14}$$

$$\mathrm{w}_t - p_t = \varphi n_t + \frac{\sigma}{1-\sigma}\tilde{c}_t^r \tag{15}$$

$$\tilde{c}_t^r = E_t\tilde{c}_{t+1}^r - \frac{1-h}{\sigma}(\mathrm{i}_t - E_t\pi_{t+1}) \tag{16}$$

In equations (11) to (14), lower-case letters represent the logs of their upper case counterparts, while $\tilde{c}_t^r = c_t^r - hc_{t-1}^r$ and $\pi = p_t - p_{t-1}$ is the overall consumer price inflation.

The liquidity-constrained households have the same utility function as the optimizing agents. They decide only on their consumption and work hours subject to real budget constraint:

$$C_t^{nr} = \frac{W_t}{P_t}N_t$$

The first-order conditions with respect to consumption and labour supply choices are identical to those of the optimizing households except that we have binding budget constraint and no habit formation for the rule-of-thumb households.

3.2 The Real Exchange Rate, Terms of Trade, and Inflation

The terms of trade (ToT) or the competitive index between the tradable sectors of the domestic (exports) and the foreign economy (imports) can be defined as:

$$S_t = \frac{P_{F,t}}{P_{H,t}}$$

which is equivalent to $s_t = p_{F,t} - p_{H,t}$ in logarithmic terms. The ToT measures the price of foreign-produced goods per unit of locally produced goods. In this case, a rise in s_t signifies improvement in the competitive position of the domestic economy as this implies an increase in the prices of foreign goods, a decrease in the prices of home-produced goods or both. The log-linearization of the CPI expression described as part of equation (7) establishes an intuitive relationship between the terms of trade and the general price level:

$$\begin{aligned} p_t &\equiv (1-\alpha)\, p_{\mathrm{H},t} + \alpha\, p_{\mathrm{F},t} \\ &= p_{\mathrm{H},t} + \alpha s_t \end{aligned} \tag{17}$$

By first differencing equation (16), we achieve an identity in which the gap between general and domestic CPI inflation rates is proportional to the change in the terms of trade:

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \tag{18}$$

$$\Delta s_t = \pi_{F,t} - \pi_{H,t} \tag{19}$$

Equation (18) follows directly from the definition of the ToT. It is important to note that the degree of openness of the economy α has direct bearing on the coefficient of proportionality.

Next we exploit insights from the law of one price (LOP) and the nominal exchange rate to derive another important relationship that captures relevant aspects of dynamics in a small open economy. Let ε_t be the nominal exchange rate measuring the value of a foreign currency (or weighted average of basket of currencies) per unit of domestic currency. Given this convention, we define the LOP gap and the real exchange rate as:

$$\Psi_t = \frac{\varepsilon_t P_t^*}{P_{F,t}} \text{ and } Q_t = \frac{\varepsilon_t P_t^*}{P_t}, \text{ respectively.}$$

When the law of one price is satisfied, that is $\Psi_t = 1$, then the local currency import price index $P_{F,t}$ is simply the product of the foreign price index and the nominal exchange rate. The LOP gap captures the extent to which the world price and the domestic price of imports diverge from each other. Replacing ψ_t in the expression for the terms of trade (all in logs) yields:

$$s_t = p_t^* - e_t - p_{H,t} - \psi_t \tag{20}$$

where e_t denotes the logarithmic transformation of the nominal exchange rate. Combining equation (19) with the definition of (the log-transformed) real exchange rate q_t generates the relationship:

$$\begin{aligned} q_t &= e_t + p_t^* - p_t \\ &= p_{H,t} + s_t + \psi_t - p_t \\ &= \psi_t + (1-\alpha)s_t \end{aligned} \tag{21}$$

$$\psi_t = [q_t - (1-\alpha)s_t]$$

The last expression in describes inverse proportionality between the LOP gap on the one hand and the real exchange rate and the terms of trend on the other.

3.3 Incomplete Capital Markets and Uncovered Interest Rate Parity

By combining equations (11) and (12), under the assumption of incomplete international financial markets, we can formalize a powerful relationship between the nominal interest rates and the nominal exchange rates in the domestic and foreign economies:

$$1 + i_t = (1 + i_t^*)\Omega(NFA_t)\left(\frac{\varepsilon_{t+1}}{\varepsilon_t}\right) \tag{22}$$

The log-linearization of equation (22) around the steady state produces a relationship in which the expected change in the real exchange rate responds to the real interest rate differential between the home and the foreign economies:

$$i_t - i_t^* - \omega_t = E_t(\Delta e_{t+1})$$
$$i_t - i_t^* - \chi nfa_t + v_t^{risk} = E_t(\Delta e_{t+1}) \tag{23}$$

Equation (23)[12] is a modified uncovered interest rate parity (UIP) relationship that shows a time-varying risk premium as the sum of the net foreign asset position of the domestic economy and an exogenous component v_t^{risk}. All variables are in log-deviation from their steady states with nfa corresponding to NFA. We close the capital market dynamics by specifying the path for net foreign asset position that evolves according to the inter-related rules:

$$\frac{\varepsilon_t NFA_t}{P_t} = \frac{(1+i_{t-1})}{(1+\pi_H)}\Omega_t\left(\frac{\varepsilon_{t-1} NFA_{t-1}}{P_{t-1}}\right) + NX_t \tag{24}$$

$$NX_t = \frac{P_H}{P_t}(Y_t - C_t - G_t) \tag{25}$$

$$\mathrm{CA}_t = \frac{\varepsilon_t NFA_t - \varepsilon_{t-1} NFA_{t-1}}{P_t} \tag{26}$$

where NX_t is net export which equals to the gap between production one the one hand and consumption by the public and private sectors on the other; while CA_t denotes the current account as changes in the real net foreign asset position. The log-linearization of equations (24) to (26) together with the definition for Ω_t produces the following relationships:

$$\mathrm{nfa}_t = (1 + i_{t-1} - \pi_{H,t})\omega_{t-1} nfa_{t-1} + nx_t \tag{27}$$

$$nx = y_t - (1-\rho_c)c_t - (1-\rho_c)\alpha(s_t + \psi_t) - \rho_c g_t \tag{28}$$

where $nfa_t = \frac{\varepsilon_t NFA_t}{P_t}$ and $c_t = \lambda c_t^{nr} + (1-\lambda)c_t^r$.

3.4 Firms: Production Sector

[12] Note that $\omega_t = \log \Omega_t = \chi nfa_t + v_t^{risk}$

The economy is made up of a continuum of identical, monopolistically competitive firms each maintaining some degree of monopoly over a differentiated product Y_j employing constant returns to scale (CRS) production technology of the form:

$$Y_t(j) = A_t N_t(j) \tag{29}$$

where A_t is the firm specific productivity index; its log $a_t = \log A_t$ follows $AR(1)$ process, $a_t = \rho_a a_{t-1} + \varepsilon_t^a$ and ε_t^a is the unanticipated productivity shock affecting the level of technology and productivity of the firm. The aggregate production of the concerned economy is given by $Y_t = \left[\int_0^1 Y_t(j)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}$. Imposing symmetry across all j firms yields the following first order log-linear approximation for the aggregate production function:

$$y_t = a_t + n_t \tag{30}$$

where $n_t = \lambda n_t^{nr} + (1-\lambda)\,\mathrm{n}_t^r$ suggesting work hours differ across groups of households.

Under the assumption of perfectly competitive labour market in which wages are the same for both Ricardian and Non-Ricardian households, the total production of the monopolistic firm, given its technology, is $TC_t = \frac{W_t}{P_{H,t}} \frac{Y_t}{A_t}$. Consequently, the log of the real marginal cost which is common across all domestic firms is:

$$mc_t = w_t - p_{H,t} - a_t \tag{31a}$$

$$\begin{aligned} &= w_t - p_t + p_t - p_{H,t} - a_t \\ &= w_t - p_t + \alpha s_t - a_t \\ &= \sigma c_t + \varphi n_t + \alpha s_t - a_t \end{aligned} \tag{31b}$$

We arrive at equation (31b) by manipulating the FOCs with respect to consumption and labour supply for both categories of households as well as using $c_t = \lambda c_t^{nr} + (1-\lambda)c_t^r$ and $n_t = \lambda n_t^{nr} + (1-\lambda)\,\mathrm{n}_t^r$. Now we have established a relationship where the real marginal cost of production decreases with productivity and increases with consumption, work hours, and terms of trade.

3.5 Price Setting Behaviour and Incomplete Pass-Through

The said monopolistic firms in the domestic economy set their prices in a staggered fashion due to Calvo (1983). In each period, a random fraction $1-\theta$ ($\theta \in [0,1]$) of firms adjust their prices optimally. The remaining fraction θ are assumed to follow an adjustment process that exploits indexation of current prices to inflation in the previous period:

$$P^{I}_{H,t}(\mathrm{j}) = \mathrm{P}_{H,t-t}(j)\left(\frac{P_{H,t-1}}{P_{H,t-2}}\right)^{\theta} \tag{32}$$

Equation (32) can be re-written in log-linear form as $p^{I}_{H,t}(\mathrm{j}) = \mathrm{p}_{H,t-1}(j) + \theta\pi_{H.t-1}$. Under symmetric equilibrium, we have $P_{H,t}(j) = P_{H,t}(k), \forall j,k.$ Denoting the price level that the optimizing firm chooses in each period by $\overline{P}_{H,t}$, the aggregate price level in the domestic economy evolves according to the pricing rule:

$$P_{H,t} = \left\{ (1-\theta)\overline{P}^{1-\xi}_{H,t} + \theta\left[P_{H,t-1}\left(\frac{P_{H,t-1}}{P_{H,t-2}}\right)^{\theta}\right]^{1-\xi}\right\}^{\frac{1}{1-\xi}} \tag{33a}$$

$$\text{or } \pi_{H,t} = (1-\theta)(\overline{p}_{H,t} - p_{H,t-1}) + \theta^{2}\pi_{H,t-1} \tag{33b}$$

Those optimizing firms that are able to adjust their prices in the current period will choose $\overline{P}_{H.t}$ in such a way as to maximize the present discounted sum of future streams of profits subject to the sequence of demand constraints as stated in:

$$\max_{\overline{P}_{\mathrm{H},t}} \sum_{k=0}^{\infty} (\beta\theta)^{k} \left\{ Q_{t+k}\left(Y_{t+k}\left(\overline{P}_{H,t} - MC^{n}_{t+k}\right)\right)\right\} \tag{34}$$

$$\text{Subject to } Y_{t+k} \leq \left(\frac{\overline{P}_{H,t}}{P_{H,t+k}}\right)^{-\varepsilon}\left(C_{H,t+k} + C^{*}_{H,t+k} + G_{t}\right)$$

where MC_{t+k}^{n} is the nominal marginal cost while $\theta^{k} E_{t} Q_{t+k}$ is the effective stochastic discount factor. The resource constraint imposes the restriction that domestic production should at least cover exports and consumption spending by the government and households. Considering the fact that firms have a $1-\theta$ probability of being able to reset their prices in each period, the first order condition for the optimal price-setting rule is:

$$\sum_{k=0}^{\infty} \theta^{k} E_{t}\left\{Q_{t+k} Y_{t+k}\left(\bar{P}_{H,t}-\frac{\varepsilon}{1-\varepsilon} MC_{t+k}^{n}\right)\right\}=0 \tag{35}$$

where $\frac{\varepsilon}{1-\varepsilon}$ is the marginal cost of production under perfectly competitive setting. Substituting out Q_{t+k} using the consumption Euler equation in (11) and dividing by P_{t+k} across all terms gives:

$$\sum_{k=0}^{\infty}(\beta\theta)^{k}\left\{C_{t+k}^{-\sigma} Y_{t+k} \frac{P_{H,t-1}}{P_{t+k}}\left(\frac{\bar{P}_{H,t}}{P_{H,t-1}}-\frac{\varepsilon}{\varepsilon-1} MC_{t+k} \frac{P_{H,t+k}}{P_{H,t-1}}\right)\right\}=0 \tag{36}$$

where $MC_{t+k}=\frac{MC_{t+k}^{n}}{P_{H,t+k}}$ is the real marginal cost. The log-linearization of equation (36) around the zero-inflation steady state to get the decision rule for $\bar{p}_{H,t}$ yields:

$$\bar{p}_{H,t}=p_{H,t-1}+\sum_{k=0}^{\infty}(\beta\theta)^{k}\left\{E_{t}\pi_{H,t+k}+(1-\beta\theta) E_{t} mc_{t+k}\right\} \tag{37}$$

Equation (37) states that optimizing firms choose their prices to in line with the present discounted values of future streams of inflation and deviation of the real marginal cost from its steady state. Re-writing this same equation we have:

$$\bar{p}_{H,t}=p_{H,t-1}+\pi_{H,t}+(1-\beta\theta_{H}) mc_{t}+(\beta\theta)\sum_{k=0}^{\infty}(\beta\theta_{H})^{k}\left\{E_{t}\pi_{H,t+k+1}+(1-\beta\theta_{H}) E_{t} mc_{t+k+1}\right\} \tag{38a}$$

$$=p_{H,t-1}+\pi_{H,t}+(1-\beta\theta_{H}) mc_{t}+\beta\theta_{H}(\bar{p}_{H,t+1}-p_{H,t})$$

$$\bar{p}_{H,t}-p_{H,t-1}=\pi_{H,t}+\beta\theta_{H} E_{t}\pi_{H,t+1}+(1-\beta\theta_{H}) mc_{t} \tag{38b}$$

Combining equations (32), (33) and (38) and rearranging provides the path for domestic inflation:

$$\pi_{H,t} = \beta(1-\theta_H)E_t\pi_{H,t+1} + \theta_H\pi_{H,t-1} + z_H mc_t \tag{39}$$

where $z_H = \frac{(1-\beta\theta_H)(1-\theta_H)}{\theta_H}$. This last result presents the so-called New Keynesian Phillips Curve (NKPC) and it describes the current domestic consumer price inflation as a function of expected future inflation, realized previous inflation, and the real marginal cost. Without Calvo-type pricing behaviour (that is with the price stickiness parameter $\theta_H = 0$), only the forward-looking component determines current inflation and there would be little cost to be incurred from advancing disinflationary policy choices.

Similarly, we employ a Calvo-type strategy to capture the pricing behaviour of local retailing firms which distribute imported goods to domestic consumers. While the LOP holds at the wholesale level, we do observe deviations from the LOP mainly because of costs and inefficiencies associated with transportation, inventory management, taxation, uncertainty about exchange rate movements, and monopoly power over the distribution of the specific imported product. As domestic retailers of imported goods set import prices over and above the marginal cost, the LOP is no longer satisfied.[13] As a result, the optimal pricing rule for the domestic import retailer looks like:

$$\overline{p}_{F,t} = p_{F,t-1} + \sum_{k=0}^{\infty}(\beta\theta_F)^k\{E_t\pi_{F,t+k} + (1-\beta\theta_F)E_t\psi_{t+k}\} \tag{40}$$

where $\theta_F\,(\theta_F \in [0,1])$ is the fraction of import retailers that cannot adjust their prices optimally every period and ψ_t is the markup over the wholesale import price. Here, the imported goods inflation is explained by previous period inflation, expected future inflation and the LOP gap. The gulf between the international prices and the domestic retailing prices of imports establishes the mechanism for an incomplete pass-through in the short run where

[13] The common practice in the open economy literature is to assume total exchange rate pass-through, that is, the law of one price holds. Recent studies for developing economies confirm imperfect pass-through into domestic prices: see, for example. Adebayo and Mordi (2011) for Nigeria and Mwasse (2008) for Tanzania.

the domestic economy responds to changes in import prices. Log-linearization of equation (40) around its zero-steady state yields a type of NKPC for domestic import retailers:

$$\pi_{\mathrm{F},t} = \beta(1-\theta_F)E_t\pi_{\mathrm{F},t+1} + \theta_F\pi_{\mathrm{F},t-1} + z_F\psi_t \tag{41}$$

where $z_F = \dfrac{(1-\beta\theta_F)(1-\theta_F)}{\theta_F}$. We can also derive the log-linearized version of the overall CPI inflation, which is a weighted average of domestic and imported inflation:

$$\pi_t = (1-\alpha)\pi_H + \alpha\pi_F \tag{42}$$

3.6 Equilibrium in the goods market

In the domestic economy, for the goods market to clear it must be the case that what is produced in the economy is equal to the sum of local consumption and foreign consumption of locally produced goods (home economy's exports):

$$y_t = (1-g_c)(1-\alpha)c_{\mathrm{H},t} + \alpha c^*_{H,\mathrm{t}} + g_c g_t \tag{43}$$

Given the fact that $C^i_{H,t} = (1-\alpha)\left(\dfrac{P_{H,t}}{P_t}\right)^{-\eta} C^i_t$ and $C^*_{H,t} = \alpha\left(\dfrac{P_{H,t}}{\varepsilon_t P^*_t}\right)^{-\eta} C^*_t$, the log-linearization of the two demand functions yield:

$$\begin{aligned} c^i_{H,t} &= (1-\alpha)[-\eta(p_{H,t}-p_t)+c^i_t] \\ &= (1-\alpha)[\alpha\eta\,\mathrm{s}_t + c^i_t] \end{aligned} \tag{44}$$

$$\begin{aligned} c^*_{H,t} &= \alpha[-\eta(p_{H,t}-\mathrm{e}_t - p^*_t)+c^*_t] \\ &= \alpha[-\eta(p_{H,t}-p_{F,t}-\psi_t)+c^*_t] \\ &= \alpha[\eta(\mathrm{s}_t+\psi_t)+c^*_t] \end{aligned} \tag{45}$$

where $i \in (r, nr)$ identifies each category of household.

Plugging equations (44) and (45) back into the market clearing condition given in equation (44) we get:

$$y_t = (1-g_c)(1-\alpha)[\eta\alpha s_t + c_t] + \alpha[\eta(s_t+\psi_t) + c_t^*] + g_c g_t$$
$$= (1-g_c)(1-\alpha)c_t + \alpha c_t^* + (1-g_c)(2-\alpha)\alpha\eta s_t + \alpha\eta\psi_t + g_c g_t \quad (46)$$

where the demand for locally produced output increases with domestic household and government consumption spending, world demand, and improvement in the terms of trade.

3.7 Monetary and Fiscal Policy Rules

The standard tradition of modeling the monetary sector in the small open economy literature is to assume an interest rate feedback rule that describes the monetary policy behaviour in response to endogenous changes in key macroeconomic fundamentals. In this setting, central banks set short-term nominal rates conditional on the degree of departure of inflation, output and sometimes the exchange rate from their targets. Such monetary policy stance usually adopts a variant of the famous Taylor rule and is defined by the following reaction function:

$$r_t = \rho_r r_{t-1} + [\gamma_1 \pi_t + \gamma_2 \Delta y_t] + \upsilon_t^i \quad (47)$$

where υ_t^i captures unanticipated monetary policy innovation in the small open economy; γ_1 and γ_2 are the relative weights on inflation and output growth. The lag of the nominal interest rate is included in the monetary policy feedback rule to account for possible persistence in the evolution of the interest rate.

In view of the issues raised by Mishra et al. (2010), we recognize that the standard reaction function rule is not well-suited in describing the central bank behaviour in poor subsistence economies. As a result, we follow O'Conell and others (2009), Berg and others (2010) as well as Shen and Yang (2012) and adopt a monetary policy framework in which money plays a role consistent with the monetary aggregate targeting practice in many low income countries.

Regarding the activities of the fiscal and monetary authorities, the following relationships have been adopted consistent with the practice in low-income countries where the central bank relies on targeting monetary aggregates along with foreign exchange intervention as the main instrument to stabilize inflation and the output gap. However, it is assumed that public spending is exogenous as the fiscal policy process mainly responds to solving structural deficiencies such as the removal of infrastructural bottlenecks regardless of the state of the economy.

$$\mu_t^m = \rho_m \mu_{t-1}^m - k_{i,\pi}\pi_t - k_{i,y} y_t - v_t^m \tag{48}$$

$$\mu_t^m = m_t - m_{t-1} + \pi_t \tag{49}$$

$$m_t = y_t - \rho_i r_t^n \tag{50}$$

$$ir_t = x_1 e_t + x_2 (e_t - e_{t-1}) \tag{51}$$

$$g_t = ARg_{t-1} + g_y y + g_b b + v_t^g \tag{52}$$

$$t_t = t_y * y + t_b * b \tag{53}$$

$$b = b_{t-1}(1 + i - \pi_{H,t}) + g_t - t_t \tag{54}$$

Equations (48) and (49) indicate the money growth process while (50) describes the monetary equilibrium condition where the demand for nominal money balance depends on real income and the nominal interest rate. Following Sarno and Taylor (2001), the intervention in foreign exchange market is summarized by equation (51) where ir is the level (in log-deviation) international reserves representing purchases of foreign currency by the central bank. The intervention responds both to the level and depreciation of the nominal exchange rate. The parameters x_1 and x_2 take negative values and measure the extent to which the central bank reacts to the level and depreciation target, which is consistent with a policy of leaning against the wind (Sarno and Taylor). When these parameters are fixed at zero, the rule is compatible with a fully flexible exchange rate system while for non-zero values it closely mimics a managed currency regime. The last three equations capture the law of motion for public debt as well as the fiscal policy process with spending and taxation rules responding to deviations of output and debt from their steady states. I assume that taxation is procyclical with respect to output and debt while spending is procyclical with respect to output and countercyclical with respect to debt.

4 Empirical Analysis

This section starts by describing the calibration of the model parameters for the Ethiopian economy. The non-stochastic subjective discount factor β is set to 0.99, which amounts to a steady state riskless short-term interest rate of 4 percent. The inverse elasticity of consumption σ and labour supply φ are fixed at 3 and 4, respectively. The Calvo price stickiness parameters for both the domestic θ_H and imported θ_F goods sectors are assumed to be the same and each takes a value of 0.75, which is compatible with an average price rigidity of about four quarters or one year. The elasticity of substitution between imported and locally sourced goods is assumed to be 0.85. We set the degree of habit persistence h for saving households to 0.25 in view of the modest habit maintenance in low-income communities. Based on historical average for the period 2000.1 to 2013.4, we set the fraction of public purchases of goods and services relative to GDP to 0.22. Similarly, the degree of openness α is fixed at 0.31 consistent with the average import/GDP ratio for the same period. The home economy's debt elasticity χ with respect to its net foreign asset position takes a value of 0.01, which suggests that a one percent fall in the net foreign asset position induces a 0.04 percent increase in the external borrowing premium on annual basis.

The choice of the size of subsistence households is not immediately verifiable. There is no consensus in the determination of its value as estimates for developing countries are quite scarce. There are two options to consider. The first is the percentage population which lives under the World Bank delimited poverty line of 1.25 dollars per day. The records of the ministry of finance and economic development of Ethiopia show that this figure is around 27 per cent in 2014. The second is to rely on the global multidimensional poverty index (MPI) reported by the Oxford Poverty and Human Development Institute which takes into account multiple factors including access to health, education, electricity, safe drinking water, and sanitation among other qualities other than income. Based on this index the proportion of the population classified as multi-dimensionally poor is about 95 percent while those classified as destitute is close to 70 per cent. The first approach underestimates the extent of liquidity constraint while the second appears to overstretch it. Because of this huge discrepancy between the two measures, we seek a middle ground and set the fraction of hand-to-mouth households to 0.50.

On the monetary policy front, we chose the central bank weight on inflation to be 1, consistent with the observed reality that Ethiopia's monetary authorities tend to entertain considerable inflation aversion. Similarly, the weight attached to output gap is set to 0.11, reflecting the relatively high level of unemployment/output gap in the country and the relatively less aggressive response to it. In the fiscal feedback rules, both taxation and spending elasticity parameters with respect to output are fixed at 0.42 and the parameters with respect to debt are set to a value of 0.02.

Finally, the persistence parameter values for the shock processes are fixed as follows: total factor productivity at 0.95; monetary policy at 0.8; fiscal policy at 0.95; terms of trade at 0.65; nominal exchange rate at 0.65 while foreign output, inflation, and interest rate each takes a value of 0.45. See Appendix A for the complete list and corresponding sources of calibrated parameters.

Figure 1: IRFs to productivity shock

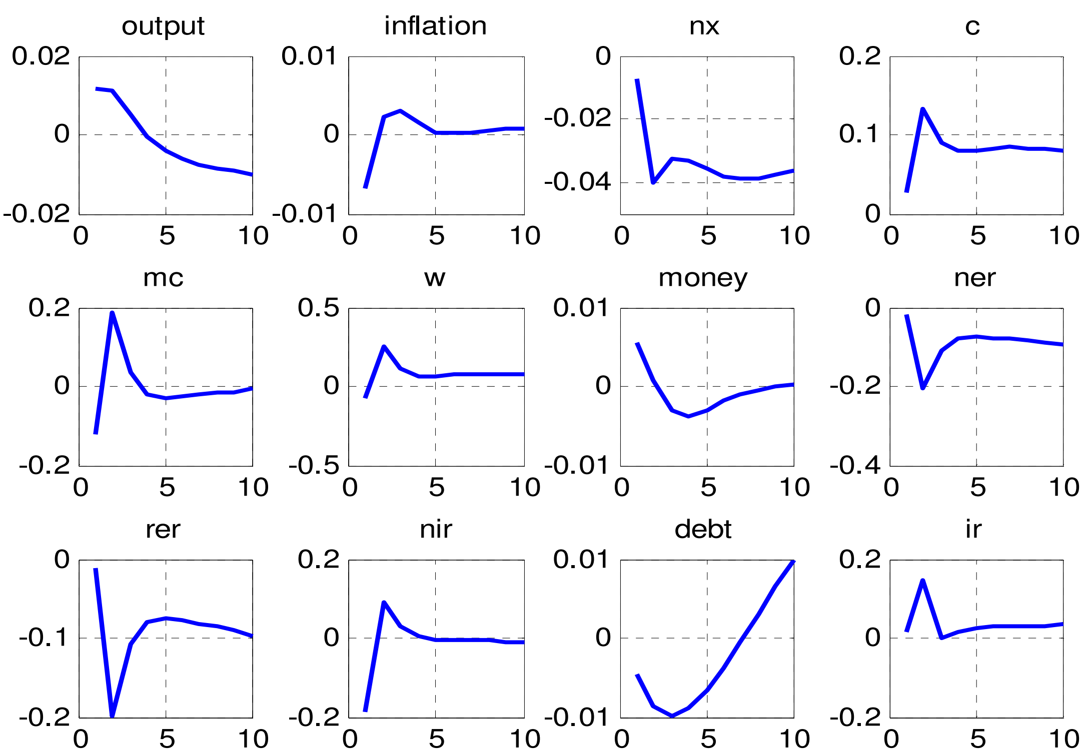
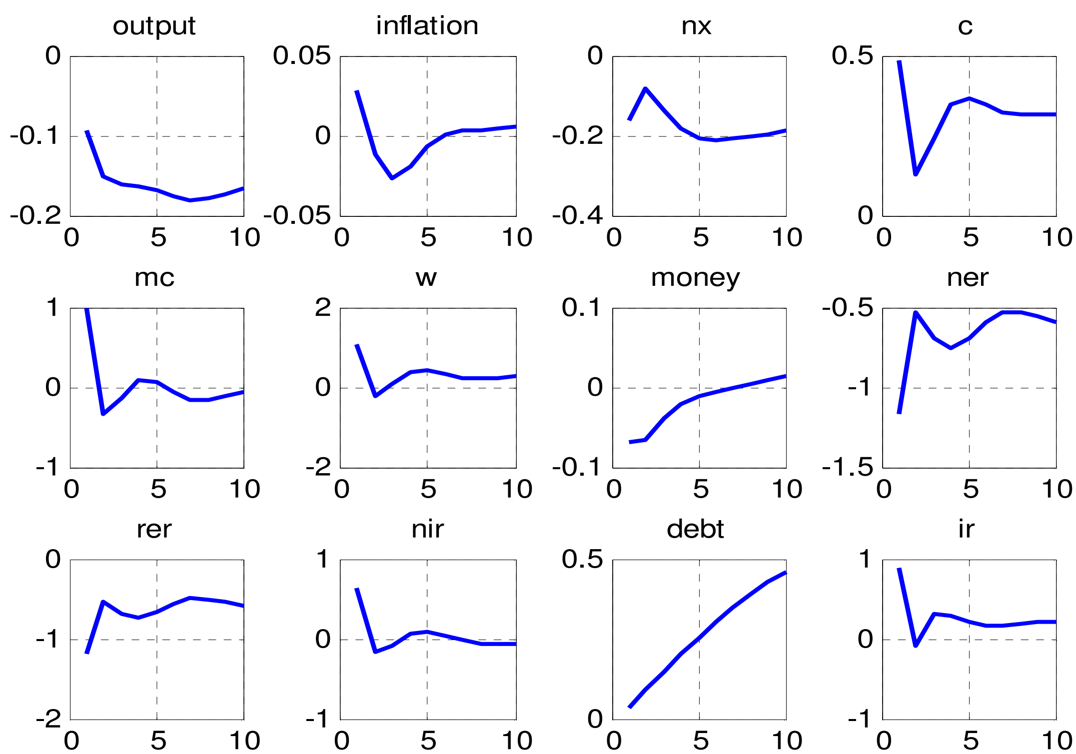


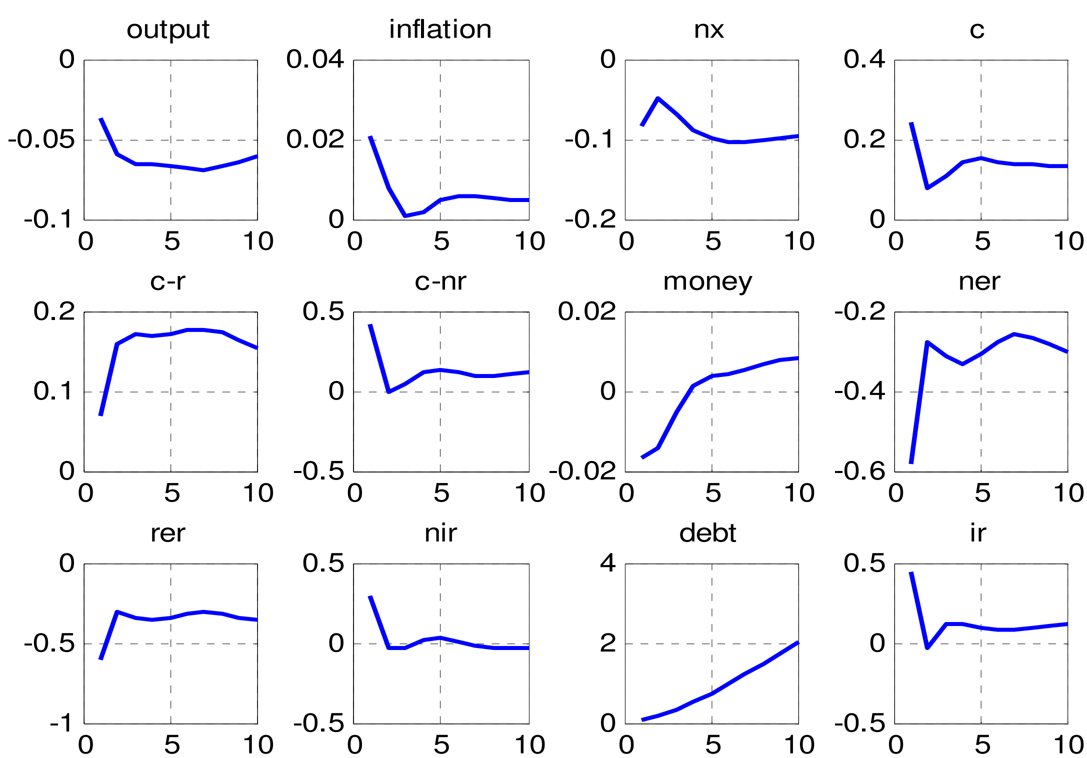
Figure 1 displays the impulse response functions of selected endogenous variables to exogenous productivity shock. In conformity with existing empirical evidence, unanticipated positive technological development generates expansion in output and consumption as well as a decline in public debt. Technological progress reduces the marginal cost of production on impact and inflation falls. Net export deteriorates due to appreciation in the nominal and real exchange rates. This line of interpretation is compatible with the Balassa-Samuelson hypothesis that predicts strong national currency along with increased specialization and sophistication in the domestic economy. As inflation gets stronger over time due to higher real wages and marginal cost, the central bank would reduce the supply of money and the nominal interest rate tends to rise. Moreover, the monetary authority responds by boosting its purchase of foreign currency in order to arrest the appreciating nominal and real exchange rates.

Figure 2: IRFs to Monetary Policy Shock



It is true that central banks can influence the path of key macroeconomic variables in the economy. As Figure 2 suggests net export and output fall following policy tightening by the monetary authorities. Inflation rises on impact but declines in the next few quarters but the decline in inflation is much less pronounced than the decline in production, which appears to mimic the ‘price puzzle’ observed in VAR analyses. Both nominal and real exchange rates appreciate in response to a surprise reduction in the stock of money growth rate and this triggers a surge in imports, a decline in exports, causing net export to decrease significantly. In the external sector, prices (both nominal and real) as well as quantities exhibit persistent responses. Despite the immediate increase in the aftermath of policy tightening, nominal interest rate appears unmoved by central bank actions consistent with the observation of “interest rate stickiness” in low-income countries. The real and nominal exchange rates appreciate following liquidity withdrawal from the model economy and the central bank tries to prevent further appreciation by increasing its purchases of foreign currency in the exchange market.

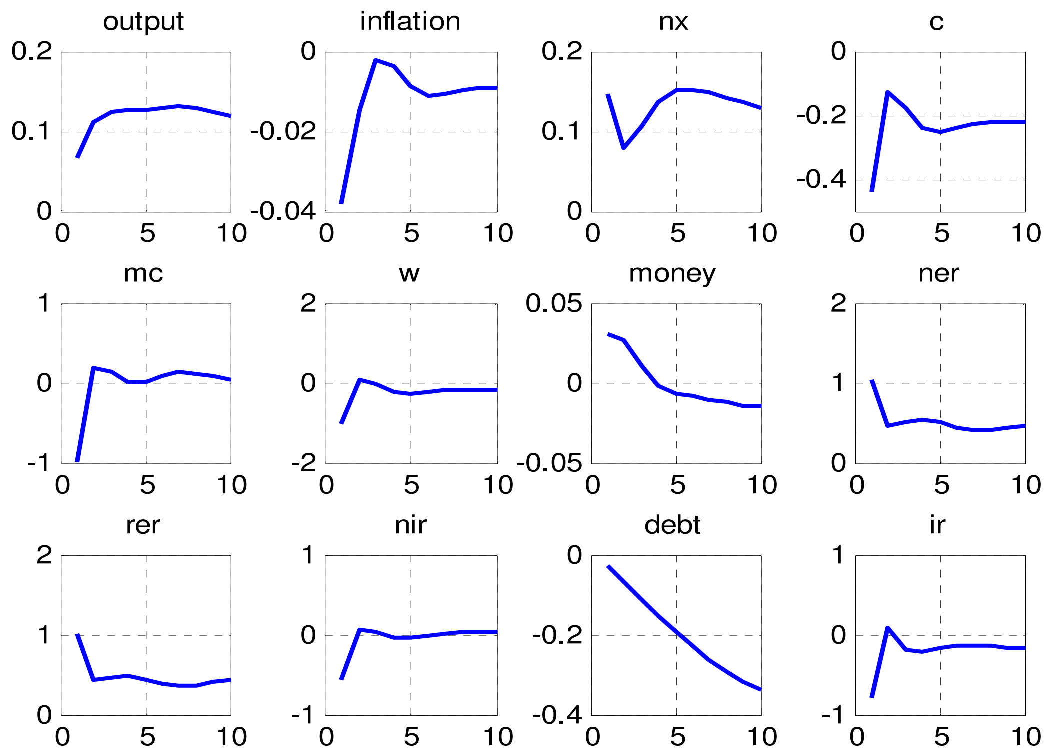
Figure 3: IRF to Fiscal Policy Shock



As captured in Figure 3, a positive shock to general government consumption spending causes a decrease in output and a persistent increase in the consumption of saving and liquidity constrained population. Theory predicts that rational forward-looking agents correctly anticipate the implication of current fiscal policy actions and they retrench their spending to set aside enough money in order to meet future tax obligations. Here, however, both Ricardian and non-Ricardian consumption profiles increase over time suggesting that accumulating government debt benefits both the rich and the poor in the short run. Nevertheless, the benefits are distributed asymmetrically. The consumption of saving households is higher and more persistent than their liquidity constrained counterparts. This is consistent with Mankiw's (2000) observation that high debt incurred by the public sector raises income and consumption inequality in equilibrium. The idea is that a higher level of debt induces a higher level of taxation for interest payments on the debt. The tax obligation affects both rich (who are the savers) and poor households but the savers are the sole beneficiaries as they collect interest payments from the fiscal sector. Moreover, in conformity with the fiscal theory of price level, increasing deficit financing raises inflation and the value of the exchange rate, which in turn reduces net export, inflates the debt stock, and shrinks output. In order to arrest inflation, the monetary authorities respond by withdrawing liquidity and to tackle the problem of currency appreciation, they intervene in the exchange market by increasing the purchase of foreign currency.

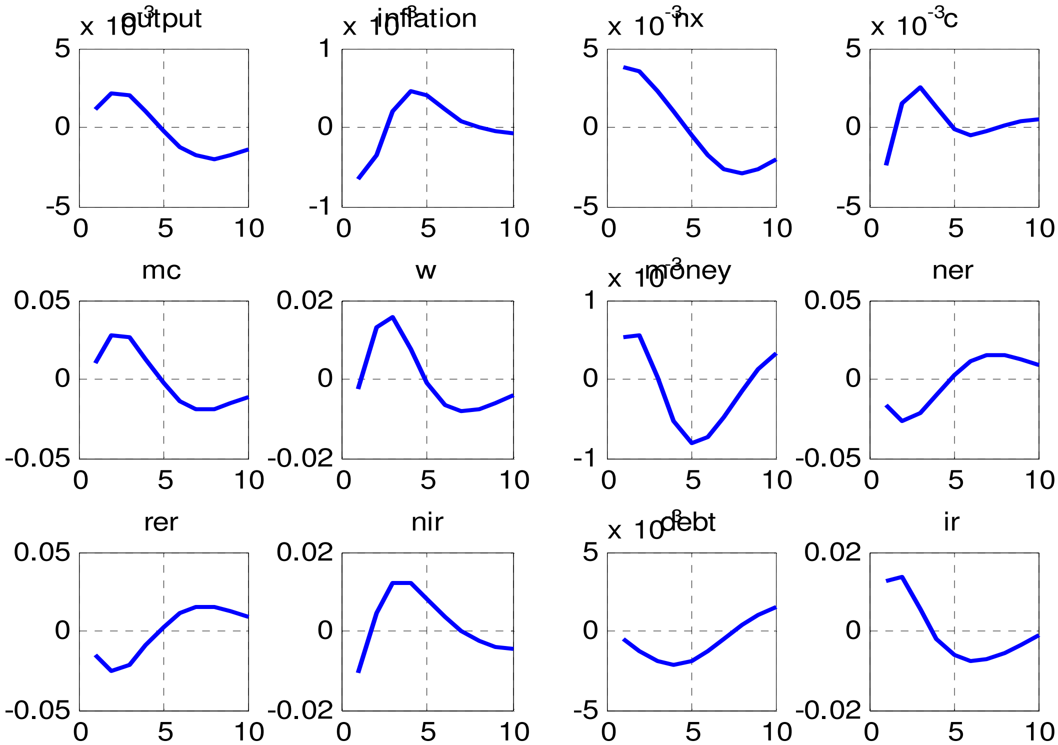
The positive co-movement between price and output in response to demand shocks and negative co-movement in response to supply shocks is common in empirical research. In figure 3, however, we observe that output falls and inflation rises following sudden increase in government spending. There are several explanations to this phenomenon. First, positive co-movement between prices and output to demand shocks is not necessarily the case when government spending is wasteful (i.e. when spending occurs on consumption only). For instance, Algozhina (2012) built a small open economy DSGE model for an emerging nation calibrated based on Hungary data. In the paper, the author distinguishes between productive investment and wasteful consumption made by the fiscal authority. Not surprisingly, the simulation results show that price and output increase (positive co-movement is maintained) when public expenditure is productive and adds to the capital stock. By contrast, output persistently declines and inflation rises following a shock to wasteful government spending programme. This finding by Algozhina appears to be confirmed by the simulation exercise I performed in this chapter, which also relies on non-productive public spending. Moreover, such contradictory findings are quite common. Furlanetto (2006) has also documented an increase in output, a decline in inflation and interest rate, and a fall in the exchange rate after allowing positive public spending in the production function.

Figure 4: IRF to Nominal Exchange Rate Shock



The impact of nominal exchange rate depreciation on prices and output remains a major academic battleground for economists despite decades of rigorous theoretical treatment and empirical research. Figure 4 depicts that a fall in the nominal exchange rate (positive shock) results significant and persistent increase in net export and output. Consumption, however, declines. One possible explanation is that weak currencies make imports very expensive and this reduces the import content of consumption while expanding output through increased next export. To the extent that expansion in output is persistent, it relieves price pressure and as a result wages and the marginal cost of production remain subdued. With inflation staying low, and despite the persistent depreciation in the nominal exchange rate, the central bank has now some room to inject additional liquidity. Additional liquidity injection along with the fall in the exchange rate further encourages production and output increases substantially. The foreign exchange intervention now tries to limit further depreciation in the exchange rate by shrinking available reserves and selling them in the money market.

Figure 5: IRF to Terms of Trade Shock



The terms of trade is an important relative price especially in the context of commodity exporting economies like Ethiopia. Unexpected positive shock to the terms of trade makes domestic exports more attractive in the eyes of foreign buyers and this raises net export and output. The persistent increase in output reduces inflation modestly which enables employers to offer higher wages and consequently the marginal cost of production increases. Over the short run, this competitive advantage declines as both the nominal and real exchange rates appreciate due to an increase in the terms of trade (imported component) of the overall consumer price inflation. The real value of the national debt also falls as a result of appreciating domestic currency and stronger exports. Consistent with the bigger weight attached to inflation by the monetary authority, the path of liquidity supply tends to mimic the inverted movement of the Phillips curve. The nominal interest rate also imitates the inverted movement of money supply as the former rises when the central bank reduces the quantity of the latter (and conversely the former falls as the central bank injects more liquidity into the national economy).

Figure 6: IRFs to Exogenous Foreign Output

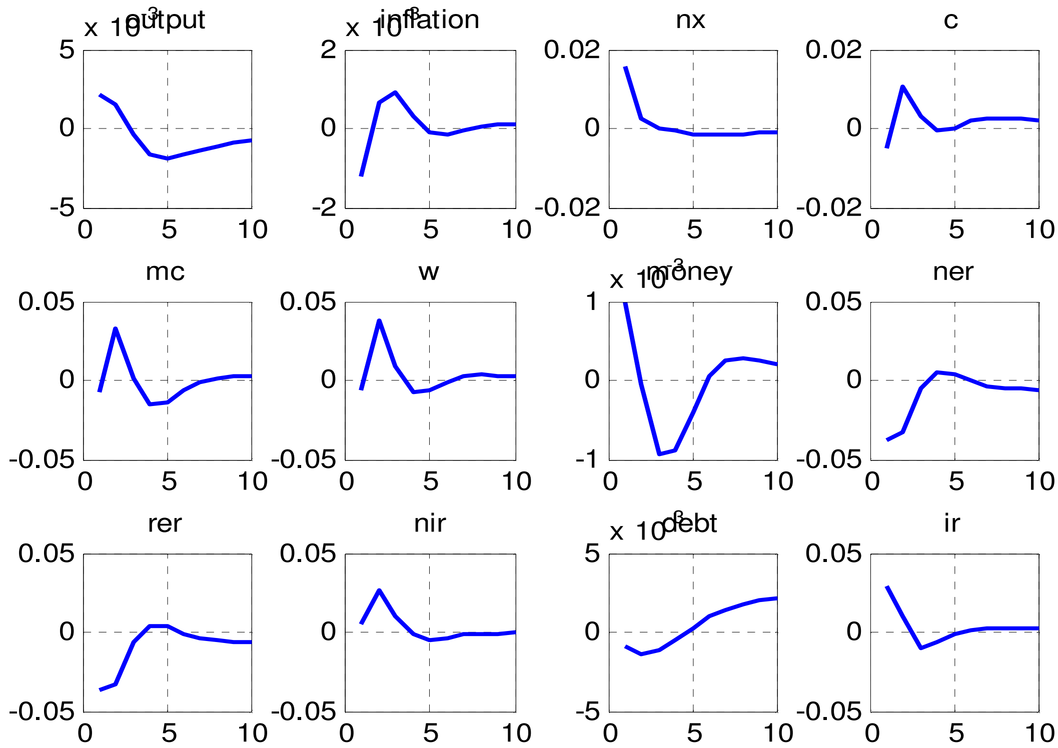
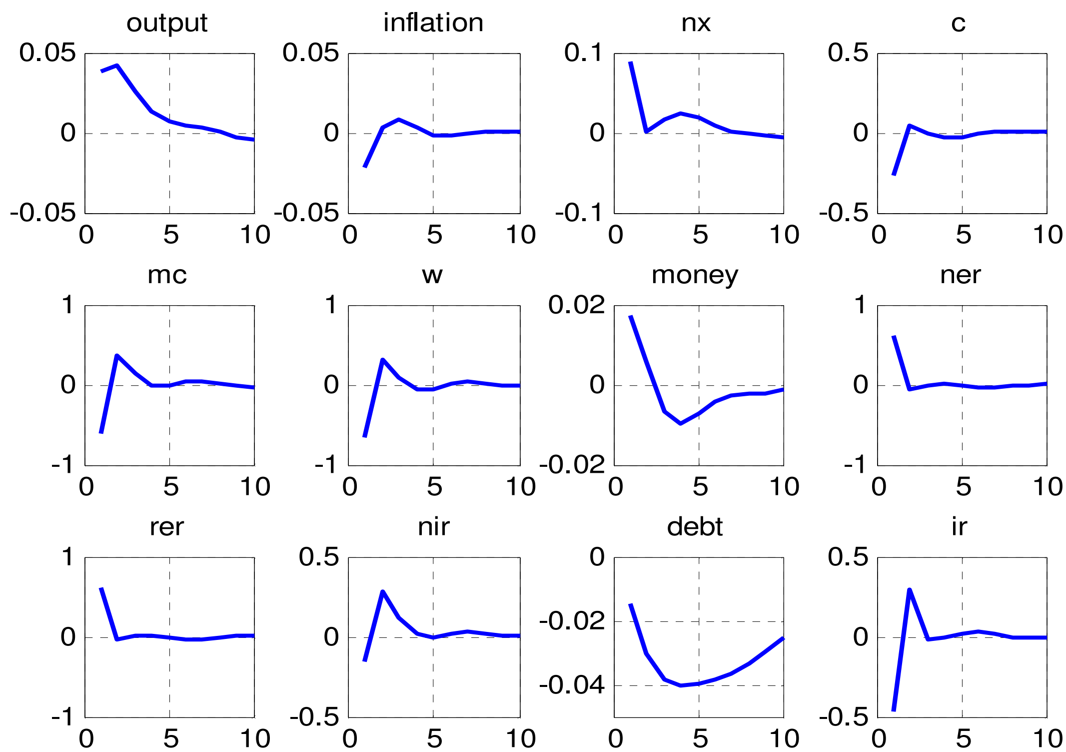


Figure 6 shows that the small domestic model economy is sufficiently wedded with the rest of the world. A rise in foreign output increases domestic production via increased demand for the country's exports. As a result, when foreign income prospects improve, output and next export increase. Improved current account position from better trade performance has a tendency to put upward pressure on nominal and real exchange rates. The central bank then responds by injecting more liquidity in the first few quarters to accommodate the new influx in export receipts. This measure attempts to prevent further appreciation in the exchange rate and to improve the international competitiveness of local exporting firms. The higher export performance also improves the ability of the domestic economy to pay off part of its debt as well as to offer higher wage compensation. With the exception of the next exports, nominal and real exchange rates, all other variables display considerable persistence in their response to foreign output shock. When inflation picks up because of rising wages and marginal cost, the central bank withdraws liquidity and the nominal interest rate rises in line with the conventional feedback rule maintained so far.

Figure 7: IRFs to Exogenous Foreign Interest Rate Shock



The impulse response function plots of key variables to the foreign monetary policy shock are shown in Figure 7. The reaction of output is stronger and somewhat more persistent compared with its response to exogenous foreign income shock. On impact, net export and aggregate production increase following unanticipated increase in the global interest rate. The higher world interest rate generates capital outflow which in turn causes the exchange rate to depreciate over the medium run. In the short run, the central bank expands its sales of foreign exchange to contain the falling domestic currency; overtime, however, the bank rebuilds its reserves and the exchange rate returns to its long run equilibrium value.The spike in world interest rate slightly reduces domestic debt (by 0.04 upon maximum) mainly due to the surge in exports (by 0.08 upon maximum) and this improves the external financial position of the government to pay off part of its financial obligation. However, declining exchange rate means that it inflates the local currency value of the national debt and the reduction in the level of debt is reverses its course after the fifth quarter. The competitiveness of the national economy as proxied by the real eaxchange rate measure improves largely because of the significant decline in the marginal cost, wages, and inflation in the short run. Thus weaker domestic currency triggered by a rise in world interest rate tends to improve export revenue in the short run.

Before concluding it is worth commenting on the significance and effectiveness of uncertainty when an economy is operating in direct interaction with foreign consumers, investors, and governments. Ilzetzki et al. (2013), for instance, suggest that fiscal multipliers are comparatively bigger for economies with predetermined exchange rate regimes but is zero for economies with flexible systems; public spending multipliers are smaller in open economies than they are in autarkic counterparts; and that fiscal multiplies in highly indebted economies are negative. The effects of exchange rate movements, capital mobility across countries, asset price and interest rate fluctuations in overseas economies can also be important constraints when setting fiscal and monetary policy objectives in the domestic economy.

In Figure B1 reported in the appendix, I present the comparative dynamic responses of inflation and output under closed and open economy settings with money growth rule. Monetary, fiscal, and productivity shocks are considered. Clearly, production and price changes respond significantly differently in the two models. Firstly, when the economy is subjected to adverse monetary policy shock, output hardly falls in the closed economy while inflation rises on impact and declines subsequently. In the open economy, however, we see significant and relatively more persistent reduction in output and a rise in inflation on impact following unexpected monetary tightening. A sudden withdrawal of liquidity by the central bank increases the cost of consumption via the Euler equation and this reduces output and the fall in production will extert upward pressure on prices and inflation increases on impact. Secondly, a positive shock to total factor productivity increases production and lowers inflation in both closed and open economies, with much more pronounced movements in the former. This result indicates that eventhough the model with money growth rule is relatively better in replicating the negative co-movement between prices and output, the open economy version (as in the Taylor rule based counterpart) has difficulty in accentuating this negative co-movement. Thirdly, in response to positive fiscal shock output increases in the closed economy while it falls permanently in the open economy setting. The fact that the responses are relatively stronger under autarky appears to confirm the findings of Iltezki et al. (2013) who suggest bigger multipliers in self-sufficient, closed societies. The opposite applies to inflation: it increases when the economy is open and decreases under autarky. Thus the fiscal theory of price level holds up strongly when the spending occurs in an open economy framework. When the economy is closed, a rise in public expenditure only causes an increase in the short term interest rate (a reduction in liquidity) and the drop in output can be checked because of the increase in consumption by rule-of-thumb households.. But when we open up the economy to the rest of the world, the increased government spending also causes the exchange rate to appreciate and this reduces net export and output. Despite the presence of liquidity-constrained consumers—to the extent that the fall in net export is relatively significant--the decline in output should be bigger in open economies and inflation increases.

Finally, Figure B2 presents a similar comparison as discussed above but this time I stick to an open economy setting under alternative monetary policy instruments and consider an additional exogenous shock emanting from unexpected depreciation in the exchange rate. The predictions from both models are broadly similar, especially with respect to monetary policy, exchange rate changes, and public spending adjustment.[14] With regard to positive productivity shock, however, the model with interest rate feed back rule generates a decline in output and an increase in inflation, which are at odds with conventional empirical regularities. Such contradictions are not uncommon when standard Taylor-rule based DSGE models are modified to accommodate implications of certain desirable theoretical arguments in the context of general equilibrium models. For instance, Furlanetto (2006) experimented with introducing productive public spending (government investment expenditure in the production function) as a clear departure from exogenous fiscal feedback rule. In response to a positive fiscal shock, while many of the standard results were maintained, there were some contradictory findings including a decline in prices and the interest rate, a depreciation of the exchange rate and an expansion in trade surplus. Another and more relevant example of such inconsistent results is from Ramayandi (2008). This paper estimated small open DSGE model for five Asian economies, namely, Indonesia, the Philippines, Thailand, Singapore and Malaysia using Maximum Likelihood method. The paper has several similar features related to this study except that I depart from Ricardian equivalence, perfect capital markets, and interest rate rule. One observation is that the response of output to positive technology shock could be sensitive to the value of the invese elasticity of substitution parameter. Rayamandi

[14] All parameters are the same for both models. The only exception is that in the model with Taylor rule the fraction of rule-of-thumb households was set to 0.28 instead of 0.5 to avoid indeterminacy.

found that the estimated values for this parameter were 0.86 for Indonesia, 0.32 for Malaysia, 0.09 for the Philippines, 0.17 for Singapore, and 0.74 for Thailand. While the response of output to positive technological shock was positive for Indonesia, Malaysia, and Thailand, it was negative for the Philippines and Singapore, two countries with by far the lowest values for the inverse elasticity of substituition parameter. The findings in Rayamandi (2008) also suggest that the lowest value of the inverse elasticity parameter (0.09 for the Philippines) is associated with the biggest drop in output (0.37%) compared with Singapore with a parameter value of 0.17 and a drop in production equal to about 0.1%.

Overall, contradictory results in general and the negative reaction of production to positive productivity shock in particular are quite common in Taylor-rule based DSGE models, especially as one moves from baseline specification to relative complication. In regard to this study, I tried experimenting with different values for the inverse elasticity of substituition parameter and was able to generate positive response of output to positive technology shock. However, this was achieved at the expense of contradicting other established results. So one key message of this paper is that in interest rate rule based DSGE models further modification could compromise certain established relationships and that this could be interpreted as one major shortcoming of general equilibrium methods.

Another implication of Figure B2 is that the model with money growth rule produces plausible results even though the respones are relatively more muted. Moreover, it is apparent that the Taylor interest rate reaction function appears to imply more prounounced and relatively more volatile respones to all shocks under consideration. This need not be the case when the monetary authorities rely on monetary aggregates as their policy instruments. One important implication is that the model economy with money growth rule is less powerful in amplifying and propagating the expantionary or contractionary effects of unexpected changes in fiscal polcy, monetary policy, technological progress, and exchange rate movements. For instance, this would mean that a central bank regulating some measure of monetary stocks should not expect (fear) as much expansion (contraction) in output following currency devaluation (liquidity withdrawal) as a sister central bank that relies on an interest rate feedback rule. Thus, these results imply that general equilibrium models with variants of Taylor rule may not offer appropriate guidance for policy wonks who seek to balance internal and external constraints when formulating policy measures and setting broader macroeconomic objectives.

Thus, the stronger and more persistent transmission mechanism under the Taylor rule is only representative of advanced industrial economies with efficient asset and bond markets as well as with flexible exchange rate regimes and independent central banks. As emphasised by Mishra et.al. (2010) these conditions are hardly existent in emerging and developing economies targeting monetary aggregates; hence the relatively weaker responses of output and inflation in the model with money growth rule.

4.1 Parameter Bifurcation Issues

One major problem with DSGE models is "parameter bifurcation"—the idea that small smooth changes in parameter values lead to signifcant changes in the impulse response results of our endogenous variables. While it is virtually impractical to check the sensitivity of the results to every parameter, I have assessed how sensitive the results are to variations in the values of policy parameters, namely, those in the central bank reaction function rule, the public spending rule, and the taxation rule. The impulse response functions were overall robust to such small changes in the policy variables.

5 Conclusion

This paper develops a small open low-income economy New Keynesian model that reflects the existence of imperfect capital market, a role for liquidity constrained consumers, and a monetary policy regime relying on monetary aggregates. The results suggest that the open economy setting reveals stronger transmission mechanism for monetary policy shocks while autarky is more effective (from the view point of the policy maker) in propagating shocks emanating from the fiscal authority. Another key result from the simulation exercise suggests that the model economy with money growth rule is substanially less powerful for the amplification and transmission of exogenous shocks originating from governemnt spending programmes, monetary policy, technological progress, and exchange rate movements. For instance, this would mean that a central bank regulating some measure of monetary stocks should not expect (fear) as much expansion (contraction) in output following currency devaluation (liquidity withdrawal) as a sister central bank that relies on an interest rate feedback rule.

As final remarks to this chapter, it is importatnt to point out the main limitations of this study and directions for future research.

The first weakness can be outlined in the context of general equilibrium models which for instance assume endogenous labour supply decisions. It could well be true that households increase their work hours through moonlighting and other productive engagements. But the idea that workers consciously balance the trade-offs between leisure and supply and that unemployment is voluntary could hardly pass the sniff test of empirical regularities. In the middle of the great financial crisis that broke out in 2008, desperate, jobless men and women around the world were seen actively protesting against their governments for failing in assisting them out of the bad labour market situations. The participants of the Occupy Wall Street movement in the U.S., the indignant in Spain, and the Aganaktismenoi in Greece clearly demonstrated that most people do not choose to become voluntarily unemployed. Trying and incorporating exogenous labour supply decisions is a good option for future research.

Second, the money growth rule implemented in this study is based on money market equilibrium conditions and assumes that the monetary policy makers formulate monetary aggregates based on the full knowledge they have about the current state of the economy. As emphasised by Berg et.al. (2010) and O'Connell (2011), quite often monetary authorities need to take actions without a complete understanding of the current state of the economy. In view of this observation, future studies can augment the current analytical framework employed in this chapter by allowing for monetary policy instruments that account for the existence of incomplete information in the policy formulation process.

Third, calibration has been the main methodology implemented in this chapter because of insufficient higher freqency data for low-income countries. Overtime, when more data points are available, future reseachers can try to estimate the model through a variety of methods including maximum likelihood, bayesian and generalized method of moments. Estimated parameters will provide a better benchmark for analyzing the behaviour of low-income economies when subjected to internal and external shocks.

Finally, it is important to acknowldege the limitations of DSGE models in business cycle analysis. Reality could and should be very different from what is portrayed via such optimization based models. As argued by Joeseph Stiglitz in his book 'The Price of Inequality,' class allegiance maybe more important than economic reasoning, say, when the central bank wants to smooth fluctuations over the business cycle. If Stiglitz is right, then decisions that concern the enforcement of fiscal discipline and liquidity management issues mainly reflect commitments to particular ideological positions (such as blind faith in the wonders of the free market). Such arguments indicate that economic life is neither linear nor log-linear and that we need to look well beyond approximated equations to get a good sense of the actual operation of our intricate economic systems. If , for instance, it is true that lop-sided distribution of economic resources is responsible for the delayed recovery and protracted unemployment that we witnessed globally in the past decade, then reducing the short term interest rate and keeping it at a low level might not be the appropriate response to the crisis. Policy proposals that aim at progressive taxation in the short run and expanding equality of opportunity over the long run appear better tools in such situations. In any case, if income inequality is the problem that prevent quick recovery, using short term interest or money growth rates is not a good idea in responding to the recession in the model economy. It gives a false or misleading impression that the central bank is fighting joblessness by lowering the policy rate (or by expanding the monetary base) when such instruments have little relevance in practice.

In conclusion, while DSGE models are interesting as alternative analytical frameworks, it is important to recognize their weaknesses including those outlined above. They can and must be used in combination with other approaches that fill the gap left by general equilibrium models.

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Appendix A

Table A1: Current Account (2005-2012), Nominal Exchange Rates per American Dollar (2001-2014), and Illicit Financial Flows (IFFs) rankings for Selected African Countries

Country	Currency Per US Dollar 2001-2014		CA/GDP 2005-2012		Rate of Change		IFF Rank 2003-2012
					Currency	CA	
Burundi	830.35	1544.69	-0.5	-10.3	86.3%	1,960%	122/145
Djibouti	177.72	177.72	+2.8	-10.9	0	489%	90/145
Ethiopia	**8.46**	**20.5**	**-12.6**	**-6.9**	**142%**	**+45%**	**39/145**
Ghana	**0.72**	**1.95**	**-10.3**	**-11.0**	**171%**	**7%**	**93/145**
Kenya	78.5 -	87.92	-1.3	-8.4	12%	546%	121/145
Madagascar	1317.7	2414	-13.8	-7.6	83%	+45%	83/145
Mali	733.04	494.41	-8.3	-2.6	+32%	+69%	85/145
Mauritius	29.13	30.62	-5.2	-7.2	5.12%	38%	110/145
Mozambique	20.7	31.35	-11.6	-42.5	51.4%	266%	118/145
Nigeria	111.2	158.5	+32.5	+4.4	42.5%	86%	10/145
South Africa	8.61	10.85	-3.1	-5.2	26%	68%	12/145
Sudan	**2.59**	**5.74**	**-9.3**	**-10.0**	**121%**	**8%**	**52/145**
Uganda	1755.56	2599.79	-0.1	-7.0	48.1%	6,900%	70/145

Table A2: Calibration values for consumer and firm related parameters

Parameter	Value	Description
α	0.31	Degree of openness
β	0.99	Subjective discount factor
η	0.85	Elasticity of substitution between locally produced and imported goods
θ_H	0.75	Calvo price rigidity for domestic goods
θ_F	0.75	Calvo price rigidity of imported goods
σ	3	Inverse elasticity of intertemporal substitution
φ	4	Inverse elasticity of labour supply
h	0.25	Habit formation in consumption
λ	0.57	The fraction of hand-to-mouth households

Table A3: Central bank and government related parameters

Parameter	Value	Description
φ_{π}	1	Central bank weight attached to inflation gap
φ_{y}	0.11	Central bank weight attached to output
x_1	-0.5	Foreign exchange intervention coefficient
x_2	-0.62	Foreign exchange intervention coefficient
χ	0.01	Sensitivity of risk premium to foreign bond holdings
ρ_c	0.22	Share of government spending in output
t_b	0.02	Sensitivity of taxation to debt (same but negative value for spending)
t _ y	0.42	Sensitivity of spending to output (same value for taxation)

Table A4: Persistence parameters

Parameters	Values	Description
ρ_a	0.95	Total factor productivity shock persistence
ρ_m	0.8	Monetary shock persistence
ρ_{miu}	0.8	Money growth persistence
ρ_g	0.95	Fiscal smoothening/persistence
ρ_{ex}	0.65	Exchange rate shock persistence
ρ_{tot}	0.65	Terms of trade shock persistence
ρ_{y*}	0.45	Ar(1) coefficient for foreign output
ρ_{i*}	0.45	Ar(1) coefficient for foreign interest rate
ρ_{pie*}	0.45	Ar(1) coefficient for foreign inflation

Appendix B

Figure B1: Impulse Response Functions of Output and Inflation under Autarky and Interaction with the Rest of the World

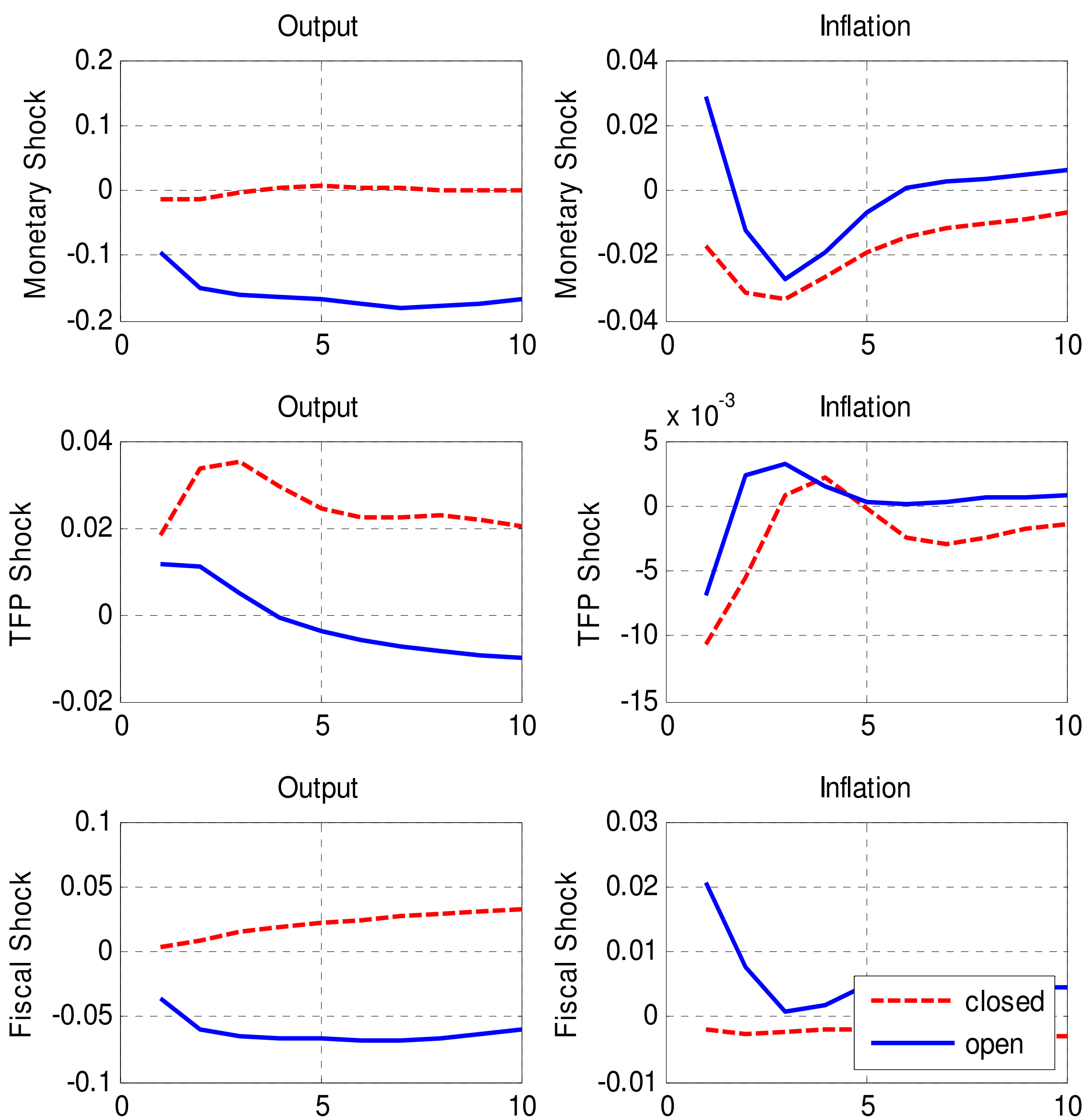
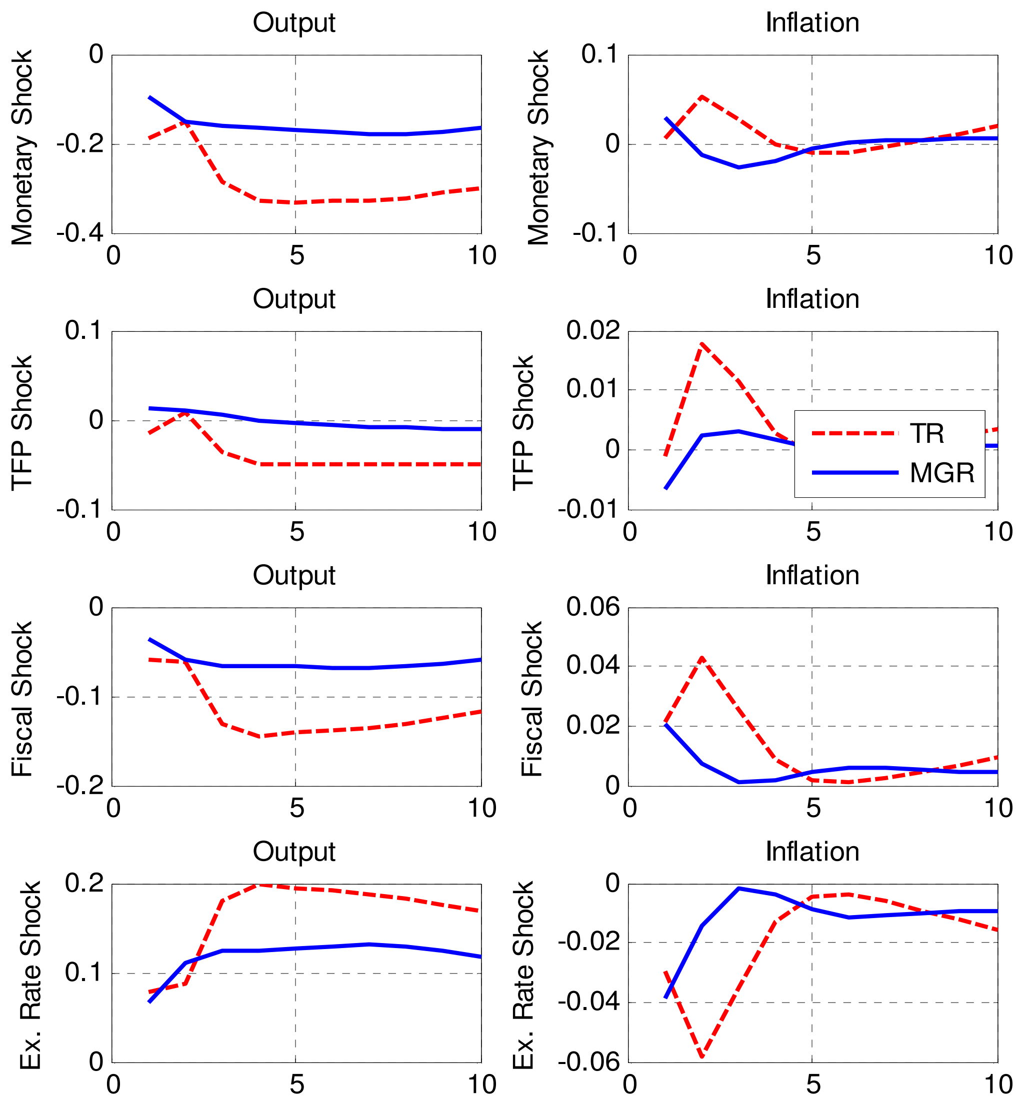


Figure B2: The Comparative Responses of Output and Inflation in an Open Economy with Taylor Rule (red dotted line) and Money Growth Rule (blue solid line)



CHAPTER 2

"Small Enterprises, Business Cycles, and Financial Frictions with Money Growth Rule"

1 Introduction

Over the past few years, applied research has attached due emphasis to the explicit role of the financial sector in amplifying and propagating disturbances into the real economy. The financial crisis that broke out in 2007 has spurred a wide range of investigations into the importance of banking and financial activities in shaping business cycle fluctuations. Previously, economic thinking was widely influenced by the Modigliani-Miller (MM) principle in which financial structure was irrelevant for both banking and non-banking business funding considerations. As a result, it did not matter whether a firm financed its investment opportunities by issuing bonds (debt) or shares (equity) and the valuation of the firm would be deemed independent of its capital structure.

However, the MM hypothesis rests on numerous suspicious assumptions that are incompatible with empirical evidence. Some of those assumptions include absence of distortionary taxation, symmetric distribution of information among transaction parties, efficient goods and financial markets, and zero bankruptcy costs. Since financial markets are perfect, there is no wedge between lending and borrowing rates, and in fact, there is no need for financial intermediaries as businesses can directly source their external funds from households. The MM principle, therefore, would rule out the monetary policy transmission aspects of bank asset and liability management as well as the effects of leverage ratio on business investment choices.

Theory and empirical regularities show that agency problems such as moral hazard and information asymmetry play a huge role in influencing access to credit and, therefore, the balance sheet structure of entrepreneurial firms, especially small and micro enterprises (SMEs). Stiglitz and Weiss (1981) have shown how existence of agency problems could generate credit rationing in which among observationally identical applicants some are offered credit and others are rejected. Thus applicants who are denied credit would not be able to get external funds even if they were willing to accept a higher interest rate than the one prevailing in the market or post more collateral than was required of eligible borrowers. Under such circumstances, banks would reconcile the supply of loanable funds with demand for credit not by raising the lending rate or demanding more collateral but by restricting the number of borrowers via rationing.

One important force behind the screening and filtering barriers erected by lenders is that agency problems can operate through the size of the borrowing firm.[15] Size can affect the capital structure of the firm because of the role of scale economies in reducing asymmetric information, degree of risk exposure, the extent of transaction costs, and access to market facilities. Smaller firms receive less capital or pay higher rates as it is relatively more expensive for them to solve informational problems with their potential creditors. This implies that the effect of size on financing structure should be more pronounced among start-ups as new firms are more informationally dense than their established counterparts. Moreover, to the extent that firm size is inversely correlated with risk, bankruptcy costs, and market barriers, this would discourage smaller firms from accessing outside financing options. Consequently, in light of these frictions and imperfections, the capital structure of firms and financial intermediaries could be vastly different from the one predicted by the MM principle.

Size is particularly relevant in the context of low income countries where small and micro enterprises (SMEs) have great potential in terms of employment creation as well as in their contribution to GDP but face significant barriers against access to finance.[16] The World Bank report on small and micro enterprise financing in Ethiopia (WB, 2015) confirms this observation. The report shows that in both manufacturing and service sectors, job creation is higher among established and older firms than under young businesses, suggesting a lack of competitiveness and innovation in the private sector. The retail and service sectors were also more important than manufacturing in job creation and employment. Regarding financial constraints, the report indicates small firms struggle the most in getting access to credit, smaller and young firms are more likely to be rejected for a loan or a line of credit, and that

[15] See Cassar (2004) for more detail on financing issues affecting business start-ups. Additionally, owner characteristics (level of education or experience), asset structure or collateral, legal organization (presence or absence of limited liability) and other factors can shape financing structure.

[16] For instance, under the five-year Growth and Transformation Plan (GTP), the government of Ethiopia recognized the industrial potential embedded in SMEs and it planned to generate more than 3 million jobs between 2010/11 and 2014/15,a goal which was realized by more than threefold by the end of July 2015.

SMEs are discouraged or willingly distance themselves from applying for loans due to prohibitive collateral requirements. The report also identifies a 'missing link' in which small firms are disproportionately affected compared with micro, medium, and large enterprises.[17]

In light of the practical credit market impediments faced by smaller firms, we construct a DSGE model with financial frictions to understand how limited business net worth affects the terms and conditions of credit contract as well as subsequent investment and production decisions. We consider frictions stemming both from the demand and supply side of credit markets.

2 Small and Micro Enterprises in Ethiopia

The vast majority of firms around the world belong to the class of micro, small- or medium enterprises (SMEs). In terms of enterprises, more than 95 percent fall into this category, but even in terms of employment in low- and lower-middle-income countries, more than 50 percent of employees work in companies with fewer than 100 employees (Ayyagari, Demirguc-Kunt and Maksimovic, 2011a). In the case of Ethiopia, the country's central statistical authority (CSA) identifies SMEs as either cottage and handicraft entities that conduct their activities manually and using manpower driven machines or establishments employing less than ten workers and using motor operated equipment. This definition, while easy to understand, has two major shortcomings. It solely focuses on manufacturing and ignores activities in other sectors of the economy. Moreover, it also fails to consider capital as a key parameter in the classification process.

The aforementioned gaps have been addressed in the revised 2011 federal MSE development strategy paper, which relies on the level of paid up capital and the size of labour employment. It also classifies SMEs by industry in addition to the size of seed money and asset stock. According to the new definition, micro enterprises are those business establishments that absorb at least five employees and their total asset value not exceeding Birr 100,000 if the firm is in the industrial sector (manufacturing, construction, and mining) or Birr 50,000 for a firm operating in the service sector (retailing, ICT, maintenance, and hotel and tourism). Similarly, businesses are considered small if they employ between six and thirty people with

[17] According to this report only 1.9 percent of small firms have loan or line of credit while the corresponding figures for micro, medium and large firms are 6, 20.5, 35.5 percent, respectively.

their maximum asset value being Birr 100,001-1,500,000 for manufacturing firms and Birr 50,001-500,000 for firms engaged in providing services.

Table 1: Definition of MSE According to the 2011 Federal SME Development Strategy

Level of the Enterprise	**Sector**	**Human Power**	**Total Asset in Birr (also in $ or €)**
Micro Enterprise	Industry	≤ 5	≤ 100,000 ($6,000 or €4,500)
	Service	≤ 5	≤ 50,000 ($3,000 or €2,200)
Small Enterprise	Industry	6-30	≤ 1.5 million ($90,000 or €70,000)
	Service	6-30	≤ 500,000 ($30,000 or €23,000)

Like elsewhere in Africa, small and micro enterprises in Ethiopia face significant challenges in their access to finance. Beck and Cull (2014) based on World Bank enterprise survey data from over 100 countries observe that African firms are more likely to identify financing issues as the most important constraint on their operation and growth than enterprises outside the continent. More than 25 percent of the surveyed enterprises in Africa rated the affordability and availability of finance as the most important barrier. Specific findings consolidate this observation, especially for Ethiopia. For instance, Kuntchev et al. (2014) find that around half of the surveyed enterprises in Ethiopia are fully credit constrained. This is substantially higher when compared with the figures for other countries in the region: Eritrea (8.2%), Mauritius (8.5%), Kenya (11.7%), Rwanda (17.6%), Uganda (19.3%), Burundi (20.6%), Tanzania (22.3%), Madagascar (22.6%), Malawi (25.2%), and Mozambique (30.9%)[18].

Even though SMEs have enormous potential to contribute to GDP and employment, lack of credit has been a major obstacle for such businesses to start, survive, and grow. In some cases, credit is totally unavailable, and in others, it proves to be insufficient or extremely costly. Since most SMEs lack the ability to post collateral or to offer equivalent guarantee, the formal banking system is not willing to extend loans to them--or when the credit line is

[18] The survey year is different for each country. For instance, the result for Ethiopia is based on inputs from 2011.

available--there is a kind of "poverty premium" attached to it to compensate for the possible default of the borrowers. This reinforces the proverbial vicious circle of impoverishment in which high interest rates discourage SMEs from undertaking or expanding profitable projects which in turn overshadows the prospect of timely loan repayment.

In view of the difficulty that SMEs face, the government of Ethiopia has developed a comprehensive small business support strategy document (FSMEDSP, 2011) that promises to provide an integrated package of financial and non-financial assistance to small and micro firms to spur entrepreneurship. The support covers firms through their different stages of life cycle from start up through growth to maturity. Assistance to SMEs includes technology extension and human resource development; market linkages through sub-contracting, franchising, and outsourcing; the provision of sales facilities; and most importantly credit and finance support services. The credit support scheme is aimed at strengthening the financial position of SMEs by improving their financial skills and saving culture, offering credit guarantee arrangements that involve regional governments, microfinance institutions, and SMEs. It also facilitates machinery-leasing services in which the dominant state owned commercial bank (CBE) works jointly with microcredit organizations. In this leasing system, the beneficiaries are expected to save 40% of the value of the machine while the bank finances the remaining 60%. Such arrangements are very useful as they enable SMEs to get bank loans without collateral and to mitigate a long-standing capital/asset insufficiency problem.

3 Literature Review

Despite their popularity as the workhorse for monetary policy scenario analysis, standard New Keynesian general equilibrium models had devoted insignificant role to financial market frictions in magnifying and driving macroeconomic volatility.[19] These models replicate business cycle properties only with heavy reliance on extensive and persistent shocks whose existence cannot easily be verified and explained (Brazdik et al., 2012). In this paper, we

[19] For instance, influential papers like Clarida et al. (1999), Smets and Wouters (2003), and Christiano et al. (2005), do not consider financial frictions at all in their New Keynesian models

introduce explicit roles for both business and financial market rigidities that facilitates the amplification and propagation of real and nominal shocks affecting the economy.[20]

As noted by Markovic (2006), we can identify between two distinct categories of modelling frameworks featuring financial market imperfections. The first category includes bank balance sheet models that emphasise the supply side aspects of financial markets such as bank balance sheet status. The second group focuses on corporate or business balance sheet conditions like the financial accelerator mechanism influencing firm net worth. While most of the literature has so far concentrated solely on the demand side, we also consider interaction with the supply side to account for frictions arising from banking and financial markets.

On the demand side, Bernanke and Gertler (1989) and Bernanke et al. (1999) constitute the foundation by incorporating information asymmetry in credit markets as a source of agency costs influencing investment-spending behaviour among firms. This approach formulates a basis for the interaction of financial and real markets as a result of firm borrowing costs being driven by endogenous changes in its net worth. This link is particularly strong when the economy is stuck below its capacity. In recession, for instance, demand shortfall negatively affects revenue and consequently firm profit and equity[21] fall substantially. The attendant increase in leverage ratio (or decrease in net worth) aggravates the already existent agency problem and creditors respond by raising the finance premium on their loans. The higher external financial premium reduces the demand for capital investment which, in turn, further undermines the net worth position and survivability of the firm. This self-reinforcing mechanism is known as the “financial accelerator” and illustrates the pro-cyclical nature of adverse changes in business net worth and their impact on the ability of firms to access external funding opportunities.

The financial accelerator principle implicitly assumes that producers can get unlimited amount of funding at the prevailing lending rate subject to the strength of their balance sheet

[20] Brazdik et al. (2012) offer expanded exposition on both the demand and supply side aspects in the context of DSGE framework. See also Borio and Zhu (2012) on the role of bank capital contrasting a wide range of methods and Vousinas (2013) on the financial-real linkage.

[21] Throughout the discourse, I use net worth, equity and capital interchangably both in the context of bank and business balance sheets.

structures (banks demand no guarantee that the loan be repaid in full). In this setting, the external risk premium only affects their capacity to borrow without facing the possibility of credit rationing or some other quantitative restrictions imposed by lenders. Kiyotaki and Moore (1997) consider collateral constraints that facilitate the magnification of business cycle volatility and persistence as a result of dynamic association between credit prices and quantities.

In the past, the vast majority of the literature focused its attention on credit market imperfections affecting firms while the role of banking was understated or totally ignored. Incorporating the financial sector permits an important role for the supply side of the credit market by activating banks' liquidity and capital structures, which creates a two-way bridge between banking services and the broader non-financial economic activity. Consequently, introducing an active banking sector creates a double-agency-cost problem between banks and their shareholders on the one hand and between borrowers and creditors on the other.[22] Van den Heuvel (2002), Markovic (2006), Aguiar and Drumond (2007), Christensen and Dib (2008), and Dib (2010), among others, have rationalized how capital sufficiency regulations imply a breakdown of the Modigliani-Miller principle: the bank's credit supply policy is a function of its capital structure, lending opportunities, and market interest rates. For instance, a sharp fall in bank capital—from cancellation of large non-performing loans or other adverse shocks—will force the bank to reduce the supply of credit because of regulatory capital requirement or the punitive cost of attracting new capital. A similar argument can be deployed regarding the role of insufficient bank liquidity in amplifying tight monetary policy measures and other negative shocks affecting the broader economy.

As emphasised by Aguiar and Drumond (2007), the discussion on the importance of bank equity in business cycle fluctuations is relevant in view of the implementation of the Basel Capital Accords (the first in 1988/1992, the second in 2004, and the third motivated by the 2007 financial crisis and yet to be implemented). This series of international standards establishes the basis for a host of central banks and other regulatory authorities to make sure that commercial banks have adequate capital to weather individual and aggregate risks

[22] This agency problem has two dimensions: moral hazard (when one agent--the bank--cannot costlessly verify the intention, activity or action of another agent--the borrower) and adverse selection (when one agent has access to private information).

stemming from within and outside the financial system. By imposing risk and capital measurement and management requirements, such standards can influence bank credit offer and investment decisions: if a bank finds itself exposed to large outstanding risky loans, it will be required to increase its capital to avoid total collapse, and this should reduce lending to the wider economy.

The cost of bank capital can be an important factor for the smooth operation of credit providers. Markovic (2006) identifies three key bank capital channels that cause a variation in the expected return and thus a variation in the cost of bank capital: 1) *the default risk channel* due to the possibility of banks defaulting on their capital. This channel is active in equilibrium and its strength is, in turn, a function of firms defaulting on bank loans 2*) the adjustment cost channel* which rests on the existence of information asymmetry between depository institutions/banks and their investors/shareholders, and the associated monetary cost necessary to minimize this asymmetry. If this channel is real, raising fresh capital is costly, as this would send a bad signal to potential investors about the financial conditions of the target bank. As a result, prospective investors would buy bank shares only after incurring search costs (costs involved in checking the health of specific banks) 3) *the capital/equity loss channel* works via existing shareholders' expectation of future bank losses. During recession, shareholders anticipate that in the future there will be a decline in the value of their bank capital. The higher the expected erosion in bank equity, the stronger the capital loss channel.

Though not explicitly modelled in this paper, credit rationing is another major potential channel through which strict capital requirement regimes could affect bank lending and investment spending by businesses. This strand of literature holds that an increase in regulatory capital requirement can induce bank deleveraging and this creates two conduits of credit rationing. First, downsized balance sheets reduce the banks' capacity to offer additional loans. And, second, lower debt-to-equity ratio incentivizes banks to minimize the variability of their portfolio. If this logic is operational, banks are willing to sacrifice more profits on [potentially] successful loan advancements by increasing screening and monitoring of loan applicants (Agur, 2010).

On the empirical front, there have been numerous studies accentuating the significant role of the financial sector in intensifying and propagating the effects of adverse shocks affecting the economy. Fukunaga (2002) built upon the Bernanke et al. (1999) framework to develop a dynamic general equilibrium model calibrated to the Japanese economy. The model features a micro-financial contractual problem involving companies/borrowers and financial intermediaries/banks. Retailors are included to introduce inertia in the price setting process with the objective of providing room for monetary non-neutrality in the short run. Moreover, capital producers and government (fiscal and monetary sectors) are included. In this decentralized, rational-expectation-equilibrium-model economy, three sources of unanticipated shocks are considered: technology (total factor productivity), monetary and demand (exogenous fiscal expenditure). The results suggest that tight monetary policy stance (negative shock) is followed by a decline in corporate investment, net worth, and demand for capital as a result of a rise in the external financial risk premium. This fall in investment is much bigger and more persistent in the model with financial accelerator than the one without credit market frictions. The paper also finds that exogenous fiscal expenditure raises output and investment even though this was accompanied by an increase in the interest rate which somewhat offsets the positive effect from fiscal stimulus. Moreover, the risk premium diminishes and firm net worth improves. Like in the monetary shock, the fiscal disturbance is also amplified under the financial accelerator mechanism. Finally, the response of the economy to the technological innovation was unconventional. Fukunaga finds that when the model economy is subject to positive total factor productivity shock, corporate net worth deteriorates and the outcome is less amplified under the financial accelerator. The author offers two explanations. First, the policy feedback rule counterbalances the positive impact of the disturbance. Second, a rise in the mark-up due to price rigidity causes the rent paid to a unit of capital (in terms of the retail price of output/good) to depreciate. The external finance premium reduces the demand for capital that offsets rather than magnifies the positive reaction of real GDP and investment.

In addition to the net worth channel, demand-side financial imperfections have also been identified to originate from collateral constraints. Brzoza-Brzezina et al. (2010)[23] compare the relative significance of the two channels in an extended medium scale New Keynesian model calibrated to the Polish economy. They compare the collateral constraint framework of Kiyotaki and Moore (1997) with the external finance premium setup of Carlstrom and Fuerst

[23] They also introduce a banking sector in both versions of frictions even though analyzing the impact of shocks emanating from the banking system is not their main objective.

(1997) and Bernanke et al. (1999). They rely on business cycle accounting, moment matching, and impulse response analyses to see the qualitative and quantitative performance of the two models. Their results indicate that both models with financial frictions add volatility to the baseline New Keynesian framework, with the external finance premium showing significantly stronger internal propagation mechanism than its collateral constraint counterpart. In terms of business cycle accounting, they find superior performance of the models with financial frictions to the baseline specification, with the model under collateral constraint offering moments closely resembling those filtered from actual data.

Recently, there have been growing tendencies to model banking activity as a potential source of economic fluctuations. For instance, Meh and Moran (2009), using a general equilibrium framework, show that bank capital can be an important channel for the transmission of shocks in view of moral hazard problems between banks and investors that provide loanable funds. Other works emphasizing the role of bank balance sheets in intensifying and transmitting exogenous shocks include Gertler and Karadi (2011), Van den Heuvel (2011)[24], Hafstead and Smith (2012), and Hollander and Liu (2013), among others. Though much of the focus has been on bank equity, there have been efforts to incorporate the importance of liquidity under a general equilibrium framework. This might involve assigning roles to interbank markets as in Carrera and Vega (2012) or studying the impact of reserve requirements as in Areosa and Coelho (2013).

The vast majority of studies on financial market imperfections are devoted to advanced industrial economies and to some extent to emerging blocks while there appears to be scant interest in low-income countries, especially those in Sub-Saharan Africa. One contribution is by Babilla (2014) who uses a mix of calibration and Bayesian estimation of a modified small open dynamic stochastic general equilibrium model for the West African Economic and Monetary Union (WAEMU). The paper evaluates the effectiveness of bank lending channel in the propagation of monetary policy measures within a currency union where financial intermediation is dominated by oligopolistic banks. Consistent with the evidence for advanced and emerging countries, the paper finds that including financial market distortions improves the performance of the model. Unlike Fukunaga (2002), who finds deteriorating net

[24] Based on panel data econometrics in which money growth and aggregate capital asset ratio for all commercial banks are used to proxy central bank monetary policy stance and the role of bank balance sheet, respectively.

worth in response to positive technology shock, here positive productivity shock improves firm net worth and investment despite an increase in the external finance premium.[25]

This paper relates to the works of Markovic (2006), Aguiar and Drumond (2007), Christensen and Dib (2008) by allowing interaction between the balance sheet structures of the corporate and banking sectors. The Bernanke et al. (1999) model of financial accelerator mechanism is augmented to accommodate distortions arising from credit suppliers. This way, a double-agency-cost problem is emphasized to capture the effects of information and moral hazard costs between banks and borrowers on one side and between banks and their shareholders on the other. It is assumed that banks raise funding by issuing shares to and collecting deposits from households. The household preference for liquidity determines the relative costs of banking finance through equity issuance and deposit mobilization.

The rest of the paper has been structured as follows. Section 3 outlines the model followed by the presentation of calibration and simulation exercise in section 4. Section 5 concludes.

4 Model

The model setup features standard elements in New Keynesian general equilibrium models augmented with financial frictions. The household sector makes consumption, labour supply and saving decisions. They use their savings to make deposits and/or buy shares in banks. Entrepreneurs rely on bank credit to purchase investment capital and combine it with hired worker to produce wholesale goods. The banks mobilize household resources in the form of deposits and equity and make loans to businesses/entrepreneurs. There is also a public sector in charge of fiscal and monetary policy. A retailing sector is included to generate price rigidity which ensures monetary non-neutrality in the short run. We follow Bernanke et al. (1999) and Aguiar and Drumond (2007) to describe the modelling framework.

4.1 Entrepreneurs

Every period the entrepreneur purchases the required capital stock which will be combined with labour to produce goods the next period. Thus, at time t entrepreneur j purchases homogenous capital for use at t+1, K_{t+1}^{j}. The return to capital is affected by both systemic risk

[25] One explanation is that a fall in real exchange and interest rates reduces the cost of investment financing for firms.

and risk that is specific to the firm. The ex post gross return on capital for firm j is $\omega^j_{t+1} R^K_{t+1}$, where ω^j_{t+1} is an idiosyncratic shock specific to firm j's return and R^K_{t+1} is the ex post aggregate return to capital. The idiosyncratic disturbance (ω^j) is independently and identically distributed both across entrepreneurs and over time, with a continuous and once-differentiable cumulative distribution function (c.d.f), $F(\omega)$, over a non-negative support, and with expected value equal to unity.

Entrepreneur j enters next period with net worth N^j_{t+1} which complements borrowed funds for the purchase of K^j_{t+1}. The borrowed money finances the difference between the total capital expenditure and own funds (net worth) and is equal to $L^j_{t+1} = Q_t K^j_{t+1} - N^j_{t+1}$, where Q_t is the unit price of capital in period t. Each entrepreneur signs a credit contract with a bank which demands a required rate of return on lending between t and t+1, R^F_{t+1}. This arrangement reflects an agency problem due to asymmetric information between the bank and the entrepreneur. This implies that only the borrower can costlessly observe the return of the project. The financial contract is designed to minimize the expected agency cost. As popularized by Bernanke et al. (1999), this gives rise to a costly state verification (CSV) problem, in which the lending bank must incur monitoring and supervision costs in order to know the actual performance of the borrower's project. We assume this monitoring cost is equal a fraction μ of the realized gross return of the entrepreneur's capital:

$$\mu = \omega^j_{t+1} R^K_{t+1} Q_t K^j_{t+1},$$

where $0 < \mu < 1$. Neither the bank nor the entrepreneur knows the idiosyncratic disturbance ω^j_{t+1} prior to the investment decision. That is both capital expenditure and the credit contract are established before the realization of the shock specific to the borrower. Once the investment project has been installed, the bank can observe the random shock but only after incurring monetary costs.

Given $Q_t K^j_{t+1}$, L^j_{t+1}, and R^K_{t+1}, the optimal contract is characterized by a gross non-default loan rate , Z^j_{t+1}, and a cut-off $\bar{\omega}^j_{t+1}$, such that, if $\omega^j_{t+1} \geq \bar{\omega}^j_{t+1}$, the borrower pays the lender the amount $\bar{\omega}^j_{t+1} R^K_{t+1} Q_t K^j_{t+1}$ and keeps the residual value $(\omega^j_{t+1} - \bar{\omega}^j_{t+1}) R^K_{t+1} Q_t K^j_{t+1}$. That is, $\bar{\omega}^j_{t+1}$ is defined by:

$$\bar{\omega}^j_{t+1} R^K_{t+1} Q_t K^j_{t+1} = Z_t L^j_{t+1} \tag{1}$$

If $\omega^j_{t+1} < \bar{\omega}^j_{t+1}$, the borrower receives nothing, while the bank monitors the borrower and receives $(1-\mu)\omega^j_{t+1} R^K_{t+1} Q_t K^j_{t+1}$.

In equilibrium, the contractual arrangement ensures that the lender gets an expected gross return on the loan equal to the required return:

$$(1 - F(\bar{\omega}^j_{t+1})] \mathrm{Z}^i_{t+1} L^j_{t+1} + (1-\mu) \int_0^{\bar{\omega}^j_{t+1}} \omega^j_{t+1} R^K_{t+1} Q_t K^j_{t+1} f(\omega) d\omega = R^F_{t+1} (Q_t K^j_{t+1} - N^j_{t+1}), \tag{2a}$$

where $f(\omega)$ is the probability density function (p.d.f) of ω.

Combining equation (1) with equation (2a) yields the following expression:

$$\left\{ [1 - F(\bar{\omega}^j_{t+1})] \bar{\omega}^j_{t+1} + (1-\mu) \int_0^{\bar{\omega}^j_{t+1}} \omega^j_{t+1} f(\omega) d\omega \right\} R^K_{t+1} K^j_{t+1} = R^F_{t+1} (Q_t K^j_{t+1} - N^j_{t+1}) \tag{2b}$$

Expanding the expression within the parenthesis on the left side, we can define the share of income going to the lender ($\Gamma(\omega)$) and the residual amount accruing to the entrepreneur ($\Theta(\omega)$):

$$\underbrace{1 - F(\bar{\omega}^j_{t+1})] \bar{\omega}^j_{t+1} + \int_0^{\bar{\omega}^j_{t+1}} \omega^j_{t+1} f(\omega) d\omega}_{\Gamma(\omega)} - \underbrace{\mu \int_0^{\bar{\omega}^j_{t+1}} \omega^j_{t+1} f(\omega) d\omega}_{\mu\Theta(\omega)}$$

Thus the optimal financial contract involves maximizing the profit share of the entrepreneur subject to the lender resource constraint discussed previously:

$$\underbrace{\max}_{\bar{\omega}_{t+1}, lev_t} E_t \frac{[1 - \Gamma(\bar{\omega}_{t+1})](1 + \mathrm{R}^K_{t+1})(\mathrm{lev}_t + 1)}{1 + R^F_{t+1}} \tag{2c}$$

$$\text{s.t. } \frac{[\Gamma(\bar{\omega}_{t+1}) - \mu\Theta(\bar{\omega}_{t+1})](1 + \mathrm{R}^K_{t+1})(1 + \mathrm{lev}_t)}{1 + R^F_{t+1}} = lev_t$$

where $lev_t = \frac{Q_t K_{t+1} - N_{t+1}}{N_{t+1}}$. The optimization leads to the following first order condition:

$$E_t\{\frac{[1-\Gamma(\overline{\omega}_{t+1})](1+R_t^K)}{1+R_{t+1}^F} + \frac{1-F(\overline{\omega}_{t+1})}{1-F(\overline{\omega}_{t+1})-\mu\Theta(\overline{\omega}_{t+1})}\left[\frac{1+R_t^K}{1+R_{t+1}^F}(\Gamma(\overline{\omega}_{t+1})-\mu\Theta(\overline{\omega}_{t+1})-1\right]\} = 0 \quad (3)$$

Bernanke et al. (1999) have demonstrated that the lender's expected return is maximized at a unique interior point $\overline{\omega}_{t+1}^j$, $\overline{\omega}_{t+1}^{j*}$, and the equilibrium is characterized by $\overline{\omega}_{t+1}^j$ always being below $\overline{\omega}_{t+1}^{j*}$. As a result, the possibility of equilibrium under credit rationing is not considered and the creditor's expected return is always increasing in $\overline{\omega}_{t+1}^j$.

In a situation where aggregate or systemic risk is present, $\overline{\omega}_{t+1}^j$ depends on the ex post realization of R_{t+1}^K. Depending on the ex post realization of R_{t+1}^K, the borrower-entrepreneur offers a state-contingent non-default debt repayment that guarantees the lender-bank a return equal in expected value to the required return R_{t+1}^F. In short, equation (3) provides a set of restrictions, one for each realization of R_{t+1}^K.

Denoting the expected discounted return to capita by the ratio, $\frac{E_t(R_{t+1}^K)}{R_{t+1}^F}$, if this ratio exceeds unity, the first order conditions of the contracting problem produces the following relationship between $\frac{Q_t K_{t+1}^j}{N_{t+1}^j}$ and the expected return to capital:

$$\frac{Q_t K_{t+1}^j}{N_{t+1}^j} = \Xi\left(\frac{E_t(R_{t+1}^K)}{R_{t+1}^F}\right),$$

where $\Xi'(.) > 0$ and $\Xi(.) > 0$. This implies that the entrepreneur incurs capital expenditures that are proportional to their net worth, with a proportionality factor that is positively correlated with the expected return to capital. Thus the probability of default should fall with a rise in the discounted return to capital. The decline in the spectre of bankruptcy enables the firm to take on more loans and expand its operation. However, future default costs rise with the leverage ratio and this limits the ability of borrowers to expand investments indefinitely.

Reformulating the preceding relationship in aggregated (over firms) we get:

$$\frac{Q_t K_{t+1}}{N_{t+1}} = \Xi\left(\frac{E_t(R^K_{t+1})}{R^F_{t+1}}\right), \tag{4}$$

where K_{t+1} represents the aggregate stock of capital bought by all entrepreneurial firms at time t, and N_{t+1} is their aggregate equity or net worth.

$$\frac{E_t(R^K_{t+1})}{R^F_{t+1}} = \upsilon\left(\frac{Q_t K_{t+1}}{N_{t+1}}\right), \tag{5}$$

where $\upsilon(.)$ is increasing in $\frac{Q_t K_{t+1}}{N_{t+1}}$ for $N_{t+1} < Q_t K_{t+1}$. Consequently, in equilibrium, the expected discounted return to capital, $\frac{E_t(R^K_{t+1})}{R^F_{t+1}}$, evolves inversely with the volume of capital expenditure financed by the firms' net worth. $\frac{E_t(R^K_{t+1})}{R^F_{t+1}}$ is what has been referred to as external finance premium in Bernanke et al. (1999) faced by entrepreneurs.

Entrepreneurial Net Worth Entrepreneurs build their net worth based on accumulated retained earnings from past capital investments and wage compensation from supplying labour. As a technical requirement, we allow entrepreneurs to start with some net worth to begin their operations. Moreover, we assume that the fraction of the population who are entrepreneurs remains constant over time: in every period the number of firms entering the market is equal to the number of firms going out of the market.

Let V_t be the entrepreneurs' total net worth accumulated from business operations, then normalizing the entrepreneurial work hour to unity we have:

$$N_{t+1} = \gamma V_t + W^e_t \tag{6}$$

where W_t^e is the wage income to entrepreneurs and γ is the chance that the specific entrepreneur survives to the next period. To rule out the possibility that firms build sufficient net worth to be fully self financed, we assume that those firms are active for finite horizons.

Note the equilibrium value of V_t can be cast as a function of the variables from the financial contract as:

$$V_t = R_t^K Q_{t-1} K_t - R_t^F (Q_{t-1} K - N_t) - \mu \Theta(\bar{\omega}_t) R_t^K Q_{t-1} K_t, \tag{7}$$

where $\mu \Theta(\bar{\omega}_t) R_t^K Q_{t-1} K_t$ represent the total default monitoring costs and

$\Theta(\bar{\omega}_t) = \int_0^{\bar{\omega}_t} \omega_t^j f(\omega) d\omega$. Equations (6) and (7) indicate that the net worth of firms is influenced by their earnings net of interest expenses to the bankers.

Entrepreneurs that exit from the market in period t are not allowed to purchase capital and simply consume their residual equity $(1-\gamma)V_t$:

$$C_t^e = (1-\gamma)V_t, \tag{8}$$

where C_t^e is the total consumption of entrepreneurs that exit the market.

4.2 Banks

In our model economy, the financial industry is dominated by banks which function by mobilizing household funds and extending loans to entrepreneurial firms. In Bernanke et al. (1999), banks are only intermediaries and their operation is totally insulated from aggregate risk or whatever risk they face is diversified away. In our approach, for simplicity, lenders are exempt subject to exogenous reserve requirement, but must satisfy a risk-based capital requirement imposed by the regulatory regime. Specifically, the banks must maintain a proportion of capital equal to a minimum threshold set by regulators such as the economy's central bank. It is presumed that banks are the sole business entities that issue equity which rests on households' willingness and ability to hold capital in addition to deposits. The asset side of the bank balance sheet reveals not just loans to entrepreneurs, but also short term treasury securities. The debt instruments have zero weight in the risk-based capital assessment as they entail no risk (the fiscal sector is assumed not to default on its obligations).

A special characteristic feature of banks concerns the facility necessary to monitor and supervise the activities of borrowers. Households—who are the major bank shareholders—lack this facility and delegate the responsibility of monitoring to banks, which grapple with the costly state verification problem described previously. Under such arrangements, each bank does not enjoy any bargaining advantage over the borrower; the financial contract outlines the maximization of borrower pay off provided that the expected return to the bank is big enough to cover only its opportunity cost of funds. In short, the banks operate in a perfectly competitive environment and obtain zero profit in the long run as entry and exit are totally unregulated.

The banks problem involves:

$$\underbrace{\max}_{S_{t+1},D_{t+1},B_{t+1},L_{t+1}} \left(R^F_{t+1}L_{t+1} + R_{t+1}B_{t+1} - R^D_{t+1}D_{t+1} - E_t(R^S_{t+1})S_{t+1} \right)$$

$$\text{s.t.} \quad L_{t+1} + B_{t+1} = D_{t+1} + S_{t+1} \tag{9}$$

$$\frac{S_{t+1}}{L_{t+1}} \geq del\_k \tag{10}$$

where $0 < del\_k < 1$ is the exogenous capital ratio. Equations (9) and (10) specify the bank balance sheet constraint and the regulatory capital requirement, respectively. Moreover, $L_{t+1}, B_{t+1}, D_{t+1}, \text{and } S_{t+1}$ denote, respectively, the loan advancement, purchase of treasury securities, deposit collection and equity issuance by banks between periods t and t+1; while $R^F_{t+1}, R_{t+1}, R^D_{t+1}, \text{and } E_tR^S_{t+1}$ represent the required gross real rate of return on loans; the gross real rate of return on treasury securities; the gross real rate of return on deposits; and the expected gross real rate of return on bank equity—in the same order.

Notice that R^F_{t+1} differs from the non-default lending rate, Z_{t+1}. The difference arises from the possibility of entrepreneurs getting bankrupt--default on their loans—and the attendant monitoring costs which are reflected in R^F_{t+1}. In addition, while the other rates of return are known in advance in period t, the rate of return on equity, $E_tR^S_{t+1}$, is uncertain and depends on the realization of the state of the economy at t+1.

Under binding bank capital requirement, $\frac{S_{t+1}}{L_{t+1}} = del\_k$, the first order conditions of the admissible solution of the bank's maximization problem are:

$$R_{t+1} = R_{t+1}^{D} \tag{11}$$

$$R_{t+1}^{F} = (1 - del\_k)R_{t+1} + del\_kE_t(R_{t+1}^{S}) \tag{12}$$

These conditions illustrate that with binding regulatory capital, the required rate of return on lending is a weighted average of the rate of return on deposits and the expected rate of return on bank equity. Thus, we have significant departure from the Bernanke et al. (1999) framework where the required rate of return on lending equals the riskless/deposit rate.

Return on Capital

The exogenous regulatory capital requirement entails that the bank must maintain a level of equity which amounts to ξ times the volume of outstanding loan advancement. The supply of credit is therefore financed by a combination of bank equity and deposits mobilized from households, who allocate their savings between these financial instruments. The relative ease of using deposits for liquidity services and the riskless rate associated with them establishes a spread vis-à-vis the return on bank capital, that is, $E_t R_{t+1}^{S} > R_{t+1}^{D}$.

Moreover, we assume that the real rate of return on physical and bank capital is the same:

$$E_t R_{t+1}^{S} = E_t R_{t+1}^{K} \tag{13}$$

The interpretation of (13) is that even if entrepreneurs are the only investors in physical capital, households would demand the same expected rate of return on both physical and bank capital if they were to make capital expenditures. Thus, equation (13) represents a no-arbitrage condition as physical and bank capital provide no liquidity services and their returns are exposed to the same systemic risk.

4.3 Capital Producers

In this section we integrate the optimal financial contract signed in a partial equilibrium setting into New Keynesian general equilibrium framework.

Capital producers buy final investment goods i_t from retailers and transform them using existing capital to generate new capital stock. Investment decisions are subject to quadratic adjustment costs. The inclusion of such costs induces volatility of entrepreneurial net worth and bank capital via the variability of the price of capital. We assume that capital producers deploy a linear technology and choose the level of investment spending to maximize profits subject to adjustment costs:

$$\max\left[Q_t I_t - I_t - \frac{\eta_{q,ik}}{2}\left(\frac{I_t - \delta K_t}{K_t}\right)^2 K_t\right] \tag{14}$$

where Q_t is the real price of capital while $\eta_{q,ik}$ and δ are parameters capturing the degree of adjustment cost and depreciation of capital, respectively. The optimization problem gives rise to the following first order condition:

$$Q_t = 1 + \eta_{q.ik}\left(\frac{I_t}{K_t} - \delta\right) \tag{15}$$

Notice that the higher the value of $\eta_{q,ik}$, the higher the volatility of the price of capital. Setting this parameter to zero entails a constant price of capital equal to unity.

The law of motion for the aggregate capital stock in the economy is evolves according to:

$$K_{t+1} = I_t + (1-\delta)K_t \tag{16}$$

4.4 Production by Entrepreneurs

Entrepreneurial firms rely on bank loans to supplement their net worth in the purchase of capital goods. They combine the purchased capital with hired labour to produce wholesale goods which they sell at nominal marginal cost in perfectly competitive markets. Only households are employed by the firm as entrepreneurs and bankers are assumed to be insignificant fraction of the labour force. The firm uses constant returns to scale Cobb Douglas production technology:

$$Y_t = A_t K_t^{\alpha_k}[(H_t^h)^{\Omega}(H_t^e)^{1-\Omega}]^{1-\alpha_k} \tag{17}$$

where $0 < \alpha_k < 1$ is the capital share in aggregate output; $(H_t^h)^{\Omega}(H_t^e)^{1-\Omega}$ is total labour supply with H_t^h and H_t^e indicating the work hours of households and entrepreneurs, respectively. Ω is the fraction of work hours provided by households.

The first order conditions yield the real marginal product of capital (MP_k) and the real wage (W_t) rates as shown in (18) , (19a) and (19b) below:

$$MP_k = \alpha_k MC_t \frac{Y_t}{K_t} \tag{18}$$

$$W_t^h = (1-\alpha_k)\Omega MC_t \frac{Y_t}{H_t^h} \tag{19a}$$

$$W_t^e = (1-\alpha_k)(1-\Omega)\,\mathrm{MC}_t \frac{Y_t}{H_t^e} \tag{19b}$$

with mc_t representing the marginal cost. Finally, the demand for capital must satisfy the following condition for the expected return on capital:

$$E_t R_{t+1}^K = \left(\frac{MP_{k,t+1} + (1-\delta)Q_{t+1}}{Q_t} \right) \tag{20}$$

4.5 Retailers

Retailers are included to generate inertia in the price setting schedule. They are monopolistic firms that set their prices in a staggered fashion due to Calvo (1983). In each period, a random fraction $1-\theta$ ($\theta \in [0,1]$) of firms adjust their prices optimally. The remaining fraction, θ, are assumed to follow an adjustment process that exploits indexation of current prices to inflation in the previous period:

$$P_t^I(\mathrm{j}) = \mathrm{P}_{t-t}(j)\left(\frac{P_{t-1}}{P_{t-2}} \right)^{\theta} \tag{21}$$

Denoting the price level that the optimizing firm chooses in each period by $\overline{P}_t$, the aggregate price level in the domestic economy evolves according to the pricing rule:

$$P_t = \left\{ (1-\theta)\overline{P}_t^{1-\tau} + \theta \left[P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\theta} \right]^{1-\tau} \right\}^{\frac{1}{1-\tau}} \tag{22a}$$

$$\text{or } \pi_t = (1-\theta)(\overline{p}_t - p_{t-1}) + \theta^2 \pi_{t-1} \tag{22b}$$

Those optimizing firms that are able to adjust their prices in the current period will choose $\overline{P}_t$ in such a way as to maximize the present discounted sum of future streams of profits subject to the sequence of demand constraints:

$$\max_{\overline{P}_t} \sum_{j=0}^{\infty} (\beta\theta)^j \left\{ Q_{t+j} \left(Y_{t+j} \left(\overline{P}_{H,t} - MC_{t+j}^n \right) \right) \right\} \tag{23}$$

$$\text{Subject to } Y_{t+j} \leq \left(\frac{\overline{P}_t}{P_{t+j}} \right)^{-\varepsilon} \left(C_{t+j} \right)$$

where MC_{t+j}^n is the nominal marginal cost while $\theta^j E_t \Delta_{t+j}$ is the effective stochastic discount factor that considers the fact that firms have a $1-\theta$ provability of being able to reset their prices in each period. The first order condition for the optimal price setting rule is:

$$\sum_{j=0}^{\infty} \theta^j E_t \left\{ \Delta_{t+j} Y_{t+j} \left(\overline{P}_t - \frac{\varepsilon}{1-\varepsilon} MC_{t+j}^n \right) \right\} = 0 \tag{24}$$

where $\frac{\varepsilon}{1-\varepsilon}$ is the marginal cost of production under perfectly competitive setting. Substituting out Δ_{t+j} from the consumption Euler equation and dividing by P_{t+j} across all terms gives:

$$\sum_{j=0}^{\infty} (\beta\theta)^j \left\{ C_{t+j}^{-\sigma} Y_{t+j} \frac{P_{t-1}}{P_{t+j}} \left(\frac{\overline{P}_t}{P_{t-1}} - \frac{\varepsilon}{\varepsilon - 1} MC_{t+j} \frac{P_{t+j}}{P_{t-1}} \right) \right\} = 0 \tag{25}$$

where $MC_{t+j} = \frac{MC_{t+j}^n}{P_{t+j}}$ is the real marginal cost. The log-linearization of equation (25) around the zero steady state inflation to get the decision rule for $\overline{P}_t$ yields:

$$\overline{p}_t = p_{t-1} + \sum_{j=0}^{\infty} (\beta\theta)^j \left\{ E_t \pi_{t+j} + (1-\beta\theta) E_t mc_{t+j} \right\} \tag{26}$$

Equation (26) states that optimizing firms choose their prices in line with the present discounted values of future streams of inflation and deviation of the real marginal cost from its steady state. Re-writing this same equation we have:

$$\overline{p}_t = p_{t-1} + \pi_t + (1-\beta\theta) mc_t + (\beta\theta) \sum_{j=0}^{\infty} (\beta\theta)^j \left\{ E_t \pi_{t+j+1} + (1-\beta\theta) E_t mc_{t+j+1} \right\} \tag{27}$$

$$= p_{t-1} + \pi_t + (1-\beta\theta) mc_t + \beta\theta(\overline{p}_{t+1} - p_t)$$

$$\overline{p}_t - p_{t-1} = \pi_t + \beta\theta E_t \pi_{t+1} + (1-\beta\theta) mc_t \tag{28}$$

Plugging equation (26) back into equation (22b) and rearranging provides the path for domestic inflation:

$$\pi_t = \beta(1-\theta) E_t \pi_{t+1} + \theta \pi_{t-1} + z_\pi mc_t \tag{29}$$

where $z_\pi = \frac{(1-\beta\theta)(1-\theta)}{\theta}$. Equation (29) presents the so called New Keynesian Phillips Curve (NKPC) and it describes the current domestic consumer price inflation as a function of expected future inflation, realized previous inflation, and the real marginal cost. Without Calvo-type pricing strategy (that is with the price stickiness parameter $\theta = 0$), only the forward looking component determines current inflation and there would be little cost to be incurred from advancing disinflationary policy choices.

4.6 Households

The economy is inhabited by an infinitely lived forward looking representative household. The household engages in key economic decisions that involve labour supply, consumption, and saving. The typical household has the opportunity to allocate its savings between riskless deposits (D_t) and risky equity investment (S_t) offered by banks, which offer expected returns of R_{t+1}^D and R_{t+1}^S, respectively. The maximization problem of the typical household is:

$$\underbrace{\max}_{C_t, N_t, D_{t+1}, S_{t+1}} \sum_{j=0}^{\infty} \beta^j \left[\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{D_{t+1}^{1-\sigma}}{1-\sigma} - \frac{(H_t^h)^{1+\varphi}}{1+\varphi} \right]$$

$$\text{s.t.} \quad C_t + D_t + S_{t+1} + T_t = W_t^h H_t^h + R_t^D D_{t-1} + R_t^S S_t + \Pi_t$$

where β is the subjective discount rate, σ is the intertemporal elasticity of substitution (same for both consumption and deposit demand), φ is the inverse elasticity of labour supply; H_t^h captures the number of hours worked, W_t^h is the hourly household real wage rate, T_t is tax expense, Π_t is the dividend receipts, C_t denotes the real composite consumption index of home produced.

The autonomous household choices over the optimal amount of consumption, labour supply, and deposits in each period give rise to the following set of first order conditions (FOCs) of the household utility optimization problem[26]:

$$C_t^{-\sigma} = \Psi_t \tag{30}$$

$$\Psi_t = \beta E_t R_t^D \Psi_{t+1} + D_t^{-\sigma} \tag{31}$$

$$\Psi_t = \beta\{E_t \Psi_{t+1} R_{t+1}^S + \text{cov}_t(R_{t+1}^S, \text{C}_{t+1}^{-\sigma}\} \tag{32}$$

$$(H_t^h)^\varphi = \Psi_t W_t^h \tag{33}$$

where Ψ_t is the Lagrange multiplier.

5 Analysis

5.1 Calibration

The non-stochastic discount factor β is set to 0.98 while the constant risk aversion parameter is fixed at 3 which together imply a stead state consumption deposit ratio of 0.22 as depicted in the household first order equation (31). We choose a value of 4 for the elasticity of labour supply. The price rigidity parameter is 0.75 which suggests that prices remain unchanged for at least four quarters. The gross mark up of retail goods over wholesale counterparts is

[26] In the simulation exercises provided in section 5, we use the log-linearized version of these and all other FOCs and definitions provided in Appendix A. Entrepreneurial consumption and bank monitoring cost are not considered in the simulation as they constitute a tiny fraction compared with the broader economic output.

assumed to be 10 per cent consistent with the limited monopoly power of small firms in less innovative low income economies.

In the money growth rule, we assume the coefficients of inflation, persistence and output gap are 1, 0.8 and 0.11, respectively. The interest semi-elasticity parameter in the monetary equilibrium equation is set at 0.005 consistent with the evidence of very low values for developing economies. We also set the auto regressive parameter to 0.8 in the shock processes for total factor productivity, money growth, and fiscal policy.

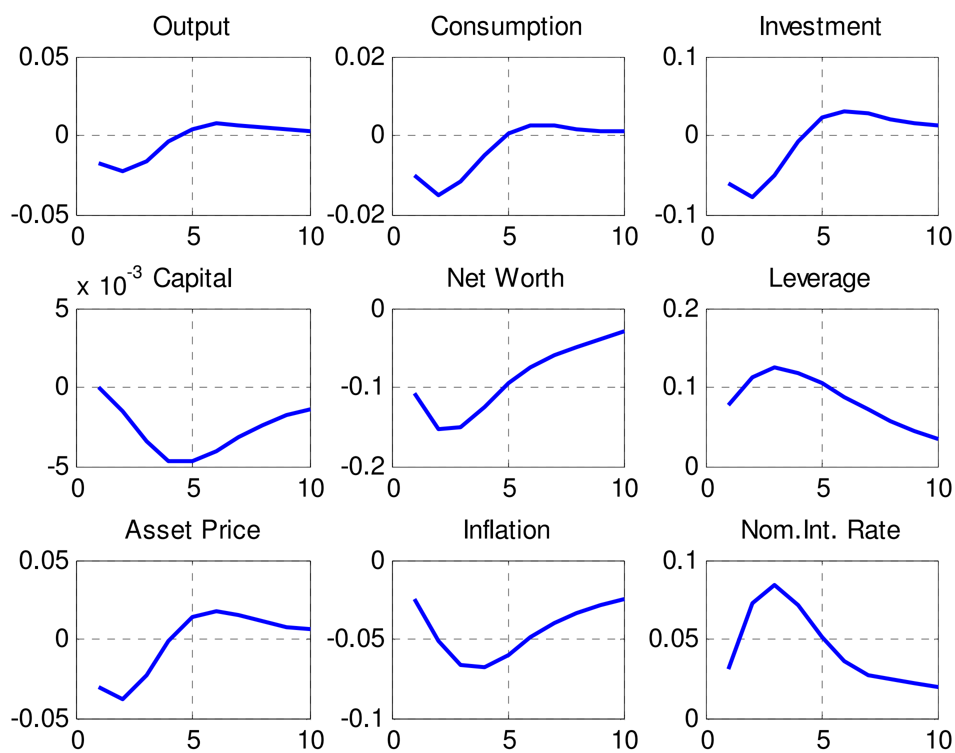
The steady state values for components of GDP are calibrated based on empirical data for the Ethiopian economy. Accordingly, we fix the investment, consumption, and government spending ratios to GDP at 0.18, 0.60, and 0.22, respectively. The quarterly capital depreciation rate δ is equal to 0.025 which implies a steady state capital stock of 7.2. The proportions of capital, household labour, and entrepreneurial labour employed in the goods production function are 0.3, 0.693, and 0.07, respectively.

The parameters related to entrepreneurial activity are determined based on standard practice in the literature and microeconomic evidence on the nature and development of small and medium enterprises (SMEs) in developing countries. The quarterly business bankruptcy rate is set to 0.0075 based on the International Development Research Centre (IDRC) survey results which report an annual 3 per cent business discontinuance rate for Ethiopia. The loan monitoring cost is fixed at 0.12 as in Bernanke eta al. (1999). The fraction of entrepreneurs who survive to the next period is assumed to be 97 percent. These values suggest a steady state leverage ratio of 1.932, an annual external finance premium of 200 basis points, and an elasticity of external finance premium to leverage ratio of 0.041. Based on these values and choosing a value of 1.01 for the quarterly gross risk-free rate, we get a quarterly gross return on capital equal to 1.0157 and a quarterly gross bank financing cost of 1.0107. See Appendix B for the complete list of parameters and their sources.

5.2 Simulation Results

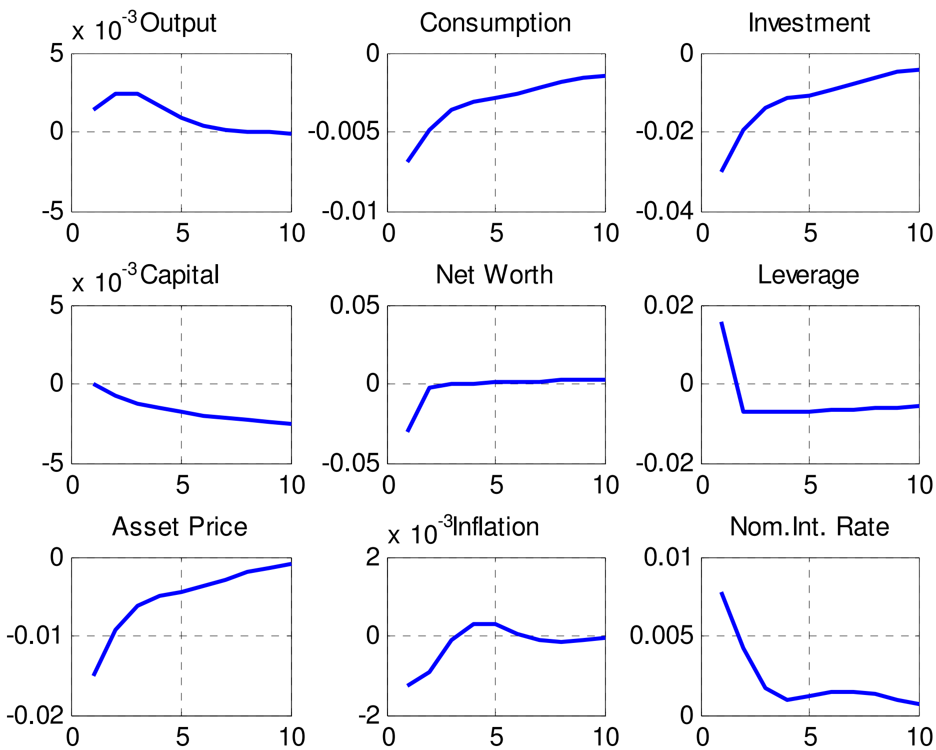
In this section I present the simulation results in which we examine endogenous developments in the model economy in response to exogenous shocks stemming from the monetary policy process, the fiscal authority and technological progress. Figure 1 displays the reaction of selected variables to unanticipated reduction in the supply of money which leads to a surge in the nominal interest rate. This contractionary measure by the central bank, combined with price rigidity in the short run, results in an increase in the real interest rate which translates into a higher external finance premium for entrepreneurs. As a result, private investment, capital, and aggregate production decline. In particular a one percent reduction in the money supply causes investment and consumption to fall by the same magnitude on impact.

Figure 1: Impulse Response to Negative Monetary Policy Shock



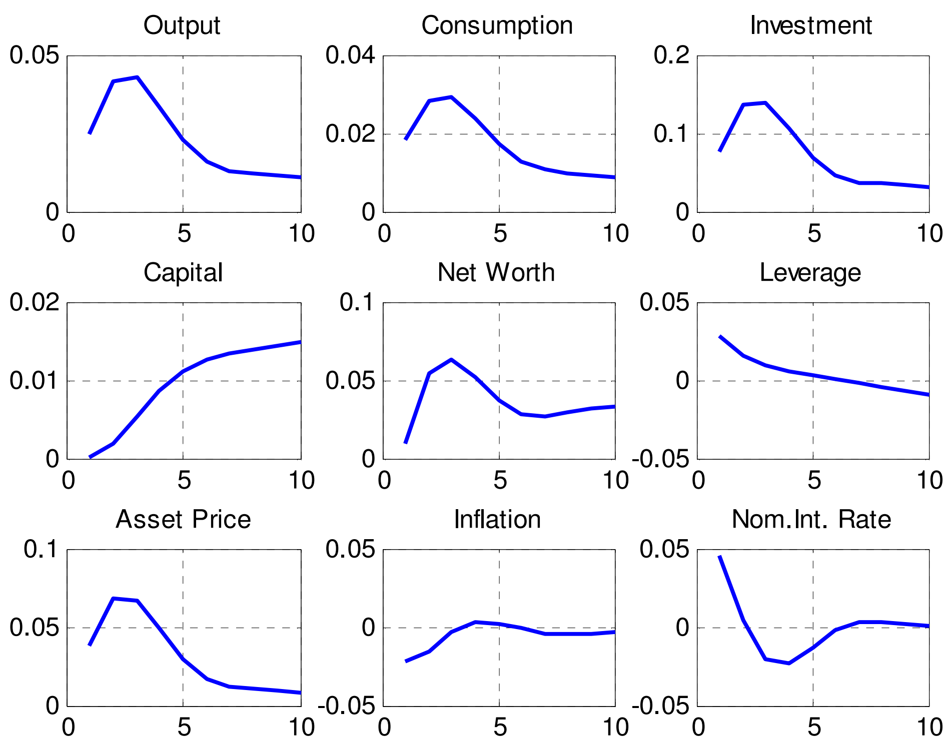
Monetary tightening also causes a fall in inflation and asset prices. The drop in asset prices reduces the net worth of entrepreneurs which raises their leverage. This opens up an asset price channel for monetary policy transmission mechanism which is absent in standard new Keynesian models without credit market distortions. The results presented in here are in line with previous findings such as Markovic (2006), Zhang (2009), and Aguiar and Drumond (2009) among others.

Figure 2: Impulse Response to Positive Fiscal Shock



The fiscal authority can influence national economic outcomes through a combination of tax and transfer policies. Even though we do not explicitly model the effect of taxation on investment and household spending, there is considerable consensus among macroeconomists that large and growing spending by the government limits the availability of credit to private players. As shown in Figure 2 above, an increase in government spending raises the interest rate which in turn drives down private consumption and investment in the short run. But the contribution of the fiscal authority more than offsets the fall in private consumption and investment spending and consequently aggregate output increases. Consistent with the results from negative monetary policy shocks, net worth, capital stock, and asset prices fall on impact in the wake of an increase in the nominal interest rate triggered by heightened public expenditure programmes. Inflation initially falls as the increased output from fiscal contribution places downward pressure on prices; however, over time, the public sector competes with households and entrepreneurs for limited resources and this causes inflation to pick up in the medium run. This suggests a significant crowding out effect in the long run where the fall in private spending more than offsets the increase in GDP from fiscal contribution. In chapter 1, both under interest and money growth rules, government spending was inflationary as we did not consider credit market conditions. Here the rise in the nominal interest rate has additional impact via the investment and production decision of small and micro enterprises. And as a result, to the extent that the contractionary effect on SMEs is significant, the fall in asset prices combined with the sharp fall in investment should create a deflationary environment.

Figure 3: Impulse Response to Positive Productivity Shock

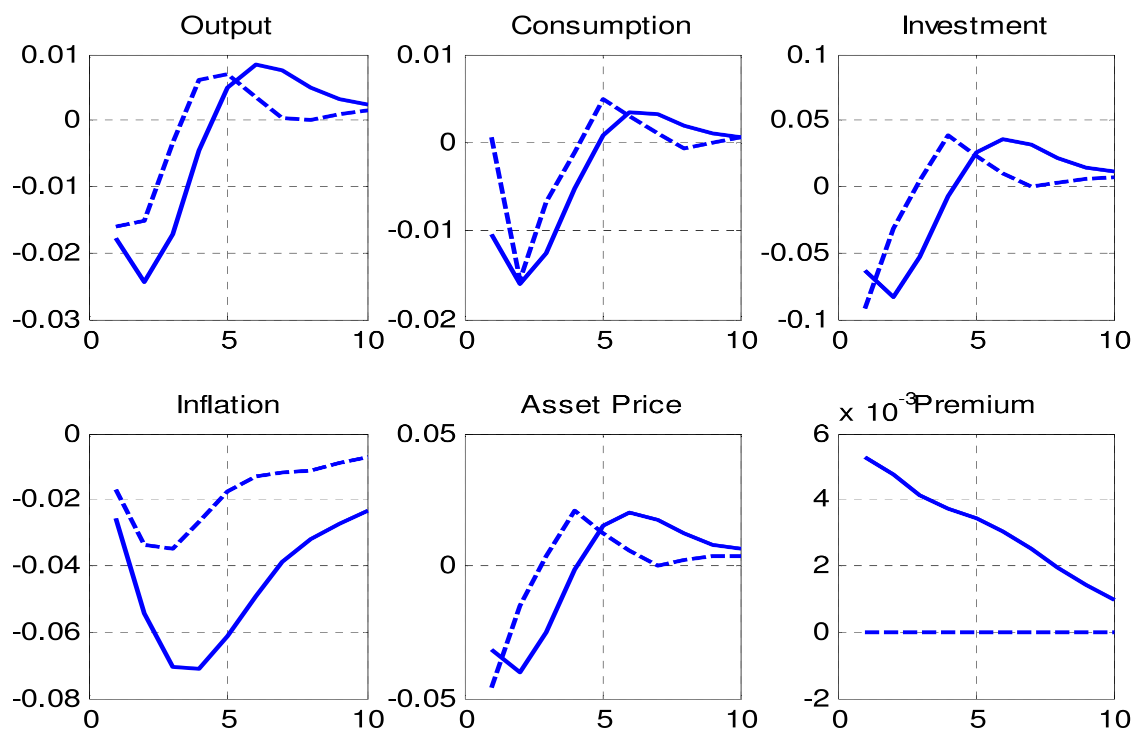


Finally, Figure 3 presents the endogenous response of the model economy to an exogenous total productivity shock. An improvement in the productive capacity of the economy generates expansion in output, capital stock, private consumption and investment spending which persists for more than two years after the realization of the shock. Inflation falls as a result of the increase in the supply of goods which can now be produced with superior technology than was previously possible. Specifically, a five percent increase in productivity lowers inflation by about three per cent on impact. To counter falling prices the monetary authority raises the policy rate.

Technological progress also appears to generate asset value appreciation which is quite persistent in the short run. For instance, a five percent increase in productivity leads to an increase in asset price by the same amount in the second quarter. A rise in asset prices improves the net worth of the entrepreneurial community and their leverage, though it increases initially, declines over time.

In all the three figures reported so far, the paths of all endogenous variables converge to their long run equilibrium value. This convergence can be interpreted as an indirect evidence for the stability of the model. I also tried changing the values of certain parameters, especially those related to the monetary policy feedback rule, to see the effect these changes on the implied evolution of the model economy. The overall qualitative and quantitative results remained reasonably unchanged.

Figure 4: Impulse Response to Monetary Policy Shock with Financial Frictions (solid line) and without Financial Frictions (dotted line)



In Figure 4 I show the relative responses of selected endogenous variables to a one-off quarterly monetary policy shock equal to 0.05 standard deviation. It is clear that the results are significantly different for the two models. In the model with financial distortions, unexpected increase in the policy rate lifts the cost of raising fresh capital for financial intermediaries which they translate into higher external premium for loan applicants. By contrast, when the role of frictions is switched off, there is no difference among the policy rate, the required rate of return on bank loans, and the rate of return on equity investment. This is summarised by the flat impulse response of the external finance premium. Consistent with conventional empirical evidence, monetary tightening is accompanied by a decline in inflation, output, consumption, investment, and asset prices. But the degree of contraction is deeper and more persistent in the model where supply and demand side financial market imperfections have been considered.

These results are broadly in line with previous findings that suggest stronger amplification of monetary policy shock in the real economy as a result of the interaction between corporate balance sheet and bank capital channels. Markovic (2006), Aguiar and Drumond (2007), and Zhang (2009) report that the effects of unanticipated central bank policy measures are amplified and propagated much more strongly with double agency cost problems in the financial markets. The innovation in this specific chapter is to see if previous findings under Taylor based rules could be replicated under money growth rules with monetary equilibrium conditions. And as shown above, the results of money growth rates are also robust under monetary aggregate rules.

One more point worth emphasizing is the negative co-movement between prices and output in response to positive fiscal shock which we observe both with financial frictions and without in chapter one. In chapter one, the fall in inflation in the closed economy was mainly due to the presence of liquidity-constrained households who spend their income and stimulate further growth, thus countering the adverse effect of a rise in the short term interest rate. In this chapter, the fall in inflation is mainly due to the presence of the financial distortion channel whereby an increase in the borrowing rate from heightened public spending causes a ripple effect via a decline in investment, consumption and production, which in turn places downward pressure on inflation.

Figure 5: Impulse Responses of Output and Inflation under Interest Rate (dotted) and Money Growth (solid) Rules

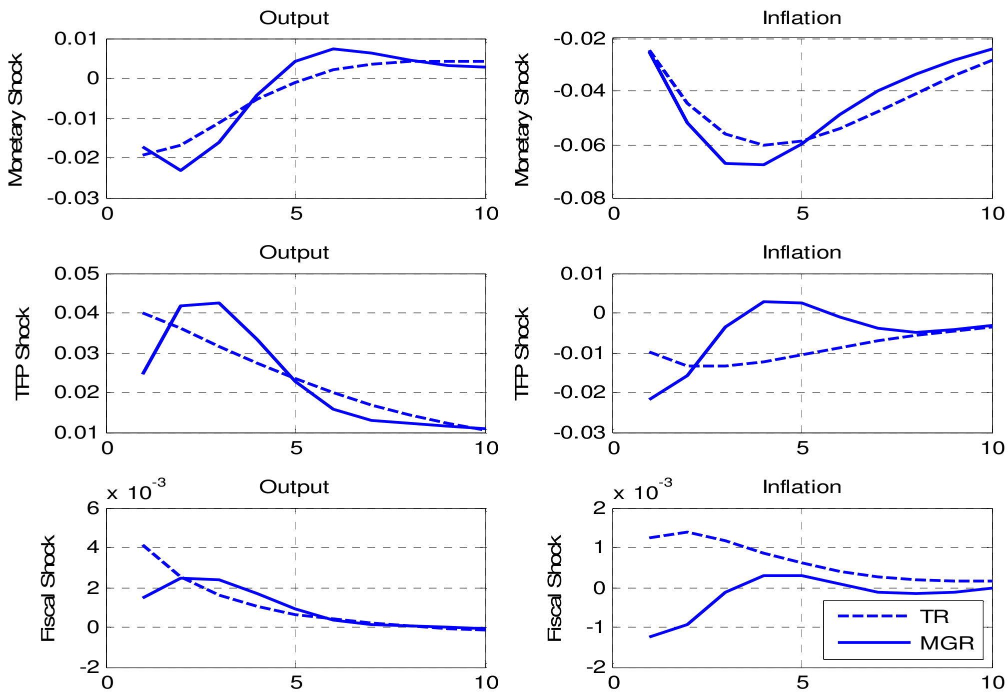


Figure 5 presents the responses of output and inflation to shocks under alternative monetary policy regimes. The qualitative aspects of the results are more or less preserved. For instance, contractionary monetary policy (a rise in the policy rate or a fall in money supply) leads to noticeable reduction in output and inflation while improvement in factor productivity boosts production and eases upward pressure on price changes. Increased fiscal intervention also expands output under both monetary policy rules. However, the effects of a rise in public expenditure on inflation clearly depend on the operational instrument deployed by the central bank. When the monetary authority sticks to an interest rate rule, increased government borrowing feeds into higher inflation. But under money growth rule expanded fiscal activism results in a decline in inflation. Thus with money growth as an instrument of macroeconomic stabilization, the fiscal theory of price does not appear to hold at least in the short run. To the extent that the output effect of a fiscal stimulus is more persistent, the money growth rule contributes to a fall in price changes in the short run. Over all, the model with money growth rule generates slightly higher volatility in output and inflation than the one with interest rate rule.

6. Conclusion and Policy Implications

In the last few years, macroeconomic modeling has emphasized the role of credit market frictions in magnifying and transmitting nominal and real disturbances and their implication for macro-prudential policy design. In this chapter, we construct a medium-size small New Keynesian general equilibrium model with active banking sector. In this set-up, the financial sector interacts with the real side of the economy via firm balance sheet and bank capital conditions and their impact on investment and production decisions. We rely on the financial accelerator mechanism due to Bernanke et al. (1999) and combine it with a bank capital channel as demonstrated by Aguiar and Drumond (2007). We calibrate the resulting model from the perspective of a low income economy reflecting the existence of relatively high investment adjustment cost, strong fiscal dominance, and underdeveloped financial and capital markets where the central bank uses money growth in stabilizing the national economy. Then we examine the impulse response of selected endogenous variables to five per cent standard deviation shocks stemming from the fiscal authority, the monetary policy process, and technological progress.

The findings are broadly consistent with previous studies that demonstrated stronger role for credit market imperfections in amplifying and propagating monetary policy shocks. While most studies assume an interest feedback rule to capture the behaviour of monetary authorities, we rely on a money growth rule to adapt to the dominant policy practice in low income economies. It is interesting that in our model the interaction of corporate and bank balance sheets generates similar results as those which employ interest rate rules (Markovic, 2006; Aguiar and Drumond, 2007; and Zhang, 2009, for instance).

The policy implication of this result is particularly relevant in low income countries where small and fragile firms face very high external finance premium. With little or no net worth to post as collateral, these firms often have to pay above market rates on small loans obtained from banks and microfinance institutions. Even though adding a default premium on poor borrowers makes perfect financial sense, it creates a kind of self-fulfilling prophesy where the higher lending rate undermines the ability of the poor borrower to start and operate profitable projects. A clear market failure is present in the loan market for poor households, which justifies well-designed and targeted intervention that facilitates the creation and provision of special loans to struggling businesses. The world has long recognized the importance of arranging concessional loans at lower rates and with grace periods for poor countries. And poor countries eligible for such programmes have made effective use of this arrangement in reducing poverty and creating employment for their citizens. A similar logic should apply at the micro level to rectify credit market failures for the penniless.

On the fiscal side, there is a longstanding disagreement regarding the role of public expenditure in national and regional economies. The conservative view disdains government activism on the ground that excessive deficit financing and the resulting public debt buildup generate higher inflation and interest rates. On the other hand, the progressive camp quite often supports increased intervention to mitigate the effects of income inequality and unemployment. In this chapter, we saw that fiscal expansion improves production and eases price pressure under money growth targeting regime (even though there is still an increase in nominal interest rate). This finding suggests that there is no necessarily causal relationship between increased fiscal spending and runaway inflation and that the public sector may not be as monstrous as it is often depicted by some elements on the right. Of course, on top of what has been done so far, future research will have to sort out the conditions under which public budgeting can smooth out businesses cycle fluctuations and enhance social welfare over the long run.

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Appendix A

First Order Conditions and Definitions

$$Q_t = 1 + \eta_{q,ik}\left(\frac{I_t}{K_t} - \delta\right) \tag{A1}$$

$$R_t^K = \left(\frac{MP_{k,t} + (1-\delta)Q_t}{Q_{t-1}}\right) \tag{A2}$$

$$K_{t+1} = I_t + (1-\delta)K_t \tag{A3}$$

$$\frac{E_t(R_{t+1}^K)}{R_{t+1}^F} = \upsilon\left(\frac{Q_t K_{t+1}}{N_{t+1}}\right), \tag{A4}$$

$$R_{t+1}^F = (1 - Del\_K)R_{t+1} + Del\_KE_t(R_{t+1}^S) \tag{A5}$$

$$N_{t+1} = \gamma V_t + W_t^e \tag{A6}$$

$$V_t = R_t^K Q_{t-1}K_t - R_t^F(Q_{t-1}K - N_t) - \mu\Theta(\bar{\omega}_t)R_t^K Q_{t-1}K_t, \tag{A7}$$

$$\begin{aligned} &E_t\{\frac{[1-\Gamma(\bar{\omega}_{t+1})](1+R_t^K)}{1+R_{t+1}^F} \\ &+\frac{1-F(\bar{\omega}_{t+1})}{1-F(\bar{\omega}_{t+1})-\mu\Theta(\bar{\omega}_{t+1})}\left[\frac{1+R_t^K}{1+R_{t+1}^F}(\Gamma(\bar{\omega}_{t+1})-\mu\Theta(\bar{\omega}_{t+1})-1\right]\} = 0 \end{aligned} \tag{A8}$$

$$MP_k = \alpha_k MC_t \frac{Y_t}{K_t} \tag{A9}$$

$$W_t^h = (1-\alpha_k)\Omega MC_t \frac{Y_t}{H_t^h} \tag{A10}$$

$$W_t^e = (1-\alpha_k)(1-\Omega)\,\mathrm{MC}_t \frac{Y_t}{H_t^e} \tag{A11}$$

$$\sum_{j=0}^{\infty}\theta^{j}E_{t}\left\{\Delta_{t+j}Y_{t+j}\left(\overline{P}_{t}-\frac{\varepsilon}{1-\varepsilon}MC_{t+j}^{n}\right)\right\}=0 \quad \text{(A12)}$$

$$C_{t}^{-\sigma}=\Psi_{t} \quad \text{(A13)}$$

$$\Psi_{t}=\beta E_{t}R_{t+1}^{D}\Psi_{t+1}+D_{t}^{-\sigma} \quad \text{(A14)}$$

$$\Psi_{t}=\beta\{E_{t}\Psi_{t+1}R_{t+1}^{S}+\mathrm{cov}_{t}(R_{t+1}^{S},\mathrm{C}_{t+1}^{-\sigma}\} \quad \text{(A15)}$$

$$(H_{t}^{h})^{\varphi}=\Psi_{t}W_{t}^{h} \quad \text{(A16)}$$

Regarding the activities of the fiscal and monetary authorities, the following relationships have been adopted consistent with the practice in low income countries where the central bank relies on targeting monetary aggregates as the main instrument to stabilize inflation and the output gap. The money growth rule (A17 and A18) in combination with the monetary equilibrium condition (A19) capture the monetary policy framework. However, it is assumed that public spending is exogenous as the fiscal policy process mainly responds to solving structural deficiencies such as the removal of infrastructural bottlenecks regardless of the state of the economy.

$$\mu_{t}^{m}=\rho_{m}\mu_{t-1}^{m}-k_{i,\pi}\pi_{t}-k_{i,\mathrm{y}}y_{t}-v_{t}^{\varepsilon} \quad \text{(A17)}$$

$$\mu_{t}^{m}=m_{t}-m_{t-1}+\pi_{t} \quad \text{(A18)}$$

$$m_{t}=y_{t}-\rho_{i}r_{t}^{n} \quad \text{(A19)}$$

$$g_{t}=ARg_{t-1}+v_{t}^{g} \quad \text{(A20)}$$

Appendix B

Parameter	Description	Value	Source
β	Subjective discount factor	0.98	
$k_{i,\pi}$	Central bank weight attached to inflation gap	1	
$k_{i,y}$	Central bank weight attached to output	0.11	
ρ_i	Interest semi-elasticity	0.0035	
θ	Calvo price rigidity	0.75	
ρ_m	Money growth rate smoothening/persistence	0.8	
AR	Coefficient for each exogenous process	0.8	
1/σ	Inverse elasticity of intertemporal substitution	1/3	
φ	Inverse elasticity of labour supply	4	
v	Elasticity of external premium with respect to leverage	0.041	
$\eta_{q,ik}$	Sensitivity of price of capital to the investment-capital ratio	0.5	
δ	Capital depreciation rate	0.025	
r^K	Steady state gross return on entrepreneurial project	1.0157	
r^F	Steady state cost of raising funds by lender	1.0107	
r	Steady state deposit/riskless rate	1.01	
K/N	Steady State leverage ratio	1.932	
Y/N	Steady State output net worth ratio	0.2383	
MP_K	Steady state marginal product of capital	0.0407	
Del_K	Exogenous capital requirement ratio	0.12	
C/D	Steady state consumption-deposit ratio	0.22	
α	Capital share in production	0.3	
$(1-\alpha)\Omega$	Fraction of labour supplied by households	0.693	
$(1-\alpha)(1-\Omega)$	Fraction of labour supplied by entrepreneurs	0.007	
MC	Steady state gross cost mark up	1.1	
μ	Loan monitoring cost	0.12	
γ	Business survival rate	0.97	
$\bar{\varpi}$	Steady state profit division parameter	0.4805	
$F(\bar{\varpi})$	Quarterly business bankruptcy rate	0.0075	
I/Y	Steady State ratio of Investment to GDP	0.18	
C/Y	Steady State ratio of Consumption to GDP	0.60	
G/Y	Steady State ratio of Public spending to GDP	0.22	

Appendix C

In this section I follow Gulan and Martin (2012) to compute the steady state elasticity of the external financial premium with respect to the leverage ratio. Based on the financial contract problem we discussed in the main text and its FOCs, we can start by defining $s(\bar{\omega}) = \frac{\lambda(\bar{\omega})}{\psi(\bar{\omega})} = \frac{R\_k}{R\_f}$ for the external finance premium and $\mathrm{k}(\bar{\omega}) = \frac{\psi(\bar{\omega})}{1-\Gamma(\bar{\omega})} = \frac{QK}{N}$ for the steady state leverage ratio where $\psi(\bar{\omega}) = 1-\Gamma(\bar{\omega}) + \lambda(\bar{\omega})[\Gamma(\bar{\omega}) - \mu\Theta(\bar{\omega})]$ and $\lambda(\bar{\omega}) = \frac{\Gamma'(\bar{\omega})}{\Gamma'(\bar{\omega}) - \mu\Theta'(\bar{\omega})}$. Then the elasticity parameter is computed as:

$$\eta_{q,ik} = \frac{d\,\mathrm{log}s(\bar{\omega})}{\mathrm{dlogk}(\bar{\omega})} = \frac{d\,\mathrm{log}s(\bar{\omega})/d\bar{\omega}}{\mathrm{dlogk}(\bar{\omega})/d\bar{\omega}} \tag{C1}$$

Substituting for the terms we defined above and differentiating with respect to the cut-off, we get a workable expression for the elasticity parameter:

$$\eta_{q,ik} = \frac{\left[\frac{\lambda'(\bar{\omega})}{\lambda(\bar{\omega})} - \frac{\psi'(\bar{\omega})}{\psi(\bar{\omega})}\right]}{\left[\frac{\psi'(\bar{\omega})}{\psi(\bar{\omega})} + \frac{\Gamma'(\bar{\omega})}{1-\Gamma(\bar{\omega})}\right]} \tag{C2}$$

Remember that $\Gamma(\bar{\omega})$ and $\Theta(\bar{\omega})$ are standard normal cumulative density functions and they are related to each other through $\Gamma(\bar{\omega}) = \Phi(z-\sigma) + \bar{\omega}[1-\Phi(z)]$ where $\Theta(\bar{\omega}) = \Phi(z-\sigma)$.

Since it is assumed that the idiosyncratic shock is log-normally distributed with mean $-0.5\sigma^2$ and variance σ^2, it has the following log-normal probability and cumulative density functions, respectively:

$$f(\omega) = \frac{1}{\omega\sigma\sqrt{2\pi}}\exp\left(-\frac{(\log\omega - E(\log\omega))^2}{2\sigma^2}\right) \tag{C3}$$

$$F(\bar{\omega}) = \int_0^{\bar{\omega}} f(\omega)d\omega \tag{C4}$$

Given that $F(\bar{\omega}) = \Phi(z)$ is the business bankruptcy rate and that z is related to the cut-off $\bar{\omega}$ via $z \equiv \frac{\log(\bar{\omega}) + 0.5\sigma^2}{\sigma}$, we only need to work out the first and second order derivatives of the density function embedded in C(2) to get the value of our elasticity parameter.

CHAPTER 3

"Exchange Rate Transmission into Consumer Price Inflation in Ethiopia-SVAR Approach"

I. Introduction

Many developing countries had for a long time resisted the allure of letting the value of their currencies be determined in the market. The reason is that while fixing the exchange rate eliminates conversion costs and unnecessary volatilities, allowing it to freely float entails destabilizing macroeconomic consequences. If the government and private firms have accumulated massive amount of foreign-currency-denominated debt, a fall in the exchange rate should raise the local currency value of the debt burden because of currency mismatches. The drop in the exchange rate also makes imported goods more expensive and this in turn feeds into—passes through—overall consumer price inflation. The threat of inflationary spiral along with potentially swelling debt have made currency pegs more attractive vis-à-vis flexible exchange rates.

Yet, fixing the exchange rate requires that the central bank is willing to subjugate other policy priorities to maintaining the desired level of the currency peg. This is what is commonly known as 'the Trilemma'—the notion that a country cannot enjoy monetary independence, free capital mobility, and a fixed exchange rate all at the same time. In other words, if policy makers prefer to fix their currency and retain the ability to set interest rates autonomously, they must decide to impose tough restrictions on capital account transactions. Because the government's reserves to defend a currency peg can be exhausted—thus risking abrupt devaluation-- it is often suggested a country adopts flexible exchange rate in tandem with monetary policy independence and allow capital to get into and out of the country freely.

It was partly in line with this wisdom that the transitional government of Ethiopian decided to let the national currency float in 1992[27], ending an almost five-decade-long regime in which the national currency, birr, had been pegged to the U.S. dollar. As pointed out earlier, floating[28] a currency makes

[27] The value of birr was fixed at 2.5 per U.S. dollar from 1945 to 1971. With the collapse of the Bretton Woods arrangement in the early 1970s it experienced a slight revaluation to 2.3. The socialist regime that took power in 1974 further revalued it to 2.07 and kept it there till its demise in 1991/1992.

[28] The dichotomy between fixed and flexible is not clear-cut and in fact many central banks adopt a middle ground. In the case of Ethiopia, for example, the monetary policy framework of the central bank states that

the concerned economy vulnerable to domestic price volatility arising from exchange rate pass-through which is typically the case for a small open economy like Ethiopia with a high degree of dependence on international trade, significant import content in domestic production, and sizeable share of tradable commodities.

Now that more than two decades have passed since greater exchange rate flexibility was introduced in Ethiopia, it is time that we measure the speed and size of exchange rate pass-through into domestic general and sectoral consumer prices. This is of interest to policy makers in at least two respects. First, if the degree and size of pass-through is subdued, then the central bank has the liberty to vary the exchange rate in an attempt to improve the country's balance of trade. This implies that the monetary authorities should not be concerned about the potentially inflationary repercussions of financial developments that place downward pressure on the national currency. Second, sectoral pass-through analysis provides the degree of exchange rate transmission across each specific consumer price category. Knowing which sectors respond more strongly to exchange rate fluctuations presents valuable insights for policy action aimed at furthering the overall welfare of the society. Third, while other studies have examined the issue of exchange rate pass-through for developing countries, almost none use government spending as a source of demand shock. And this paper aims at filling this gap.

In this paper I endeavor to examine exchange rate pass-through into domestic consumer price changes in Ethiopia. Quarterly observations covering the period from 19997.3 to 2011.4 are used for estimation and analysis. I employ recent developments in multivariate time series tools. A modest five dimensional structural VAR is estimated to trace out the effect of shocks in one variable on the path of price and other endogenous variables included in the model. Impulse response functions and forecast error variance decomposition are used to understand consumer price behaviour to changes in fiscal policy stance, monetary policy variables, world oil price and trade weighted exchange rates.

The impulse response function analysis indicates that nominal effective exchange rate plays a short-lived role in shaping consumer price developments in Ethiopia. In particular, a unit change in the trade weighted exchange rate (appreciation) caused the consumer price inflation to fall by about 0.01 after four quarters (or an accumulated response of about 0.11 after 14 quarters). The forecast error variance decomposition exercise shows own shock explains about 63 percent of the forecast error variability of inflation followed by world oil price (20 percent) and exchange rate (13 percent). Monetary aggregate

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"considering the underlying economic situation of the country, managed floating exchange rate regime is being practiced in Ethiopia since 1992. This exchange rate regime will continue to be adopted in the years to come."

has trivial effect for all horizons considered.

The rest of the paper follows this organization: the next section presents a brief review of the theoretical and empirical literature. Section II outlines the methodology followed by discussion of the estimation results in section IV. The last section provides the conclusion.

2 Pass-through literature

The question of how much of the change in the exchange rate is incorporated into domestic prices, import/export prices and trade volumes has long taken up the attention of empirical economists. Exchange rate pass through (ERPT) measures the percentage change in local currency price indices for a unit change in the exchange rate. A one-for-one pass through is called complete while a less than unity pass through is considered to be partial or incomplete.

Dornbusch (1985) and Krugman (1987) were some of the early influential contributions that developed models of partial equilibrium price adjustment in response to exchange rate changes within the context of industrial organization. Dornbusch relied on a framework where time is an important element in the adjustment process evolving around market concentration and the degree of substitution between imported and home produced goods. For instance, in the short run, the number of firms in an industry and their locations can be assumed to be unaffected, and wages do not respond to fluctuations in production and profitability. These assumptions, however, break down in the long run as persistent real appreciation in the exchange rate starts taking its toll on competitiveness. In such circumstances, affected firms will be compelled to slash wages causing unemployment in their industries with corresponding rise in wages and employment in expanding sectors. As a result, firms facing sharp increase in payroll expenses shut down and exit while industries with relatively low labour costs experience expansion. This long term behaviour in pricing decisions shaped by relocation and entry possibilities at micro level mimics the macroeconomics of adjustment to exchange rate movements.

Import prices in destination countries can also be affected by the foreign firms' pricing strategies in light of market share and profit considerations. Krugman (1987) formally popularized this notion which is now commonly referred to in the literature as Pricing to Market (PTM). PTM predicts that contrary to conventional approach, domestic prices of imported goods may not rise following depreciation as the producers would "mark down" the export price denominated in their own currency with the objective of stabilizing price in the importing country's market. With exchange rate appreciation the foreign firm would react by raising its prices (marking up to market) in order to maintain or raise its profit margins. All these depend on the structure of the industry, the intensity of competition, and the type of demand that the foreign producer faces. Firms operating in a highly competitive industry and, therefore, facing hugely elastic demand would not be tempted to raise markups even when importing country's currency appreciates. The rationale behind this conservative pricing decision is that the exporter firm protects its existing market share by keeping importer's local price constant. In contrast, a foreign firm operating in an oligopolistic environment with less elastic demand for its product can pass through the exchange rate changes to the price of importing country.

Issues of ERPT arise when different currencies[29] are considered in pricing traded goods (e.g. Engle and Devereux 2003, Gopinath et al 2008, Goldberg and Tille 2005, 2007). An internationally traded good can be invoiced in the importing country's own currency (known as Local Currency Pricing—LCP), or in the exporter's own currency (Producer Currency Pricing—PCP). A third possibility can arise when producers invoice their goods using a third-party currency (known as Vehicle Currency Pricing—VCP). For instance, an Ethiopian sesame exporter to China may choose to price his commodity in American dollar or in the European common currency unit rather than in the local currency, birr, or the Chinese renminbi. As a result, the type and pattern of currency adoption can have significant implications in the conduct of sound monetary and exchange rate policies as well as in the determination of the sign and size of pass-through effects. When an exporting foreign firm sets its prices in its own national currency (PCP), actual exchange rate fluctuations are wholly transmitted to the prices paid by consumers in importing countries—a 100% pass-through occurs. But, if the foreign firm sets its prices in the destination market currencies (LCP), the degree of exchange rate transmission to consumer prices will be close to zero, and expenditure switching induced by relative price movements will not occur.

PTM (or PCP) along with Dornbusch's proposition imply that when pass-through effects are muted due to active price management by producers, equilibrium exchange rates will be more responsive to fundamentals as domestic inflation becomes less sensitive to nominal exchange rate movements. PTM also affects the transmission of macroeconomic disturbances across countries. Absent the dampening effects of PTM, monetary policy shocks tend to cause high positive correlation in consumption changes internationally while changes in output would be highly negatively correlated. The converse

[29] For instance, exchange rate pass through is no longer a topic for discussion for intra-regional trade within the euro zone or any other monetary union. Euro zone member countries price their commodities in the single currency and, as a result, the attendant uncertainty and risk associated with exchange rate fluctuation are irrelevant.

holds true when PTM is in action. Thus co-movements in consumption decline in response to deviations from PPP induced by PTM. At the same time, however, PTM removes expenditure switching effects from changes in the exchange rate and this strengthens the contemporaneous fluctuations of outputs across economies (Betts and Devereux, 2000).

There is empirical evidence that firms indeed use different currencies when pricing their export commodities. Goldberg and Tille (2005, 2007) used a simplified centre-periphery model in which the centre (like the Fed in the U.S. or the ECB in the Eurozone) has the legal prerogative to issue the currency and countries in the periphery (nations outside the monetary and political jurisdiction of the issuer) are free to use this currency to facilitate intra-periphery transactions not necessarily involving the centre. They find a dominant role of the dollar as vehicle currency and suggest that this can amplify the periphery's exposure (which can be either desirable or harmful) to monetary policy shocks originating from the centre. On the positive side, monetary loosening in the issuing region or country entails depreciation of that currency, making the goods of periphery countries less expensive, and therefore, boosting trade for those countries. But the authors also point out that welfare loss can be substantial when a decentralized monetary policy reaction to productivity shocks in the centre fails to take into account the impact of exchange rate movements on relative prices in the periphery. In the absence of cooperative arrangements in monetary policy formulation and implementation, the prevalence of a vehicle currency invoicing in international trade can generate substantial adverse effects.

Table1. Dimensions of the International Role of the Dollars

	Year	Exports Invoice$ (1)	ShareUS (2)	Block$ (3)	Invoice$ (4)	ShareUS (5)	Block$ (6)
Japan	2001	52.8	30.4	21.1	70.0	18.3	33.5
Korea	2001	84.9	20.8	28.2	82.2	15.9	29.6
Malaysia	1996	66.0	18.2	13.4	66.0	15.5	6.7
Thailand	1996	83.9	17.8	17.5	83.9	12.3	14.5
Australia	2002	67.9	9.6	20.0	50.1	18.3	18.5

Notes: Adapted from Goldberg and Tille (2007). Year refers to the year of invoice observation and trade shares; Invoice$ in columns (1) and (4) stands for the share of a country's export or import priced in dollar; SharesUS represent the shares sold to and bought from the United Sates; and Block$ refers to those countries that use dollar invoicing in their observed international transactions (see Goldberg and Tille, 2007 for the exhaustive list of these countries). The left block (columns 1 to 6) represent country of export while the right block (columns 4 to 6) represent country of import.

Many Asian countries use the US dollar as their invoicing currency not just for exports shipped to the United States but also for transactions concluded with other countries. For instance, in 2001 South Korea had 85% of its exports in dollar price tags even though only 20% was sold in the US markets. A similar trend had been observed in Thailand in 1996. Australia, Japan and Malaysia also priced 50 to 70% of their export goods in American dollar.

A mushrooming literature is also making inroads into the microeconomic approaches (like PTM) by developing alternative general equilibrium models that analyze the impact of monetary policy conduct on exchange rate transmission mechanism and on the choice of exchange rate regimes (e.g. Bacchetta and van Wincoop, 2000; Engle and Devereux, 2002; Corsetti and Pessenti, 2005; Betts and Devereux, 2001).

Over the last two decades, scores of central banks in advanced, emerging, and developing countries have explicitly targeted[30] inflation rates with the objective of anchoring public inflation expectations, maintaining sufficiently low inflation environment and achieving minimal variability in prices. People who favour inflation targeting claim that established central bank credibility and reputation for containing inflation not only create conducive environment for growth but also generate positive spillover effects from international trade and investment. It is argued that countries with bad track record of high inflation numbers will be vulnerable to import prices denominated in foreign currency and consequently the exchange rate pass-through effects into their imported prices will be direct and

[30] New Zealand was the first country to popularize inflation targeting with official adoption in 1990. It has not only avoided its highly persistent and volatile inflationary past but has also achieved a low inflation environment with high output growth rates. Other countries followed New Zealand's example over the years and as of 2013 about 28 central banks explicitly target consumer prices as their main macroeconomic policy goal. Inflation targeting is not confined to the advanced industrial world; emerging and developing countries like Ghana, Brazil and Armenia have also experimented with it though the target bands are wider for these countries (6.5-10.5 percentage points in Ghana, for instance, while it is 1-3 in New Zealand). Though inflation targeting may have achieved its main mission of containing price volatility, there are several downsides to its adoption. For one thing, it requires considerable central bank independence from public policy process and monetary planners cannot target other macroeconomic objectives like employment and the exchange rate.

substantial. By contrast, countries popular for sound monetary policy practice and low volatility of inflation have higher likelihood that their import goods will be priced in their own currency, which abates exchange rate pass-through even in the event of significant depreciation. It must be noted that the structure of international financial markets has significant bearing on the effects of monetary policy in influencing the behaviour of exchange rate transmission. When access to consumption risk sharing is widely available from international capital markets, it is relative, not absolute, monetary policy soundness that matters. An economy with the most stable price will get priority in getting its imports set in its own currency even when economies in the vicinity maintain comparably stable monetary policy process.

The concept of inflation targeting is closely associated with the goal of maintaining a low inflation environment. Taylor (2000) formalized it using both theoretical (staggered pricing model at micro level) and empirical methods (simulation exercise). He argued that the low exchange rate pass through observed in recent years is largely due to the conservative monetary policy stance aimed at controlling inflation rather than the diminished pricing power of firms per se. In other words, an increase in nominal marginal cost will have persistent effects in a highly unstable macroeconomic environment than one characterized by a high degree of price stability. He extends similar logic to exchange rate movements. Nations with comparable price developments with their trading partners rarely experience persistent depreciations. As a result, economies with stable prices face lower exchange rate pas through than economies with massively volatile prices irrespective of the sources of cost increase (exchange rate depreciation, upsurge in wages or goods prices). He complements his theoretical analysis with simulation exercise for the US economy and shows that the relationship between aggregate output and price level can be quantitatively significantly affected by agents' expectations on pass through. Stated differently, we would observe resurgence in pricing power of firms if actual policy contradicted low inflation goals.

Many independent researchers have attempted to verify the claims implied by Taylor's thinking. Ca' Zorzi et al. (2007) studied twelve emerging economies[31] using multivariate vector autoregressive methods. Six quarterly endogenous variables were considered, namely, oil price index, output, exchange rate, import price index, consumer price index, and a proxy for short term interest rate. Industrial production was chosen for some of the countries in the sample as quarterly output was not

[31] Their sample comprises a list of emerging and developing countries from Asia (Hong Kong, Taiwan, China, Korea, and Singapore), Latin America (Mexico, Argentina, and Chile), and Europe (Czech Republic, Poland, Hungary, and Turkey).

available. They identify the structural shocks through recursive variable ordering and exploiting Cholesky decomposition on the reduced VAR error covariance estimates. They repeat this exercise for each country in their sample. Some of their findings include: 1) ERPT is low for those countries (mostly Asian) with single digit inflation credentials and that this result is not dissimilar from those documented for richer economies 2) the pass through effect is close to unity after a passage of one to two year horizons for high inflation countries like Poland, Hungary, and Turkey in Europe and for all three from Latin America (Mexico, Chile and Argentina) 3) exchange rate pass through into consumer prices is generally lower than pass through into import prices. This was consistent for all countries investigated.

E. Ihrig et al. (2006) confirmed Taylor's doctrine by estimating a modified reduced form equation derived from the low of one price. Exchange rates, commodity prices, their lags and volatilities are used as explanatory variables. Both local and foreign factors are considered. They estimate import and consumer price equations for each country using quarterly data spanning the period 1975q1-2004q4. Their estimation results suggest that import price pass through from exchange rate changes significantly dropped in the periods from 1975 to 1989 and from 1990 to 2004. Specifically, a unit percentage decrease in local currency value would have caused a corresponding 0.7 percentage point increase in import prices on average across these countries in the 1970s and 1980s; but in the last 15 years the increase fell to only 0.4 percentage point. Moreover, exchange rate responsiveness of consumer price declined for nearly every country. A percentage point depreciation of local currency would have generated about a 0.2 percentage point increase in consumer price on average in the sample countries in the late 1970s and 1980s. The effect was almost neutral in the past 15 years (the bench mark being the year 2006 when the authors published their findings).

3 Methodology

Impulse responses functions (IRFs) trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are muted. The implied thought experiment of changing one error while holding the others constant makes most sense when the errors are uncorrelated across equations, so impulse responses are typically calculated for recursive and structural VARs. Because of the complicated dynamics of the VAR models, impulse response, Granger causality and forecast error variance decomposition statistics are more informative than estimated regression coefficients or some other statistic coming from the VAR (Stock and Watson, 2005).

To see how IRFs are computed, let Yt be a k x 1 vector of endogenous variables, a reduced form vector autregression (VAR) model has the following representation,

$$AY_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + ... + \Pi_p Y_{t-p} + B\varepsilon_t \tag{1}$$

$$AY_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + ... + \Pi_p Y_{t-p} + B\varepsilon_t$$

where ε_t is an (K x 1) dimensional white noise process such that $\varepsilon_t \sim WN(0,\Sigma)$;

c is an (K x1) vector of constants;

Π_i is an (K x K) matrix of coefficients

In assessing innovation accounting, we need to represent the finite order VAR (p) in an infinite vector moving average (VMA) form:

$$\Pi(L)Y_t = c + \varepsilon_t \tag{2}$$

where $\Pi(L) = I_K - \Pi_1 L - ... - \Pi_p L^p$ and L is the lag or backshift operator. The VAR (p) is stable if and only if the roots of the characteristic polynomial equation

$\det(I_K - \Pi_1 z - ... - \Pi_p z^p) = 0$ lie outside the complex unit circle.

One way to compute the impulse response function is first to get moving average coefficients from the corresponding VAR process and sum up all the MA coefficient matrices over the entire period of interest. The sum of these MA coefficient matrices is known as long-run effects or total multipliers (Lutkepohl, 2011).

Let

$$\Phi(L) = \sum_{i=0}^{\infty} \Phi_i L^i$$

be an operator such that

$$\Phi(L)\Pi(L) = I_n. \tag{3}$$

Pre-multiplying equation (2) by $\Phi(L)$ gives us

$$Y_t = \Phi(L)c + \Phi(L)\varepsilon_t$$

$$= \left(\sum_{i=0}^{\infty}\Phi_i\right)c + \sum_{i=0}^{\infty}\Phi_i\varepsilon_{t-i} = \mu + \sum_{i=0}^{\infty}\Phi_i\varepsilon_{t-i} \quad (4)$$

where the mean μ is obtained as follows:

$$\mu = \Phi(1)c = \Pi(1)^{-1}c = (I_K - \Pi_1 - ... - \Pi_p)^{-1}c$$

The operator $\Phi(L)$ is the inverse of $\Pi(L)$ and is therefore sometimes denoted by $\Pi(L)^{-1}$. We call the operator $\Pi(L)$ invertible if $|\Pi(z)| \neq 0$ for $|z| \leq 1$. If this condition is satisfied, the coefficient matrices of $\Phi(L) = \Pi(L)^{-1}$ are absolutely summable and, hence, the process $\Phi(L)\varepsilon_t = \Pi(L)^{-1}\varepsilon_t$ is well defined (Lutkepohl, 2011). Thus the coefficients Φ_i can be obtained from equation (3) using the relations

$$I_K = (\Phi_0 + \Phi_1 L + \Phi_2 L^2 + ...)(I_K - \Pi_1 L - ... - \Pi_p L^p)$$

$$= \Phi_0 + (\Phi_1 - \Phi_0\Pi_1)L + (\Phi_2 - \Phi_1\Pi_1 - \Phi_0\Pi_2)L^2 + ... + (\Phi_i - \sum_{j=1}^{i}\Phi_{i-j}\Pi_j)L^i + ... \quad (5)$$

Lutkepohl shows that we can recover the recursive MA coefficient matrices which are the corner stone for impulse response analysis as follows:

$$\Phi_0 = \Pi_0 \quad (6.a)$$

$$\Phi_1 = \Pi_1 \quad (6.b)$$

$$\Phi_i = \sum_{j=1}^{i}\Phi_{i-j}\Pi_j, \qquad \text{i= 1, 2,…} \quad (6.c)$$

The symmetric positive definite variance covariance matrix (Σ_ε) of the innovation process in equation (4) can be decpmposed into the product $\Sigma_\varepsilon = PP'$, where P is a lower triangular non-degenerate matrix with positive elements along its diagonal. As a result, equation (4) can be re-written as:

$$Y_t = \mu + \sum_{i=0}^{\infty}\Phi_i PP^{-1}\varepsilon_{t-i} = \mu + \sum_{i=0}^{\infty}\Theta_i\omega_{t-i}, \quad (7)$$

where $\Theta_i = \Phi_i P$ and $\omega_t = P^{-1}\varepsilon_t$ are white noise processes ($\Sigma_\omega = I_K$) which have uncorrelated components and are known as orthogonal residuals or innovations. Thus the optimal h-step ahead forecast error of the K-dimensional Y_t is:

$$Y_{t+h} - Y_t(h) = \sum_{i=0}^{h-1} \Theta_i \omega_{t+h-i} \tag{8}$$

As the orthogonal innovations ($\omega_{k,t}$'s) are uncorrelated and have unit variances, the mean square error (MSE) of the jth component, $y_{j,t}(h)$, is computed by using the formula:

$$\mathrm{E}(y_{j,t+h} - y_{j,t}(h))^2 = \sum_{k=1}^{K} (\theta_{jk,0}^2 + \ldots + \theta_{jk,\mathrm{h}-1}^2). \tag{9}$$

Equation (9) measures the contribution of the innovations originating from variable k to the overall MSE or forcaste error variability of variable j. The overall MSE in forecasting variable j is the sum of the contributions of all K endogenous variables in the system:

$$\mathrm{MSE}[\mathrm{y}_{j,t}(h)] = \sum_{i=0}^{h-1} \sum_{k=1}^{K} \theta_{\mathrm{jk},i}^2 \qquad (10).$$

The ratio of (9) to (10) gives us the proportional contributions of each innovation in the h-step forecast.

SVAR Identification

To impart economic content[32] to the shocks that drive changes in endogenous variables, we should place certain restrictions on matrix A, matrix B or both. For instance, a bivariate[33] structural system of

[32] Without theoretical guidance which would help establish some kind of causal relationships within the system, the task of identification can be quite an elusive exercise. For example, if one wishes to construct a structural VAR with five variables, there will be 5! (120) possible permutations and deciding the correct ordering of the variables will become tricky.

[33] The bivariate VAR(1) system has the form $\begin{bmatrix} 1 & a_{12} \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} c_{10} \\ c_{20} \end{bmatrix} + \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$, and has 10 unknown parameters (two constants, four auto-regressive coefficients, three elements in the symmetric

order one derived from equation (1) has 10 parameters to be estimated while its reduced form counterpart has only 9 and the SVAR is not identified. To undertake IRF and FEVD analyses, we must impose restrictions on some of the coefficients of the contemporaneous correlation matrix B. Sims (1980) suggests that the structural VAR error covariance matrix be decomposed into PP' using the so called Cholesky factorization where P is a lower triangular matrix. IRFs derived from the application of Cholesky decomposition are known as orthogonalized IRFs. A standard VAR model can be taken as the reduced form representation of a dynamic structural equation, and the lower triangular matrix P can be obtained by reorienting the structural system into a recursive representation. The orders in which the endogenous variables appear in the VAR model establish the recursive structure which in turn bears our Cholesky decomposition.

We can define an SVAR model by modifying the expression given in equation (1):

$$AY_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + B\varepsilon_t \tag{11}$$

The (KxT) dimensional structural error terms, ε_t , are assumed to be white noise processes and are independent of each other. This independence assumption is critical in the identification exercise described below. The coefficient matrices Π_i for each i = 1, . . . , p, represent coefficients of the structural model which potentially differ from coefficient matrices of the corresponding reduced form model.

By left-multiplying the preceding equation by the inverse of A and replacing the resulting constant term and coefficient matrices by alpha and phi's we get:

$$Y_t = A^{-1}c + A^{-1}\Pi_1 Y_{t-1} + A^{-1}\Pi_2 Y_{t-2} + \ldots + A^{-1}\Pi_p Y_{t-p} + A^{-1}B\varepsilon_t \tag{12}$$

$$Y_t = \alpha + \Theta_1 Y_{t-1} + \Theta_2 Y_{t-2} + \ldots + \Theta_p Y_{t-p} + u_t \tag{13}$$

with $\Theta_i = A^{-1}\Pi_i$ for all i=1,...p.

We must impose restrictions on the matrices A or B or both in order to conduct impulse response and forecast error variance decomposition within the SVAR framework. In other words, the structural model differs from the reduced form model in so far as we place restrictions on the appropriate forms

error variance-covariance matrix, and the two contemporaneous impact parameters on the left hand side (LHS) of the system. The reduced form system has no LHS parameters and provides 9 parameters.

of residual covariance matrix coefficients A and B. As a result, the residuals of the reduced form model can be recovered from the corresponding structural VAR model using:

$$u_t = A^{-1} B \varepsilon_t .$$

where

$$u_t = \begin{bmatrix} u_{o,t} \\ u_{e,t} \\ u_{g,t} \\ u_{m,t} \\ u_{p,t} \end{bmatrix}, \qquad \varepsilon_t = \begin{bmatrix} \varepsilon_{o,t} \\ \varepsilon_{e,t} \\ \varepsilon_{g,t} \\ \varepsilon_{m,t} \\ \varepsilon_{p,t} \end{bmatrix}, \qquad A^{-1} = \begin{bmatrix} \psi_{1,1} & \psi_{1,2} & \psi_{1,3} & \psi_{1,4} & \psi_{1,5} \\ \psi_{2,1} & \psi_{2,2} & \psi_{2,3} & \psi_{2,4} & \psi_{2,5} \\ \psi_{3,1} & \psi_{3,2} & \psi_{3,3} & \psi_{3,4} & \psi_{3,5} \\ \psi_{4,1} & \psi_{4,2} & \psi_{4,3} & \psi_{4,4} & \psi_{4,5} \\ \psi_{5,1} & \psi_{5,2} & \psi_{5,3} & \psi_{5,4} & \psi_{5,5} \end{bmatrix} \text{ and}$$

$$B = \begin{bmatrix} \lambda_{1,1} & 0 & 0 & 0 & 0 \\ 0 & \lambda_{2,2} & 0 & 0 & 0 \\ 0 & 0 & \lambda_{3,3} & 0 & 0 \\ 0 & 0 & 0 & \lambda_{4,4} & 0 \\ 0 & 0 & 0 & 0 & \lambda_{5,5} \end{bmatrix}$$

And its variance is computed as $\Sigma_u = \text{var}(A^{-1} B\varepsilon_t) = A^{-1} B \,\text{var}(\varepsilon_t) B' A^{-1'} = A^{-1} BB' A^{-1'}$ where we have assumed that the structural error process has a k dimension identity matrix as its variance covariance matrix.

The identification scheme can be achieved through the log likelihood method which minimizes the negative of the concentrated log-likelihood function for A and B:

$$\ln L_c(A, B) = -\frac{kT}{2}\ln(2\pi) + \frac{T}{2}\ln|\mathrm{A}|^2 - \frac{T}{2}\ln|\mathrm{B}|^2 - \frac{T}{2}\mathrm{tr}(\mathrm{A'B'^{-1}A}\Sigma_u) \qquad (14)$$

With log- likelihood, depending on the nature of restrictions, three types of SVAR- models can be distinguished:

- Model A: we set matrix B to an identity matrix I_k and the minimum number of restrictions for identification is equal to $\frac{k(k-1)}{2}$.
- Model B: now we set A to I_k while the minimum number of restrictions we need to impose for identification is the same as for model A.
- Model AB: here we impose restrictions on both matrices A and B and the minimum number of restrictions for identification is now $k^2 + \frac{k(k-1)}{2}$. In the five-variable SVAR we attempt to build, this amounts to imposing 35 restrictions.

As matrix B is already diagonal (with $k^2 - k$ restrictions in place), the remaining $(k^2 + k)/2$ restrictions have to be imposed on matrix A^{-1} which effectively reduces it to a lower triangular matrix with its diagonal elements normalized to unity. This lends economic interpretability to the reduced VAR errors which are now expressed as linear combinations of the structural innovations or shocks.

In the Cholesky decomposition employed below, supply factors are most exogenous as a small open economy like Ethiopia has little or no leverage on international commodity (including petroleum) price movements. Thus, world energy price is independent and is not contemporaneously affected by changes in other variables. This amounts to imposing four restrictions on the last four entries of the first row in matrix A. The data generating process is described as

$$u_{o,t} = \varepsilon_{o,t} \tag{15}$$

The behaviour of the exchange rate is assumed to respond to multiple factors which cannot be more directly influenced by the decisions of monetary authorities in Ethiopia. So the exchange rate should appreciate with substantial inflow of foreign aid and remittances (which depend on economic conditions in the West) or with rise in foreign exchange reserves from improvements in the country's terms of trade. Conversely, we should expect significant depreciation over time when foreign capital inflow is declining, say, because of catastrophic global financial and economic crises that disrupt capital mobility to the developing world. Equation (12) summarizes the behavior of the exchange rate shock which responds simultaneously to energy price shock but is not affected by the shocks originating from other variables:

$$u_{e,t} = \psi_{2,1}\varepsilon_{o,t} + \varepsilon_{e,t} \tag{16}$$

As in Mwase[34] (2006), demand factors precede the monetary measure. The consumer price is the most endogenous variable and appears last in the recursive representation. Previous studies that have

[34] Mwase's paper on Tanzania does not consider supply side factors arguing that the most promising candidate, world oil price, is not the appropriate proxy as it is substantially subsidized by the government. But a measure of demand-side factor represented by Hodrick-Prescott-filtered output gap is ordered before the monetary aggregate. Unlike Mwase who assumes that money demand reacts to inflation, for Ethiopia I assume that the behaviour of general price level is driven by money growth which in turn is influenced by the government's highly interventionist spending needs.

ordered price changes last in the structural equation include Ito and Sato[35] (2007), McCarthy (2006), Moshin et al. (2012) and Sanusi (2010). Equations (17) to (19) define the structural dynamic relationships for public spending, money growth and domestic price shocks, respectively.

$$u_{g,t} = \psi_{3,1}\varepsilon_{o,t} + \psi_{3,2}\varepsilon_{e,t} + \varepsilon_{e,t} \tag{17}$$

$$u_{m,t} = \psi_{4,1}\varepsilon_{o,t} + \psi_{4,2}\varepsilon_{e,t} + \psi_{4,2}\varepsilon_{g,t} + \varepsilon_{m,t} \tag{18}$$

$$u_{\pi,t} = \psi_{5,1}\varepsilon_{o,t} + \psi_{5,2}\varepsilon_{e,t} + \psi_{5,3}\varepsilon_{g,t} + \psi 4\varepsilon_{g,t} + \varepsilon_{\pi,t} \tag{19}$$

As a result, the exactly identified model to be estimated takes the form defined by equation (20).

$$\begin{bmatrix} u_{o,t} \\ u_{e,t} \\ u_{g,t} \\ u_{m,t} \\ u_{p,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \psi_{2,1} & 1 & 0 & 0 & 0 \\ \psi_{3,1} & \psi_{3,2} & 1 & 0 & 0 \\ \psi_{4,1} & \psi_{4,2} & \psi_{4,3} & 1 & 0 \\ \psi_{5,1} & \psi_{5,2} & \psi_{5,3} & \psi_{5,4} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{o,t} \\ \varepsilon_{e,t} \\ \varepsilon_{g,t} \\ \varepsilon_{m,t} \\ \varepsilon_{p,t} \end{bmatrix} \tag{20}$$

[35] The set up implemented in this study closely mimics the style followed by Ito and Sato (2007) where they examine pass through effects in a post-crisis environment in a host of Latin American and Asian economies. They consider oil price, trade weighted exchange rate, output gap, money supply measure, consumer price, producer price, and import price. The last two prices are not considered here because of the lack of long, reliable data points for these indices. However, instead of a filtered output gap, I have chosen to use government expenditure to proxy demand shocks. This is quite sensible as the public sector plays a very decisive role in Ethiopia through massive spending programms with the potential to move real and nominal aggregate variables by wide margins.

4 Estimation and Discussion of Results[36]

Visual inspection can provide rough insights into the temporal properties of the raw data[37] . The plots of the natural log-transformed series are provided in Figure 1. Most of the series appear to be non-stationary. The consumer price index, government expenditure, and broad money supply exhibit clear, persistent, and increasing trend while the trade weighted nominal exchange rate is declining over time. It is not obvious what type of path is being followed by international oil price though at first glance a fuzzy upward trend is apparent. The nominal exchange rate has been steadily and sharply depreciating, especially over the past decade.[38]

The basic summary statistics computed based on the natural log-transformed data are given in Table A.1. The log of the nominal effective exchange rate of birr registered a minimum value of about 3.7 in the late period of the sample and was more than twice as large (4.8) early in the sample period which is quite consistent with the long-term depreciating trend of birr against the currencies of Ethiopia's key trading partners.

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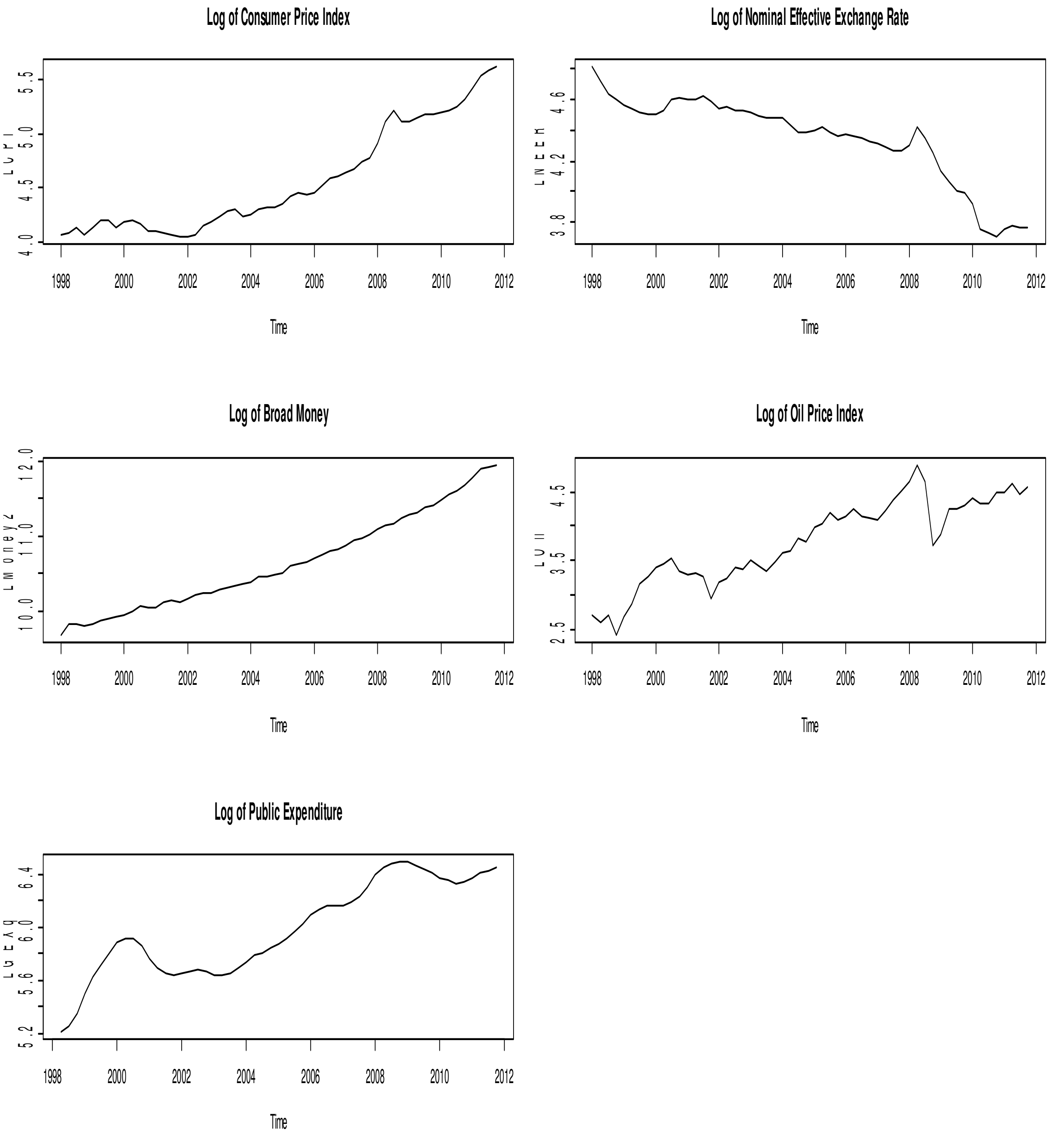
[36] Most of the time series analysis was done using R which is freely accessible software programming language widely used for statistical computation and graphics. The latest version (R 3.0.3) can be downloaded from the project's website available at http://cran.r-project.org/.

[37] The data were collected from several sources: money stock (in millions of Birr) and price series are from the National Bank of Ethiopia (NBE). The exchange rate is from the Ethiopian Development Research Institute while quarterly world oil price was adapted from the monthly West Texas crude oil price. Government expenditure was interpolated/forecast from annual observations using the Chow-Lin generalized least square method.

[38] I mentioned in the introduction section that the fixed exchange rate regime in Ethiopia was terminated in 1992 following the accession to power of the Ethiopian Revolutionary Democratic Front (EPRDF). While devaluation began in 1992, the sample period in this study starts from 1997. The reason is that even though exchange rate values are available for longer period, I start from 1997 as higher frequency series for the consumer price inflation is available only from 1997.

Figure 1. The Logarithm of Each Quarterly Series Plotted against Time



The highest variability as proxied by the respective standard deviation for each log series was observed in broad money supply (0.641), which was more than twice as volatile compared with the trade weighted exchange rate (0.29). World oil price showed the same degree of volatility as broad money while government expenditure and consumer price changes exhibited closely similar fluctuation.

Seasonal Unit Root Test

The HEGY seasonal integration test suggested by Hylleberg et al. (1990) for quarterly[39] data is implemented by estimating the following equation by OLS:

$$\Delta_4 x_t = \alpha + \sum_{i=1}^{4} \pi_i y_{i,t-1} + \sum_{i=1}^{4} \gamma_i SD_{i,t} y_{i,t-1} + \sum_{i=1}^{p} \delta_i \Delta_4 x_{i,t-1} + \xi t + \eta_t \tag{21}$$

In the augmented regression equation given above, $y_{i,t}$ for each i=1,...,4 is computed as

$$y_{1,t} = (1+L)(1+L^2)x_t = x_t + x_{t-1} + x_{t-2} + x_{t-3}, \tag{22.a}$$

$$y_{2,t} = -(1-L)(1+L^2)x_t = -x_t + x_{t-1} - x_{t-2} + x_{t-3}, \tag{22.b}$$

$$y_{3,t} = -(1-L)(1+L)x_t = -x_t + x_{t-2}, \tag{22.c}$$

$$y_{4,t} = -L(1-L)(1+L)x_t = y_{3,t} = -x_{t-1} + x_{t-3} \tag{22.d}$$

where x_t is the original observed series and L is the backshift operator. $SD_{i,t}$ are seasonal dummies, t is a deterministic time trend , and α is a drift parameter. It should be noted that the inclusion of such deterministic terms has considerable effect on the determination of the critical values of t and F tests described below.

Testing for seasonal integration is equivalent to testing for the statistical significance of π_i for each i= 1,…,4. In other words, the null hypotheses $\pi_1 = 0$ and $\pi_2 = 0$ imply the absence of seasonal unit roots at zero frequency and bi-annual frequency, respectively; while the joint null hypothesis $\pi_3 = \pi_4 = 0$ tests for the existence of seasonality at annual cycle.

Tables A.1 and A.2 (included in the appendix section) display the estimation results for the HEGY seasonal unit root test in levels and first differences, respectively. The null hypotheses for biannual and annual frequency seasonal unit roots are decisively rejected for all level series in the sample. But

[39]Given the factorization $(1-L^4) = (1-L)(1+L)(1+L^2)$, there are four possible unit roots: +1 (which corresponds to non-seasonal unit root at zero frequency), -1 (for bi-annual seasonal frequency), and two complex seasonal unit roots $\pm i1$ (at annual frequency).

seasonality at zero frequency cannot be rejected for all the series with the exception of government spending which is trend stationary[40]. For reasons primarily of comparison, I also carried out unit root tests based on standard ADF[41] method and the results are shown in Table A.3. It is evident that there is consistency of results between the HEGY test and the latter approach.

As a result the estimation of the VAR system (output included in appendix section) and the attendant innovation accounting analysis make use of all first differenced series with the exception of government expenditure which is in levels. The automatic information criteria[42] for lag selection suggested an optimal lag length of 8. But the VAR system based on 8 lags could not pass major diagnostic checks including normality tests for residuals even though the estimated model fits the data quite neatly. To overcome this problem, I implemented a specific-to-general procedure in choosing the optimal lag length by estimating systems with lag orders from one to four which are then compared with the model suggested by the information criteria.

The test scores for these models are shown in Tables 2 and 3. In Table 3 the multivariate versions of model diagnostic test results for heteroskedatsicty, serial correlation, and normality are presented. The estimated model residuals pass all diagnostic checks in VAR (1), VAR (2), and VAR (3). Clearly model VAR (8) does not satisfy any of the diagnostic checks while model VAR (4) fails to pass the sniff test of serial correlation. Finally, I decided to proceed with VAR (1) even though VAR (2) and VAR (3) are equally qualified--for two main reasons. First, overparametrization is avoided through parsimony. Second, as shown in Table 2, VAR (1) is favoured by BIC which is robust against small sample bias.

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[40] The presence of any potential co-integration relationship (the rational for vector error correction mechanism) was not considered as this would require the same order of integration among all endogenous variables. Both HEGY and ADF unit root test results suggest public spending is trend stationary at 5% level of significance. Consequently, I have chosen to focus on short run fluctuation leaving long-run dynamics open for future studies.

[41] Given a time series x, the ADF test for the existence of regular unit root is implemented by estimating $\Delta x_t = \alpha + \beta t + \phi x_{t-1} + \sum_{i=1}^{k-1} \gamma_i sd_i + \sum_{j=1}^{p} \delta_i \Delta x_{t-j} + \varepsilon_t$ by OLS. Depending on the data generating process under consideration, deterministic terms like drift (α), time trend (t) and/or seasonal dummies (sd) maybe included in the regression equation. The null hypothesis of unit root corresponds to testing whether the coefficient on the lagged variable (ϕ) is significantly different from zero.

[42] The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) suggested an optimal lag length of 9 each while the Forecast Prediction Error (FPE) selected a lag order of 8.

Table 2. Model Selection

Criteria	VAR(1)	VAR (2)	VAR (3)	VAR (4)	VAR (8)
LR	414.4	457.2	476.9	522.3	812.5
AIC	-758.8	-794.5	-783.8	**-824.6**	-1214.9
BIC	**-689.8**	-677.4	-619.6	-614.3	-840.1

Remarks: the Likelihood Ratio (LR) measures the likelihood (sic) that the data have been observed for a given parameter set. The largest positive number (or the smallest negative number in absolute value) suggests the best fit. Conversely, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) minimize the prediction mean square errors. As a result, the best model is the one associated with the smallest positive number (or the largest negative number in absolute value).

Table 3. Diagnostic Test

Test	**VAR (1)**	**VAR (2)**	**VAR (3)**	VAR (4)	VAR (8)
Serial Correlation	0.288	0.393	0.087	0.000	0.000
Heteroskedasticity	1.000	1.000	1.000	1.000	1.000
Normality	0.313	0.987	0.993	0.964	0.000
Skewness	0.548	0.318	0.922	0.966	0.012
Kurtosis	0.181	0.878	0.972	0.757	0.000

Remarks: all numbers in the table are p values. The null hypothesis in each case is that the model errors are not serial correlated, are homoskedastic, and follow normal distribution. The methods employed are the multivariate versions of Portmanteau asymptotic, autoregressive conditional heteroskedasticity (ARCH), and Jarque Bera tests, respectively.

Impulse Response and Forecast Error Variance Analyses

The CUMSUM of the residuals (provided in the appendix) confirms that structural break is not an issue as the model errors are well behaved and the SVAR is estimated based on the VAR((1). The identified structural relationships decsribed in equations (12) to (15) are shown stated in equations (19) to (23). As seen in the last expression, most of the variables have the expected sign.

$$u_{o,t} = 0.0238\varepsilon_{o,t} \quad (19)$$

$$u_{e,t} = 0.0166\varepsilon_{o,t} + 0.0464\varepsilon_{e,t} \quad (20)$$

$$u_{g,t} = 0.0203\varepsilon_{o,t} + 0.0020\varepsilon_{e,t} + 0.0356\varepsilon_{g,t} \quad (21)$$

$$u_{m,t} = 0.47e-04\varepsilon_{o,t} + 0.0049\varepsilon_{e,t} + 0.0054\varepsilon_{g,t} + 0.0275\varepsilon_{m,t} \quad (22)$$

$$u_{\pi,t} = 0.0246\varepsilon_{o,t} + 0.0198\varepsilon_{e,t} + 0.01163\varepsilon_{g,t} - 0.0029\varepsilon_{m,t} + 0.0441\varepsilon_{\pi,t} \quad (23)$$

Innovation accounting from the resulting SVAR was performed to trace out the impact of a one-time unit shock in one variable on the trajectory of other variables over time.

Table 4. Accumulated Impulse Response of General CPI Inflation to Exchange Rate

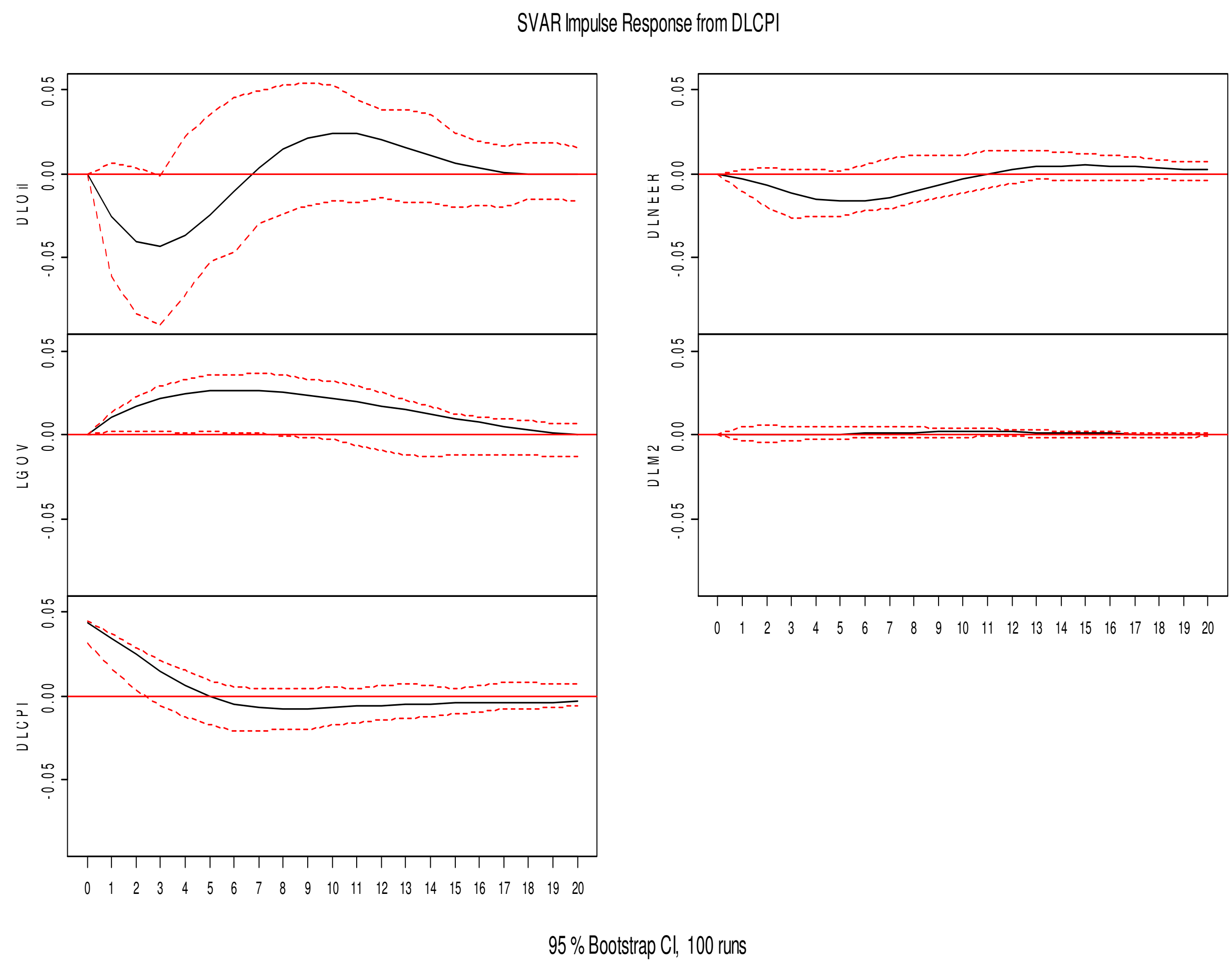
	DLOil	DLNEER	GOV	DLM2	DLCPI
Q [1]	0.0000	0.0000	0.0000	0.0000	0.0441
Q [2]	-0.0261	-0.0028	0.0102	0.0003	0.0791
Q [4]	-0.1096	-0.0218	0.0497	0.0006	0.1188
Q [8]	-0.1781	-0.0841	0.1536	0.0030	0.1138
Q [14]	-0.0588	-0.0997	0.2767	0.0129	0.0747
One SD Shock	0.2380	0.0464	0.0356	0.0275	0.0441

The impulse response function results are displayed in Figure 2. Consistent with theoretical prediction an appreciation[43] of the nominal effective exchange rate exerts downward pressure on domestic price changes in the medium term. But this effect is quite weak and quickly tapers off over the medium term (about four years). As shown in Table 4, a one standard deviation shock to the exchange rate (equal to 4.5 percent) causes the overall cumulative consumer price inflation to fall by 0.28 percent after two quarters or by 9.97 percent after 14 quarters, which correspond to an impact

[43] Normally the value of a domestic currency is expressed per unit of its foreign counterpart. The NEER was constructed using Ethiopia's national currency as a base and the currencies of trading partners as its prices. As a result, in this specific arrangement, an increase in the exchange rate implies appreciation of the local currency.

and dynamic pass-through elasticity[44] of 0.06 and 2.14, respectively. This means that exchange rate appreciation has negative but small effect on inflation throughout the sample period. As a result, exchange rate pass-through into domestic prices in Ethiopia is incomplete[45] and inconsequential.

Figure 2. Impulse Response Function for General Consumer Price Inflation



[44] The impact/dynamic elasticity is computed using the formula $\eta_E^p = \frac{\%\Delta P_t}{\%\Delta E_t}$, where the numerator indicates the percentage change in the consumer price index between period 0 (when the shock occurs) and the current time period t. The denominator is equal to the percentage change in the specific shock of interest (to the exchange rate in our case) in period 0.

[45] As shown in figures A5, A6, and A7 in the appendix, different ordering and even removal of money supply (M2) from the model leave the results considerably unchanged. The only difference is that when exchange rate is placed last, on impact the response of inflation to exchange rate shock is non-zero though in the wrong direction.

Increased government consumption and investment spending has little impact on general consumer price inflation in the first few quarters. The early trivial effect on prices maybe due to the fact that initially massive development projects and programmes sponsored by the government are associated with overcoming supply side bottlenecks. This implies that productivity gains and improved trade and exchange in the private sector can greatly benefit from increased provision of power, transportation facilities, and targeted spending on education and health. However, in the long run, large and indiscriminate public spending can be hostage to a host of factors including rent seeking and embezzlement, which is particularly the case when so many projects involve so many hierarchical transactions. As a result, the government's spending programmes only end up compounding price pressures without solving business constraints.

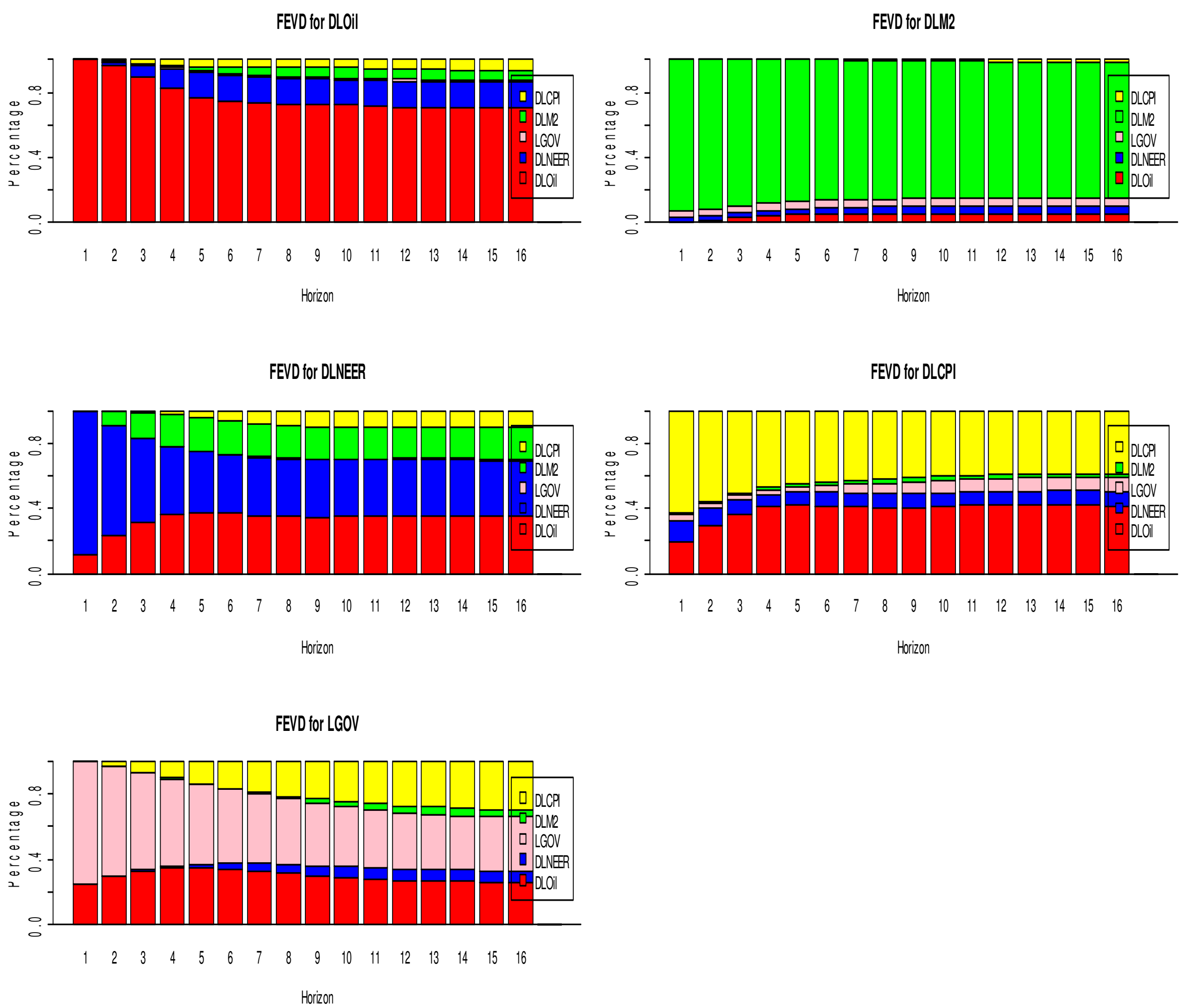
Figure 2 also shows that in the short run, world energy price increase has a contractionary effect initially causing consumer price inflation to fall by a significant amount. This can be attributed to the substantial oil price subsidies of the government that absorb much of the oil price impact away from the shoulders of consumers. It could also be the case that households and firms resort to alternative energy sources (using charcoal rather than gas or choosing public transportation over driving own car) that could potentially reduce heavy reliance on imported oil. But in the long run, global energy price surge exerts strong upward pressure on inflation as oil subsidies are replaced by other spending priorities causing business establishments to shift the final burden onto consumers.

Table 5. Forecast Error Variance Decomposition (FEVD) for Inflation (DLCPI)

	DLOil	DLNEER	LGOV	DLM2	DLCPI
Q[1]	0.196	0.127	0.044	0.003	0.630
Q[4]	0.407	0.079	0.023	0.021	0.470
Q[8]	0.403	0.089	0.064	0.023	0.421
Q[12]	0.422	0.082	0.080	0.026	0.391
Q[16]	0.416	0.089	0.080	0.028	0.386

Table 5 presents the results from the forecast error variance decomposition exercise. In the first quarter, own shock explains about 63 percent of the forecast error variance of inflation followed by world energy price (20 percent) and the exchange rate (13 percent). A one-off disturbance to the broad money growth rate contributes about 3 percent in the same period. After 4 quarters, the contribution of own shock to consumer price inflation forecast variability drops to 47 percent while that of the trade weighted nominal exchange rate to 8 percent. The only variable that shows significant increase after the passage of one year is world oil price (which rises to 41 percentage points). As time goes by, there is a general convergence pattern in which shocks to energy prices (42 percent) and consumer price changes (38 percent) together contribute about 80 percent of the variability in inflation.

Figure 3. Forecast Error variance Decomposition (based on general CPI)



One striking result both from the impulse response and the forecast error variance analyses is that money stock growth has trivial contribution and this behaviour remained consistent throughout the period. The muted impact of money growth on general consumer price inflation seems to validate the hypothesis that the process of monetization in Ethiopia primarily serves to cushion fiscal deficits[46].

Sectoral Pass-through[47]

Table 6. Sectoral Impulse Response to Trade Weighted Exchange Rate Shock

Period	Food	Non-Food	Housing	Health	Clothing	Recreation	Personal	Furniture	Transport
Q [1]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Q [2]	-0.0034	0.0040	-0.0073	-0.0041	-0.0059	0.0106	0.0071	0.0044	0.0140
Q [4]	-0.0130	-0.0309	-0.0182	-0.0178	-0.0174	0.0047	-0.0233	0.0025	-0.0020
Q [8]	-0.0164	0.0075	0.0150	-0.0112	-0.0058	0.0140	-0.0120	-0.0075	-0.0012
Q [12]	-0.0053	0.0003	0.0006	0.0036	0.0008	0.0064	0.0087	-0.0031	0.0045

The sectoral impulse responses to the exchange rate shock are displayed in Table 6[48]. Price changes in all sectors respond after the lapse of two quarters. Sectors that tend to have substantial import

[46] In an African Development Bank (AfDB) brief report produced by Gurara et al. (2012), the authors attempt to disentangle the determinants of inflation in the short and long run horizons in four East African economies-Ethiopia, Kenya, Uganda ,and Tanzania. In the case of Ethiopia, they conclude that money is the most important force that drives inflation in the short run, accounting for about 40 percent of the variability in inflation followed by world oil price (27 percent) and world food price (13 percent). They allude that one key channel through which money creation might have impacted price developments in Ethiopia is through National Bank of Ethiopia (NBE)'s purchase of government bonds and artisan gold supplies which they suggest could have played the role of quantitative easing. The idea is that increased base money finances budget deficits and thereby affect prices indirectly through the public sector. It is not obvious why the authors did not want to consider public spending as one of the major sources of price volatility in their analysis.

[47]In order to save space I have used short hand forms for sectoral categories of the CPI as follows: clothing and footwear (Clothing); house rent, construction material, water, fuel, and electricity (Housing); furniture, furnishing household equipment, and operation (Furniture); medical care and health (Health); transport and communication (Transport); recreation, entertainment, and education (Recreation); personal care and effects (Personal). Food and Non-food categories are also considered but three components, miscellaneous, drinks, and tobacco, have been excluded as they constitute insignificant fractions.

[48] The IRF and FEVD for each sector are derived from the corresponding SVAR specification in which constant is included in the reduced vector auto-regression. The housing price index was differenced twice as it was found to be integrated of order two. The optimal lag length for all sectors was two except the specification for the recreation sector which required an optimal lag length of three and the food sector for which a lag length of one was sufficient to ensure well-behaved model errors.

content (clothing and medicine/health, for example,) experience a faster degree of exchange rate transmission. For instance, a year after the occurrence of the exchange rate shock, a 10 percent appreciation leads to a 1.8 percent decline in health sector inflation and a 1.7 percent decline in clothing sector inflation. By contrast sectors that are relatively insulated from imported competition, such as furniture and recreation, have slower pass-through effect. Specifically, a 10 percent appreciation in the nominal effective exchange rate causes prices to increase by less than 0.5 percent in each sector after the passage of a year (four quarters). The furniture sector shows the conventional sign following a lag of two years while the recreation sector shows persistently positive reaction to exchange rate appreciation. Similarly, the transport sector displays a weak response which might reflect the dampening effects of state subsidies on fuel prices that tend to have significant bearing on the transportation service sector mainly due to economies of scale. Regarding the major food versus non-food classification, a 10 percent appreciation results in a 0.34 percent drop in food price inflation after two quarters and a 3.1drop in non-food price inflation after four quarters. The relatively weaker response of the former could be due to Ethiopia's reduced reliance on imported food items recently--either because of increased home production or because of a shift to cash in foreign food aid delivery.

Table 7. The Contribution of Exchange Rate to Sectoral Forecast Error Variability

Period	Food	Non-Food	Housing	Health	Clothing	Recreation	Personal	Furniture	Transport
Q [1]	0.0658	0.0003	0.0031	0.0198	0.0161	0.0337	0.0186	0.0070	0.0226
Q [2]	0.0506	0.0011	0.0131	0.0133	0.0117	0.0382	0.0324	0.0341	0.0141
Q [4]	0.0309	0.0471	0.0176	0.0144	0.0076	0.0553	0.0327	0.0319	0.0696
Q [8]	0.0600	0.1726	0.0386	0 .0342	0.0538	0.1271	0.0307	0.1565	0.2037
Q [12]	0.0720	0.1812	0.0611	0.0501	0.0834	0.1462	0.0252	0.1723	0.1816

Remarks: Q refers to quarterly period. Numbers have been rounded to fourth decimal precision to save space.

The forecast error variance decomposition provides alternative yet complementary framework to impulse response function analysis in tracking the dynamic behaviour of our endogenous variables. As shown in Table 7 above, consistent with the impulse response results, exchange rate has more predictive power in the forecast error variability of the non-food sector price development than that of the food sector. After 12 quarters (3 years), the contribution of the exchange rate to the forecast error variance of the food sector is only about 7 percent while for the non-food sector the corresponding figure is 18 percent.

5 Conclusion

This paper employs recursive structural vector auto-regression (SVAR) to study exchange rate pass-through into domestic consumer price inflation in Ethiopia. The study utilizes quarterly data covering the period from 1997.3 to 2011.4. Innovation accounting from the resulting SVAR was performed to trace out the impact of a one-time unit shock in one variable on the trajectory of other variables over time. The impulse response function analysis indicates that nominal effective exchange rate plays an important but short-lived role in affecting consumer price developments in Ethiopia. In particular, a unit change in the trade weighted exchange rate (appreciation) caused the consumer price inflation to fall by about 0.01 after four quarters (or an accumulated response of about 0.11 after 14 quarters). As a result, exchange rate pass-through into domestic prices in Ethiopia is incomplete and inconsequential. The forecast error variance decomposition exercise shows own shock explains about 63 per cent of the forecast error variability of inflation followed by world oil price (20 per cent) and exchange rate (13 per cent). Monetary aggregate has trivial effect for all horizons considered.

The potential policy recommendations that follow from this empirical exercise are twofold: 1) given the low exchange rate pass-through into general and sectoral components of CPI inflation, the monetary authorities in Ethiopia would rather not put much weight on exchange rate manipulation as a means to arrest inflation or improve the country's current account positions. All available evidence shows that the external sector has exhibited persistent deficit since greater flexibility of the exchange rate was introduced in early 1990s and domestic inflation has been steadily on the upsurge. Periodic devaluation is not the ideal remedy for an economy with heavy reliance on imports and limited export base. 2) The results show that money was almost neutral throughout and public expenditure was relatively more powerful. This suggests that government spending is one major potential channel through which monetary impulses affect aggregate demand and prices in the short-run. It is therefore important to sift out fiscal priorities and ensure through active monitoring that wasteful spending is minimized. The government may consider tying budget deficits to capital investment needs to achieve fiscal discipline. This option guarantees that badly needed investment spending will not be compromised while at the same arrests price pressure by eliminating inefficient budgeting.

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Appendix

Table A1. Summary Statistics

	LOil	LM2	LCPI	LGOV	LNEER
Minimum	2.43	9.69	4.04	5.17	3.70
1st Qu.	3.34	10.12	4.17	5.67	4.27
Median	3.80	10.50	4.34	5.92	4.41
Mean	3.77	10.65	4.56	5.97	4.34
3rd Qu.	4.27	11.14	5.11	6.33	4.53
Maximum	4.90	11.96	5.62	6.52	4.81
SD	0.62	0.64	0.49	0.37	0.29

Table A2. HEGY Test Results for Levels of Variables

Variables	Lags	$t:\pi_1$	$t:\pi_2$	$t:\pi_3$	$t:\pi_4$	$F:\pi_4 \cap \pi_4$
LGEX	0	-2.70*	-7.70**	0.97	-7.53	28.40**
LCPI	0	1.42*	-5.16**	-0.81	-5.11	14.01**
LMoney2	0	1.98*	-3.74**	-2.72	-3.20	9.64**
LOil	0	-3.26*	-4.66**	-3.73	-3.62	18.76**
LNEER	0	-1.53*	-4.09**	-2.20	-5.60	22.58**

Remarks. ** indicates significance at 99% confidence while * indicates significance at 90%. Deterministic terms like time trend and seasonal dummies were included in or excluded from the regression equation after careful examination of the statistical significance of their corresponding parameter estimates.

Table A3. HEGY Test Results for Differences of Variables

Variables	Lags	$t:\pi_1$	$t:\pi_2$	$t:\pi_3$	$t:\pi_4$	$\mathrm{F}:\pi_4 \cap \pi_4$
DLGEX	0	-3.46**	-7.07**	-3.52	-5.91	36.86**
DLCPI	0	-3.87***	-5.30**	-4.09	-2.31	13.72**
DLMoney2	0	-3.41***	-3.27**	-2.90	0.20	4.26**
DLOil	0	-4.38**	-4.49**	-4.91	-1.48	13.43**
DLNEER	2, 4, 6	-2.33**	-2.78**	-3.11	-2.26	9.77**

Remarks: ** indicates significance at 99% level while *** shows significance at 95%.

Table A4. ADF Unit Root Test Results in Levels and Differences

		Levels		Differences		
Variable	Lag	Statistic	95 Critical	Lag	Statistic	95 Critical
LGEX	1	-3.87	-3.45			
LCPI	1	-1.04	-3.45	1	-5.41	-2.89
LMoney2	1,2	1.42	3.45	0	-8.14	-2.89
LOil	0	-2.05	-3.45	0	-6.85	-1.95
LNEER	1	-1.98	-3.45	0	-4.88	-2.89

Table A5. Estimated Equation for the General Domestic Inflation (reduced VAR)

	Estimate	Std.Error	t value	Pr (>ltl)
DLOil.l1	0.069	0.023	3.043	0.004**
DLNEER.l1	-0.043	0.073	-0.594	0.556
LGOV.l1	-0.134	0.056	-2.383	0.021*
DLM2.l1	0.293	0.248	1.182	0.243
DLCPI.l1	0.794	0.082	9.971	0.000***
Constant	0.694	0.304	2.282	0.027*
Trend	0.003	0.001	2.052	0.045*

Remarks: *, **, and *** correspond to significance at 95%, 99% and 99.9% level of confidence respectively.

Figure A1. Interpolated Quarterly Gross Government Expenditure

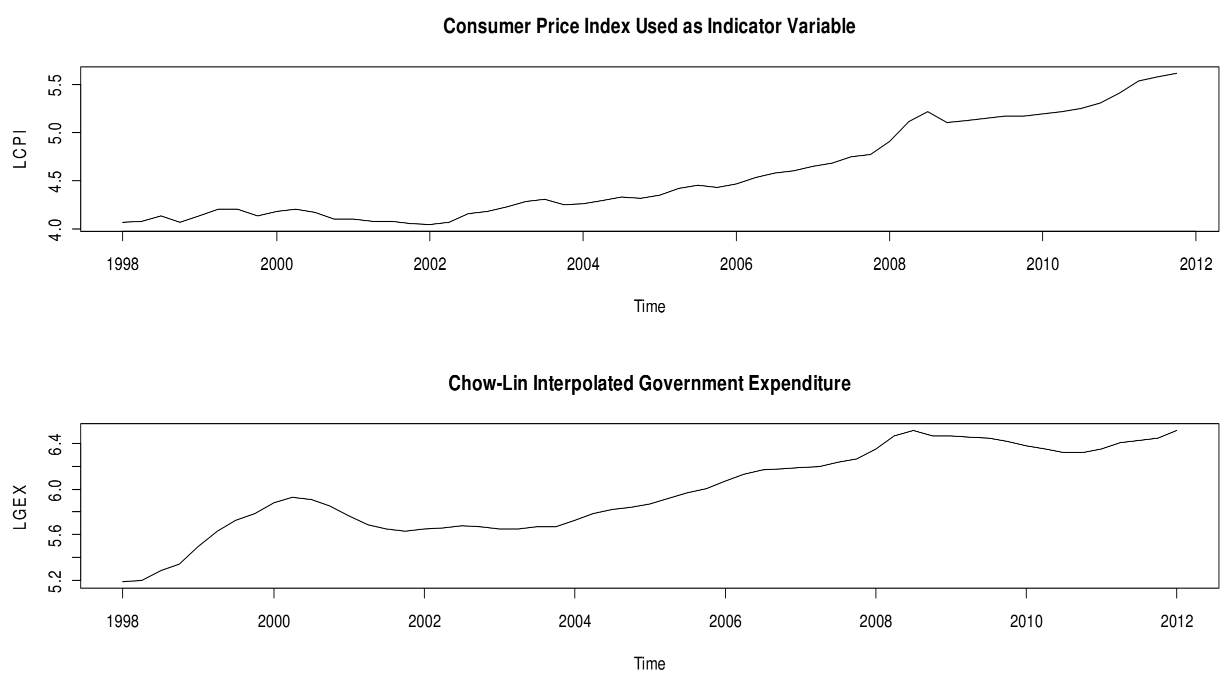


Figure A2. Actual, Fitted and Model Error Values of the General Inflation Equation

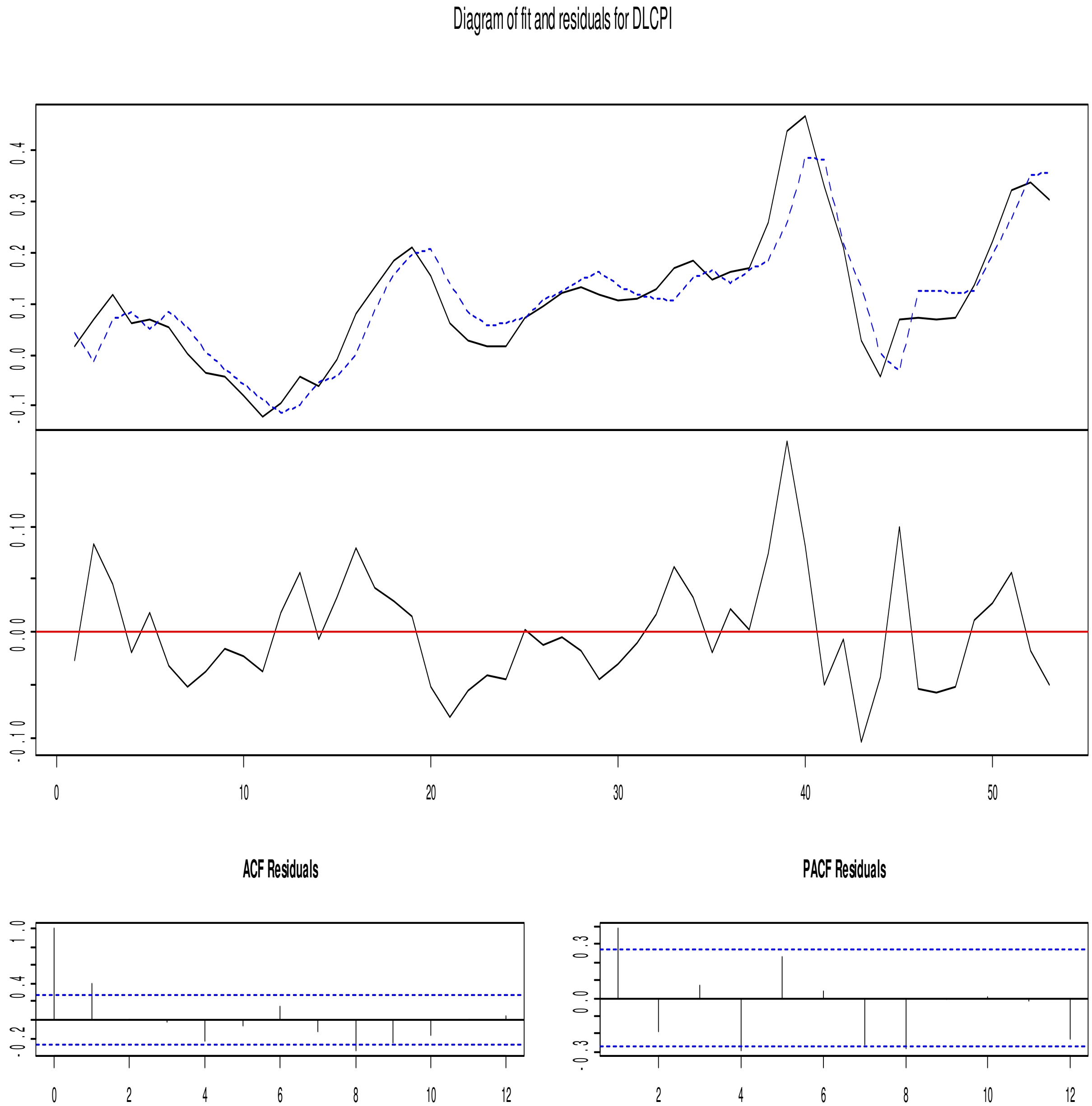


Figure A3. Ordinary Least Square Cumulative Sum Plots of Model Residuals

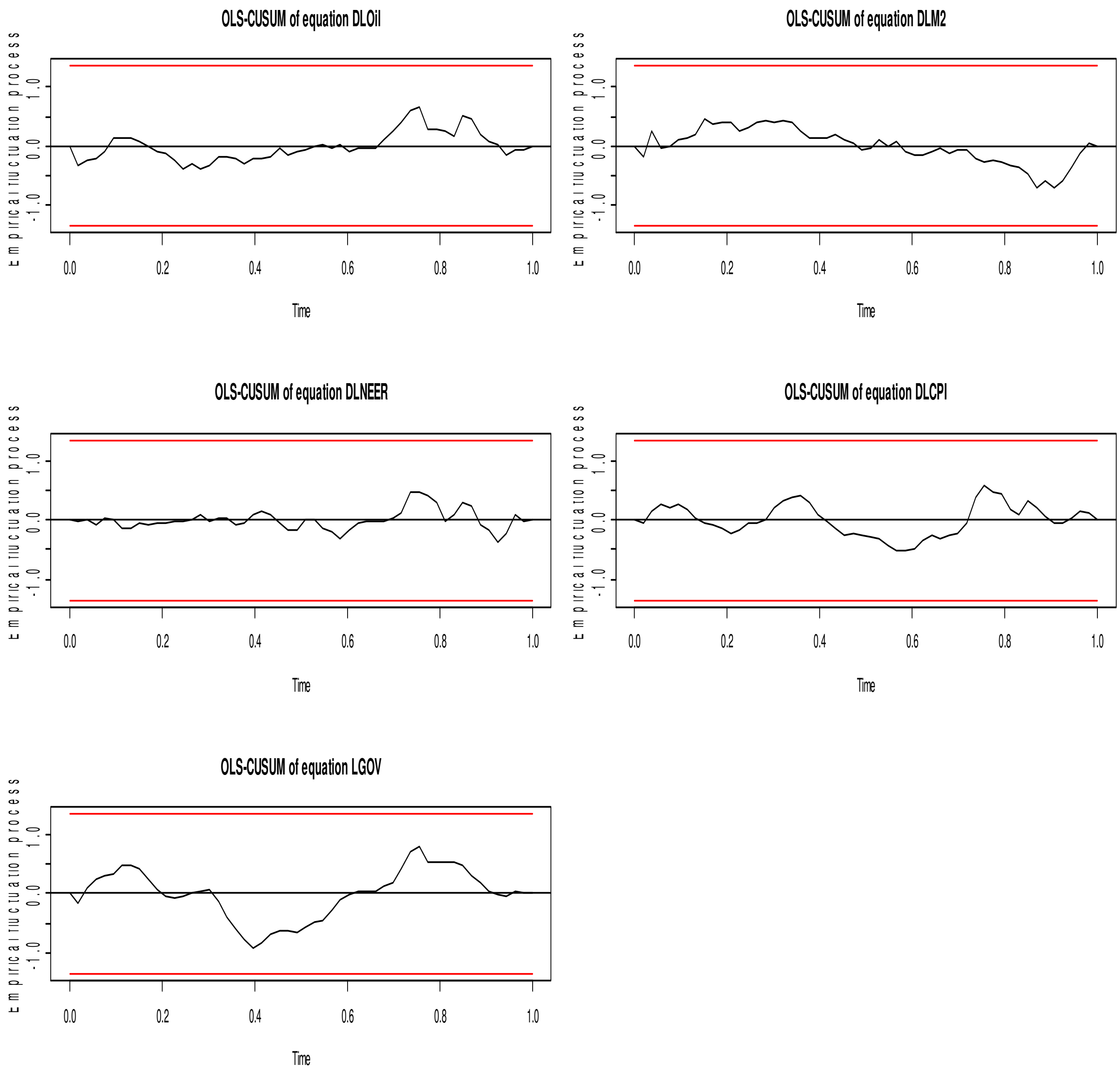


Figure A4. Diagnostic Plots of Residuals of the Inflation Equation

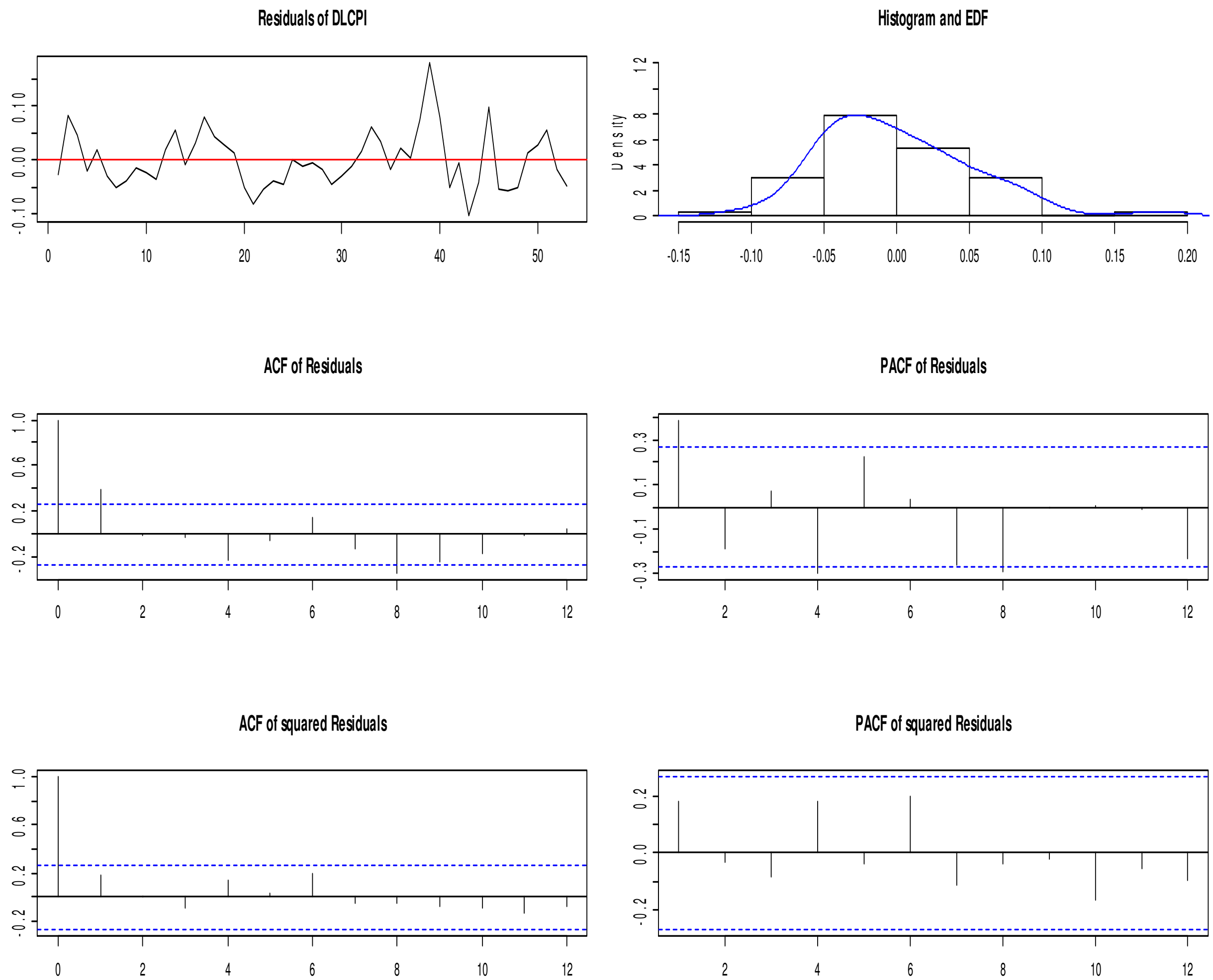
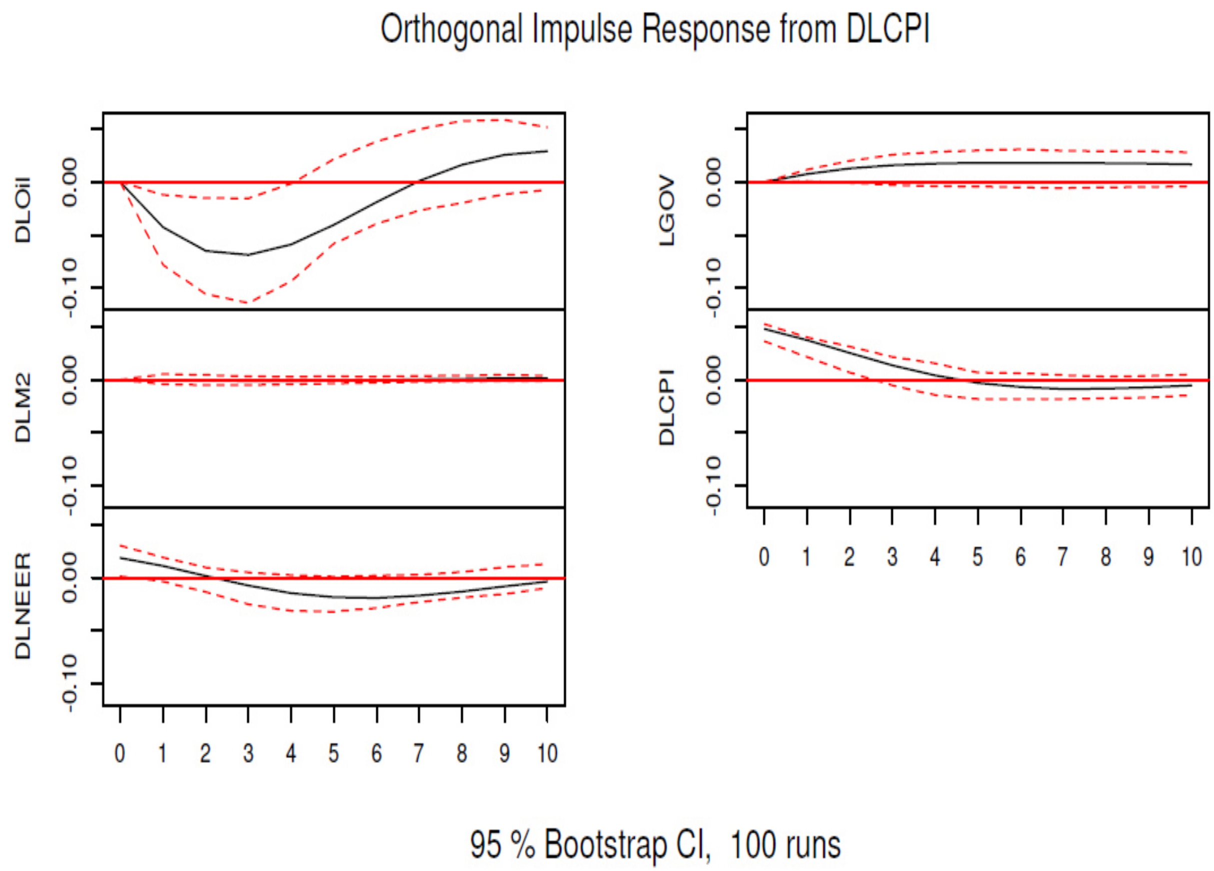


Figure A5. Impulse Response from CPI Inflation with Order Oil Price (most exogenous), Public Spending, Money Supply, CPI Inflation and Exchange rate (most endogenous)



This figure shows the responses of CPI inflation to different shocks when the ordering is changed, which can be taken as a test of the sensitivity of results to variable orders. The figure is generally very similar with figure 2 in the main text in chapter 3. The response to monetary shock is still flat. The exchange rate pass-through is incomplete; the only change is that on impact, the response of inflation to exchange rate shock is positive. This is somewhat unpalatable as this would mean that exchange rate appreciation causes the price level to increase. But after the second quarter, the pass-through closely resembles the one in figure 2. As in figure 2, it is government spending which causes persistent increase in CPI inflation. Oil shock causes a decrease in inflation on impact. This may be due to the contractionary effect of higher oil costs on the overall economy, which causes a general decline in economic activity and a fall in prices across the board. As depicted in figures A6 and A7 below, these results are maintained even after excluding broad money supply measure from the model. When the exchange rate is ordered last, we have a non-zero response of CPI inflation to exchange rate shock even when broad money supply is excluded.

Figure A6. Impulse Response of CPI inflation with Ordering Oil Price (most exogenous), Public Spending, CPI inflation, and Exchange Rate (most endogenous)

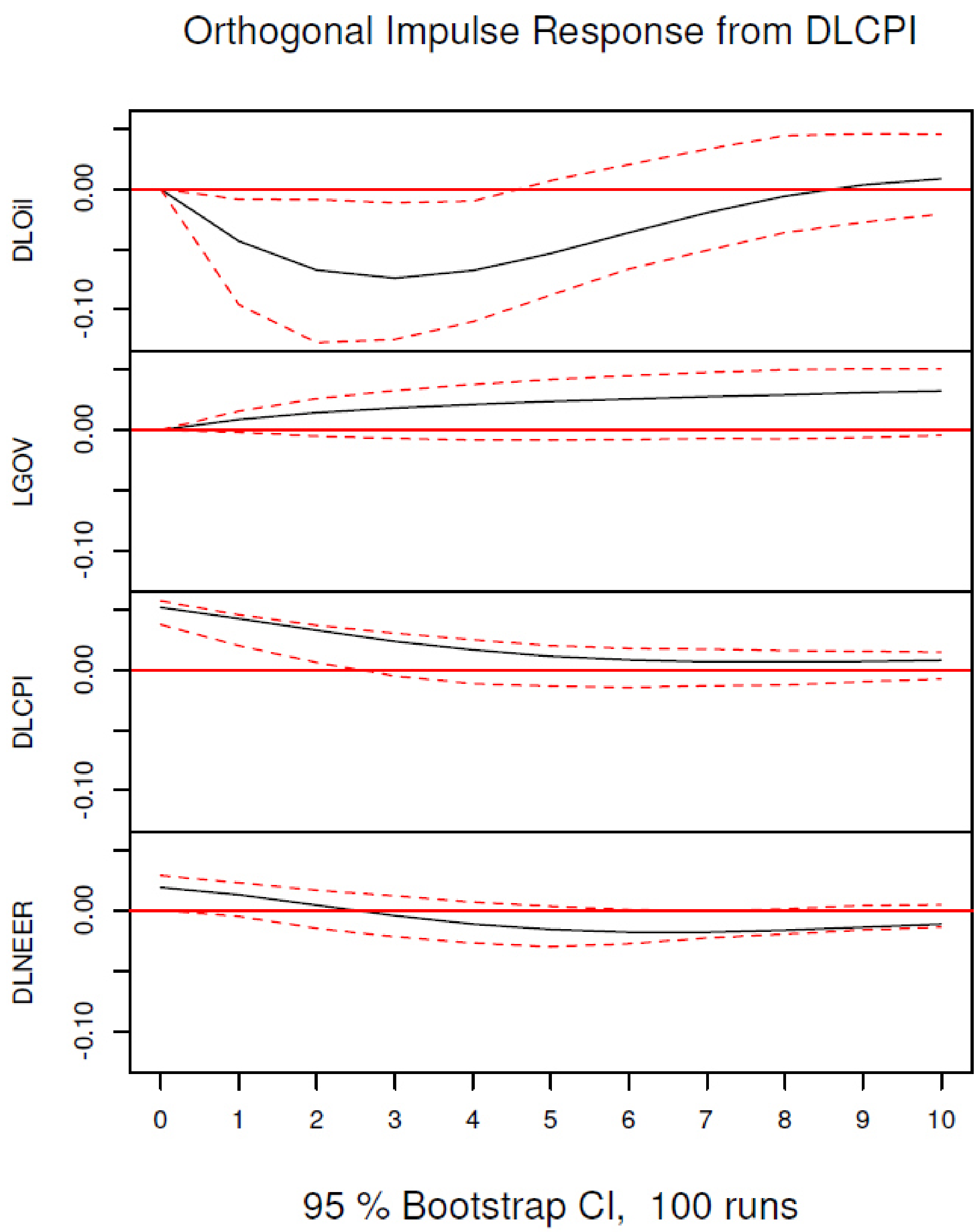


Figure A7. Impulse Response of CPI Inflation with Original ordering (Oil, Public Spending, Exchange Rate, and CPI Inflation but without Money Supply Measure)