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Credit-Supply Factors and Malawian Business Cycles

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Abstract

This study investigates the role of credit-supply factors in Malawian business cycles. A developing country banking sector is embedded into a Bayesian DGSE model using data for Malawi for the period 2004 to 2020. Financial intermediation in the model includes the issuance of loans to both households and firms, deposit mobilization, and actively financing of public debt to a cash-constrained central government treasury. Our study finds that banking sector shocks emanating from financing public debt plays a significant role in explaining variations in output in Malawi, both in the short and long run. Our study also finds that shocks from banking sector profits, intermediation role to household loans, entrepreneurs and firms do not have adverse effects on the fluctuation of output in Malawi which is contrary to the public sentiments. We also established that these shocks crowd-out private sector credit supply, and hence push interest rates up in the face of a liquidity-constrained treasury. These crowding outcomes are in the form of a trade-off of investment opportunities for banks. For every excess fund above the regulatory liquidity threshold, banks are more likely induced to invest only 20.96% in loans to households and 19.56% in loans to firms.

JEL: E30; E32; E43; E51; E52;

Keywords: Public Debt; Collaterals; Banks; Interest Rates, Crowding-Out.

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[1] Corresponding Author. Email Address: tnkumwenda@gmail.com. The corresponding author is a PhD Candidate, his research interests are in Banking, Financial and Capital Markets Developments in Malawi. The thoughts and conclusions presented in this paper are of the authors and not of their workplace. All errors belong to the authors.

1. Introduction

Since the 2007 financial crisis, there has been a reemergence of studies concerning understanding interactions between credit supply factors and the business cycle. The crisis renewed interest in macroeconomics and financial interdependence; there has been growing literature of which some have followed the seminal works of Fisher (1932), Keynes (1936) and Minsky (1964), Minsky (1977), and Minsky (1982). With the advancement in economic modeling and forecasting, many studies have concentrated much research on a strand of literature called financial frictions whose dominant approach has consisted of modeling financial frictions, embedded in a dynamic stochastic general equilibrium (DSGE) framework. Financial frictions are financial constraints that prevent firms from funding all desired investments from external resources due to either firm-level constraints or constraints emanating from the credit supply process. These are further discussed in section 3, the literature review section of this paper.

This paper investigates the extent to which credit-supply factors affect business cycle fluctuations in Malawi, and whether banks' balance sheet structure could also be a potential source of business cycle fluctuations through their firm-level investments accumulation mechanism. The main motivation to carry out the study comes from the recent debate on the accessibility and affordability of financial capital in Malawi. The debate has raged for over 42 years after the first set of economic reforms introduced in the 1980s, Abbe, A. (1990), that removed interest rate controls and caps, S.R. Chuka (1990) and has further gained ground in recent years. The ensuing debate resulted in the introduction of an interest capping bill in Parliament (Extraordinary Gazette, 5th Dec 2018 & 12th November 2021, Private Members Bill) and a *"bank interest must fall campaign"* that culminated in an introduction of *a "reference rate"* as a benchmark base lending rate for all banks, that to some extent moderates lending rates as written in the Daily Times 11th February 2019 Newspaper Banks Publication.

Our paper adopts the Iacoviello (2005) model, which was further improved by Gerali et al. (2010) by introducing a stylized banking sector with imperfect competition for the Euro area. Our paper focuses on the banking sector of a third-world country, Malawi, which has its unique characteristics. The significant departure or addition to the Gerali et al. (2010) version of the model is that in our banking sector we have introduced public debt financing mechanisms or channels by banks; banks in the model accumulate a significant amount of treasury bonds. The aim is to investigate whether by accumulating significant treasury bonds in an environment where fiscal deficits are persistent and are predominantly funded by domestic borrowings; this asset allocation can result in crowding out effects, fluctuations in output, and a resultant trade-off between offering loans to households and firms or accumulating treasury bonds. It is important to investigate how government fiscal activities enter the domestic banking sector and influence the general risk-taking behavior of banks.

Again, in the same spirit, our study seeks to investigate the validity of public claims in Malawi of whether indeed other bank balance sheet specific factors such as shock to household loans, loans to firms, bank profits shocks, collateral constraints variations, and shocks do affect the fluctuations of output in Malawi. The general public perception, that banks make huge profits and that their activities hurt output growth in Malawi must be validated with economic studies. If indeed these claims are found to have economical and statistical significance, therefore it will be imperative for policymakers to consider the potency of bank balance sheet asset build-up for wider financial sector policy reviews.

To this end, to the best of our knowledge, we do not know any studies in Malawi that have taken this approach and studied this subject matter and modeled the Malawi banking sector in the manner we have done in this paper.

The rest of the paper is organized as follows: Section 2, discusses the context of the study; Section 3 looks at the review of relevant literature; Section 4, discusses the modeling framework used in the paper; Section 5, discusses the empirical modeling approach; Section 6 discusses results from the modeling experiments, and Section 7 concludes.

2. Context of the Study

Malawi is a country with a population of 19 million, growing at an annual rate of 2.7% as of 2020. Approximately 84% of the population live in rural areas and do not have much access to formal banking services and largely depend on agriculture as a mainstay activity. The agricultural output makes up about 23% of GDP; manufacturing, wholesale and retail trade make up about 12% of GDP respectively; financial services make up about 5% of GDP, according to publications from the National Statistics Office, Ministry of Finance and Reserve Bank of Malawi.

As shown in Table 1 below; in terms of access to credit, the agricultural sector and manufacturing despite having a fair share of GDP have seen a decrease in their relative share of credit supply from the banking sector. As of quarter 1 of 2022, the agricultural sector's share of credit supply was at

15.9%, manufacturing at 9.8%; whilst wholesale and retail trade at 22.5%; community, social and personal services at 33.5%, and the Other productive sectors of the economy at 22.3%. So broadly we can summarize access to credit between the productive sector and consumption sectors of the economy as follows; production sectors at 48% and consumption sectors at 56%. It is important to understand this decomposition of credit supply to respective sectors of the economy considering our study; if our study establishes that credit supply factors have a significant effect on output in Malawi, then it will be paramount at a policy level to appreciate the effects on output of such continued credit allocation.

Table 1: Distribution of Private Sector Credit by Industry (Percent)

Sector	2020	2021				2022
	IV	I	II	III	IV	I
Agriculture, forestry, fishing and hunting	18.8	19.9	18.2	16.8	15.8	15.9
Manufacturing	13.3	11.5	13.5	13.5	12.2	9.8
Wholesale and retail trade	24.2	22.5	23.2	21.0	22.2	22.5
Community, social and personal services	18.3	30.9	29.1	31.5	32.7	33.5
Other sectors[1]	29.5	19.6	20.1	21.7	21.1	22.3
Provisions for losses	-4.2	-4.3	-4.1	-4.4	-3.5	-4.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Note: *[1]Other sectors include Transport, storage and communications; Restaurants and hotels; Construction; Electricity, gas, water and energy; Financial Services; Real Estate; Mining and quarrying and others.*
Source: Reserve Bank of Malawi

The Malawi banking sector had total assets of Mk2 trillion kwacha as of Dec 2020, granulated into the following: 13% being cash balances, 39% being Treasury Investments, 31% being net loans and advances, 17% being other assets, and on the funding side of the banking sector, deposits made up 62% of the total equity and liabilities, liabilities to other banks stood at 2%, other liabilities at 20% and shareholders' equity at 16% as of December 2020. It is important to understand this decomposition of balance sheet structure of banks and the granulation of its assets in various classes in the context of our study; if our study establishes that banks' asset accumulation structural factors have a significant effect on output in Malawi, then it will be paramount at a policy level to appreciate the effects on output of such continued asset build-up.

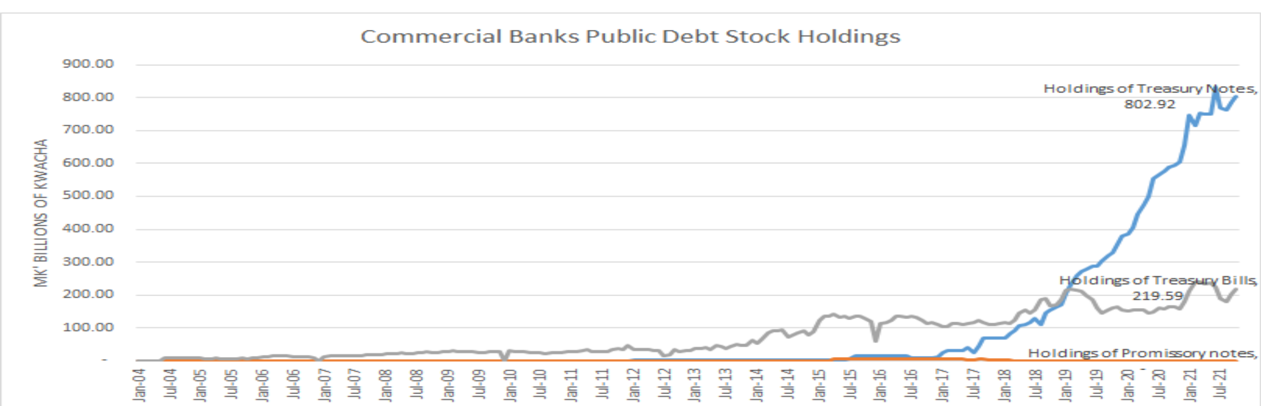
The granular distribution of loans and advances in the Malawi banking sector as of December 2020 was as follows: 24% for Wholesale and retail trades; 17% for Agriculture; 12% for Manufacturing; 17% for Community and Personal Services; 10% to other sectors; 3% to Transportation Sector, Financial services; 6% to Electricity and Energy Sectors, 4% to Construction; 3% to Restaurant and hotels; 2% to Real Estate and 0.1% to Mining and quarrying. And credit losses represent 2% of the total loans and advances as of Dec 2020.

As shown in Figure 1 below; all along the Central government's main borrowing instruments in the local commercial banking market were in the form of Treasury Bills. The Treasury bill stock for banks was at Mk230 million in January 2004; and grew over time to Mk220 billion by October 2021. The Central Government started financing its activities using Treasury notes from Dec 2011, by then the Treasury notes were only at Mk171 million, which grew to Mk803 billion as of October 2021.

The reference rate that was introduced as the base lending rate for all banks as pointed out in the introduction; in its composition as explained in appendix 1, ignores Treasury notes yields and only captures Treasury bill yields. This is so, even though Government has switched its fiscal financing to predominantly using treasury notes and not Treasury bills.

It is important to understand these fiscal funding dynamics as they also form part of the objectives of our study. Central government using treasury notes mop up significant capital in the banking sector that could have been availed to other equally productive sectors of the economy. This is the direct crowding-out effect on a gross basis, and again the other channel is the interest rate differential between normal reference rates without treasury yields in its formula and the reference rate with Treasury yields. The removal of treasury yields in the reference rate formulation mask domestic lending rates as affordable when in actual sense there is a huge trade-off between what those rates could have been if banks were to ably lend to other sectors other than the government. It is conventionally accepted that governments are not good users of capital as the private sector. The government hugely borrows due to fiscal deficits.

Figure 1: Commercial Banks Public Debt Holdings



3. Literature Review

3.1 Theoretical Literature Review - Minsky Financial Instability Hypothesis (FIH)

According to Minsky's financial instability hypothesis, business cycle dynamics systematically respond to financial cycles. The financial instability hypothesis (hereinafter referred to as the FIH) is based on Minsky's theories of money, financial evolution, and investment, as well as on Fisher's (1933) concept of debt deflation.

The FIH is the "theory of how a capitalist economy endogenously generates a financial structure which is inherently prone to financial crises" (Minsky, 1983, p. 289–290). A financial structure in this context is defined as "*the market interactions between borrowers and lenders and the balance sheets of non-financial firms, intermediaries and households that reflect these interactions"* (Pollin, 1994, p. 97). According to the FIH, economic cycles are largely influenced by the investment financing decisions of economic agents. The FIH has three distinct revenue-debt or borrower-lender relationships for economic agents, which are called hedge, speculative, and Ponzi finance.

Economic agents that are deemed as "Hedge financing oriented" under the FIH are those that can meet the contractual payments of their maturing liabilities as they fall due without difficulties: the general rule under this category is that, when equity financing of the business outweighs leverage financing; the greater the chances that those economic agents are hedging financing agents.

Economic agents that are categorized as "Speculative finance oriented" are those that can service a portion of their maturing liabilities. These economic agents often resolve debt restructuring and rollovers to create additional fiscal and cash-flow space for maturing liabilities repayments. *Governments with floating debts, corporations with floating issues of commercial paper, and banks are typically speculative finance units.*

Economic agents that are categorized as "Ponzi oriented" are those whose cash flows from their main operating activities are insufficient to fulfill their debt repayments, both principle, and interest. These agents are technically insolvent and they either resolve to be in a perpetual debt trap or they have to liquidate their other assets portfolio to make good on their debt repayments.

According to the FIH when economic agents finance themselves using hedge financing; then that economy will be an equilibrium-seeking and containing system. In contrast, when speculative and

Ponzi finance is a way of financing economic agents, then the greater is the likelihood that the economy in question is a deviation amplifying system.

The first theorem of the financial instability hypothesis is that the economy has financing regimes under which it is stable and financing regimes under which it is unstable. The second theorem of the financial instability hypothesis is that over periods of prolonged prosperity, the economy transits from financial relations that make for a stable system to financial relations that make for an unstable system (Minsky, 1992, p. 7–8). Over a protracted period of good times, capitalist economies tend to move from a financial structure dominated by hedge finance units to a structure in which there is large weight to units engaged in speculative and Ponzi finance.

The financial instability hypothesis is a model of a capitalist economy which does not rely upon exogenous shocks to generate business cycles of varying severity. The hypothesis holds that business cycles of history are compounded out of (i) the internal dynamics of capitalist economies, and (ii) the system of interventions and regulations that are designed to keep the economy operating within reasonable bounds.

Thus, the FIH demonstrates that "stability—or tranquility—in a world with a cyclical past and capitalist financial institutions is destabilizing" (Minsky, 1985, p. 37). The financial instability hypothesis, therefore, is a theory of the impact of debt on the wide system behavior and incorporates the way debt is validated.

The way the government predominantly funds itself has significant consequences on the wider economy. If the Government funds itself significantly using Speculative and Ponzi finance, that will destabilize the business cycles.

3.2 Empirical Literature Review

As improvements to the earlier studies of Fisher (1932), Keynes (1936) Minsky (1964), Minsky (1977), and Minsky (1982), , recent literature has been dominated by the modeling of financial frictions embedded in a dynamic stochastic general equilibrium (DSGE) framework. These models have been built upon the foundations of the financial accelerator model developed by Bernanke and Gertler (1989); as well as the collateral constraint model developed by Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), and Bernanke et al. (1999). The Financial accelerator is the empirical operationalization of Minsky FIH theory and is the one that is better implemented within the DSGE framework. On the overall, this literature intends to underpin the role of financial intermediation and how shocks emanating from the intermediation process potentially affects the borrowing and lending process. Additional emerging developments in the literature on financial frictions in macroeconomic models include the introduction of an imperfectly competitive banking sector (e.g., Gerali et al. 2010), the presence of asset price bubbles (e.g., Galí, 2014), and maturity transformation in the banking sector (e.g., Gertler and Karadi, 2013).

According to the "financial accelerator" model developed by Bernanke et al. (1999), borrowers must pay an "external finance premium" when they access credit to finance investment projects due to information asymmetry and moral hazard. Bernanke et al. (1999) concluded that endogenous developments in credit markets work to amplify and propagate shocks to the macro-economy and that under reasonable parametrizations of their model, the financial accelerator has a significant influence on business cycle dynamics.

According to the "collateral constraint" model by Kiyotaki and Moore (1997), borrowers must pledge collateral such as real assets, for them to obtain a loan. The collateral constrained model shows the dynamic interaction between credit limits and asset prices which turns out to be a powerful transmission mechanism by which the effects of shocks persist, amplify, and spill over to other sectors. Kiyotaki and Moore (1997) show that small, temporary shocks to technology or income distribution can generate large and persistent fluctuations in output and asset prices.

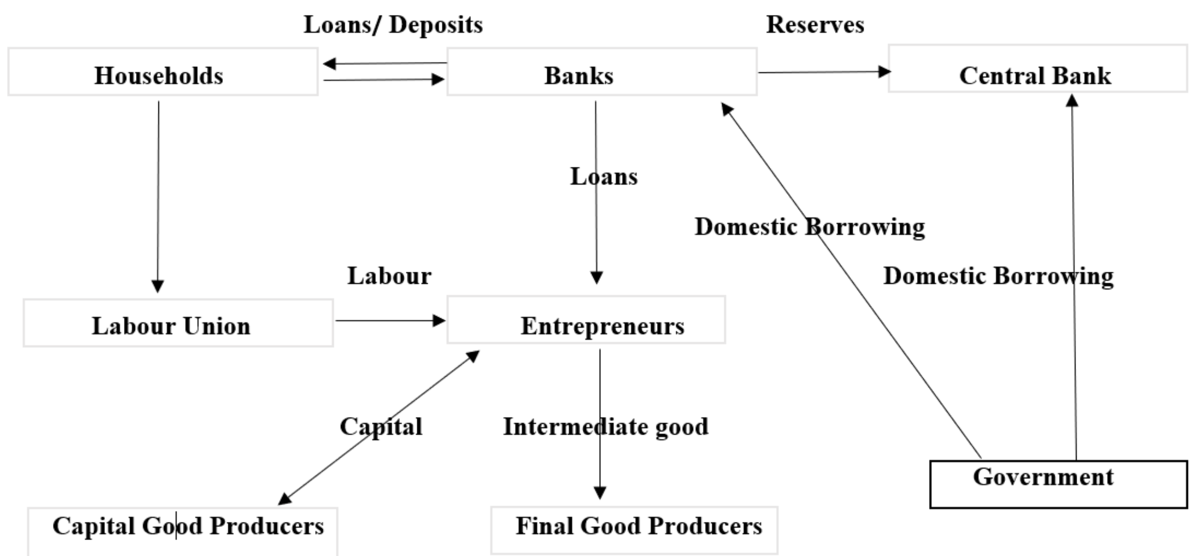
Other studies such as Bernanke (1983), Anari and Kolari (1999), Hafstead and Smith (2012), Gertler and Kiyotaki (2010), Irving Fisher (1933); Barro (1978), and Gurley and Shaw (1955) established empirical evidence that shows that instabilities in the financial markets and intermediation process has real effects on economic activity and output.

The gap that our study tries to fill in the reviewed literature is the modeling of bank-driven public debt accumulation effects on the business cycles of a revenue-challenged government treasury and the consequences for a developing country. The studies that we have reviewed including DSGE studies have focused on financial frictions in advanced economies where central governments do not face debt sustainability problems and as such modeling public debt has not been a key feature of the studies. This is a first of its kind in banking literature in Malawi.

4. Modeling Framework

We adopt a DSGE model with a banking sector by Gerali et al. (2010) by introducing public debt financing or asset accumulation by the Malawian Banks. The economy hypothetically consists of patient households *(P)*, impatient households *(I)*, entrepreneurial firms *(E)*, monopolistic banks, and a central bank. Type *P* households are savers while those of type *I*, are borrowers. In this economy, banks offer two types of one-period financial instruments, namely, savings (bank deposits) and lending (loans to government, households, and entrepreneurs). By borrowing, the agents face a credit constraint that is linked to the value of their collateral in the following period. Respectively, the credit limits faced by households and entrepreneurs are functions of the value of their resource endowment (stock of housing, and the value of their physical capital). The technical analysis of the model is in appendix 1.

Figure 1: The Overview of the DSGE Model



Source: Authors

4.1 Patient and Impatient Households

The representative household maximizes the expected utility given by

$$\max_{\{c_t^I, h_t^I, d_t^I\}} E_0 \sum_{t=0}^{\infty} \beta_{P/I}^t \left[\left(1 - a^{p/I}\right) \varepsilon_t^z \log\left(c_t^{p/I}(i) - a^{p/I} c_{t-1}^{p/I}\right) + \varepsilon_t^h log h_t^{p/I}(i) - \frac{l_t^{p/I}(i)^{1+\phi}}{1+\phi} \right], \qquad (1)$$

Where *(P)* is for patient households, *(I)* is for impatient households; β_P, β_I, and β_E, are intertemporal discount factors for, the patient households, impatient households, and entrepreneurs, respectively such that $\beta_P > \beta_I$.

Which depends on the deviation of current individual consumption ($c_t^{p/I}(i)$) from the aggregate consumption of the previous period ($c_{t-1}^{p/I}$); stock of housing ($h_t^{p/I}(i)$) and hours worked ($l_t^{p/I}(i)$). The parameter $a^{p/I}$ measures the degree of habit formation in consumption.

The disutility of labor is parametrized by ϕ. Preferences are subject to two types of shocks; one that affects consumption (ε_t^z), and another that affects the demand for housing (ε_t^h). These shocks are represented by an *AR(1)* process with normal distribution. They are also *i.i.d.* Their respective autoregressive coefficients are ρ^z and ρ^h, with coefficient standard deviations given as σ^z and σ^h, respectively.

The decisions of these households are subject to the following budget constraint (in real terms):

For Patient households:

$$c_t^p(i) + q_t^h\left(h_t^p(i) - h_{t-1}^p(i)\right) + d_t^p(i) \leq w_t^p l_t^p(i) + \frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p(i) + t_t^p(i) \tag{2}$$

For patient households' expenditures include current consumption, the variation of housing (th housing prices in real terms, are given by q_t^h), and deposits made in the period d_t^p.

Revenues consist of: remuneration for work $w_t^p l_t^p$, expansion of income arising from deposits made in the previous period $\frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p$ (where $\pi_t \equiv {}^{P_t}/_{P_{t-1}}$ is the rate of inflation), and transfers lump-sum, t_t^p which is equivalent to dividends from companies and banks, that are owned by patient households.

For impatient households:

The decisions of households are subject to the following budget constraint (in real terms):

$$c_t^I(i) + q_t^h\left(h_t^I(i) - h_{t-1}^I(i)\right) + \frac{1+r_{t-1}^{bH}}{\pi_t} b_{t-1}^I \leq w_t^I l_t^I(i) + b_{t-1}^I(i) + t_t^I(i) \tag{3}$$

where the resources with consumer spending, real estate, and loan repayments b_{t-1}^I – added to the interest rate r_{t-1}^{bH} – have to be financed by labor income (w_t^I is the wage of the impatient households) and new loans b_t^I ($t_t^I(i)$ are transferred lump-sum).

Impatient households are still subject to borrowing constraints, where the expected value of its real estate assets, which can be offered as collateral on t must be sufficient to honor the debt with the banks, that is

$$\left(1 + r_{t-1}^{bH}\right) b_t^I \leq m_t^I E_t[q_{t+1}^h h_t^I(i) \pi_{t+1}] \tag{4}$$

In expression (8) above, m_t^I is the ratio of loan-to-value (LTV) mortgages, in the model we have used an LTV of 70% in line with the practice in Malawi banking sector. From the macroeconomic point of view, m_t^I represents the volume of credit that banks are willing to offer to households.

4.2 The Labor Market

Households supply differentiated labor input to a "labor union" (or a labor packer). The labor union bundles the differentiated labor input into a homogeneous labor input and then sells it to entrepreneurs for production. The labor union sets nominal wages for each type of labor $W_t^s\ (m)$ by maximizing their utility, with the constraints of a labor demand function and a quadratic wage adjustment cost (with parameter k_w). The adjustment cost is indexed to a weighted average of lagged wage and steady-state inflation. l_w denotes the relative weights parameter. The labor union charges each member of the household a net membership fee to cover adjustment costs.

4.3 Entrepreneurs

There are an infinite number of entrepreneurs contained in the interval (0, 1]. In its utility function, entrepreneurs care about the dispersion of their consumption $(c_t^E(i))$ about the aggregate consumption, and their habit formation parameter is given by a^E. Therefore, their utility function to be maximized is:

$$E_0 \sum_{t=0}^{\infty} \beta_E^t \log(c_i^E(i) - a^E c_{t-1}^E) \tag{5}$$

It is assumed that the intertemporal discount factor β_E is strictly greater than β_p , which means that, in equilibrium, entrepreneurs are net borrowers (debtors).

Moreover, their decisions are subject to the following budget constraint:

$$c_i^E(i) + w_t^P l_t^{E,P}(i) + w_t^P l_t^{E,I}(i) + \frac{1 + r_{t-1}^{bE}}{\pi_t} b_{t-1}^E(i) + q_t^k k_t^E \ + \psi\big(u_t(i)\big) k_{t-1}^E(i)$$

$$= \frac{y_t^E(i)}{x_t} + b_t^E(i) + q_t^k(1-\delta)k_{t-1}^E(i) \tag{6}$$

where δ is the depreciation rate of capital, q_t^k is the price of capital in terms of consumption, $\psi\big(u_t(i)\big)k_{t-1}^E$ is the real cost of establishing a given level u_t of capacity utilization, with

$\psi\big(u_t(i)\big) = \xi_1(u_t - 1) + \frac{\xi_2}{2}((u_t - 1)^2$. $x_t = {P_t}/{P_t^w}$ is the relative price of wholesale good y_t^E in the competitive market, where P_t^w is the nominal price and production technology is given by

$$y_t^E(i) = a_t^E [k_{t-1}^E(i) u_t(i)]^{\alpha} [l_t^E(i)]^{1-\alpha}$$

With a_t^E being the total factor productivity (stochastic). The aggregate work l_t^E combines the input of labor of impatient and patient households as follows:

$$l_t^E = \big(l_t^{E,P}\big)^{\mu} \big(l_t^{E,I}\big)^{1-\mu}$$

Where μ is the share of a patient, relative to the sum of the patient and impatient households' income.

4.4 The Retail Market

Retailers buy a homogenous good from the entrepreneurs and attach a brand to differentiate it. Next, they sell in an imperfect market characterized by monopolistic competition and nominal price rigidity. This price is indexed by convex combination between inflation of the previous period and steady-state inflation. If the retailer adjusts the price of his goods beyond what the indexation rule suggests, he will be subject to quadratic adjustment costs, parameterized by κ_p. The problem of the retailer is to solve:

$$\max_{P_t(j)} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[P_t(j) y_t(j) - P_t^W y_t(j) - \frac{k_p}{2} \left(\frac{P_t(j)}{P_{t-1}} - \pi_{t-1}^{l_p} \pi^{1-l_p} \right)^2 P_t y_t \right] \tag{7}$$

Subject to:

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon_t^y} y_t \tag{8}$$

4.5 Capital Goods Producers

The capital goods-producing sector is introduced in the model to derive an equation of the market price of capital. This is necessary to determine the value of the collateral of entrepreneurs when they demand loans at banks. In a perfectly competitive market, these producers buy at the beginning of each period *t*, at a price P_t^k , the earlier period nondepreciated capital stock of the entrepreneurs,

$(1-\delta)k_{t-1}$. Furthermore, they buy an amount i_t units of the final good from retailers at a price of P_t , that remained unsold.

The nondepreciated capital of the previous period is converted at the rate 1×1 in new capital. The final good, bought from the retailers has its conversion subject to quadratic adjustment costs. Thus, the effective capital stock k_t which, in turn, is sold to entrepreneurs at a price P_t^k, has its accumulation equation given by

$$k_t = (1-\delta)k_{t-1} + \beta_E E_t \left[1 - \frac{K_i}{2} \left(\frac{i_t \varepsilon_t^{qk}}{i_{t-1}} \right)^2 \right] i_t \tag{9}$$

where k_i represents the adjustment cost of investment, ε_t^{qk} is a shock to the productivity of the investment and $q_t^k \equiv \frac{P_t^k}{P_t}$ is the price in real terms of the capital. As a result, the problem of the capital producer is

$$max\ E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E \{ q_t^k [k_t - (1-\delta)k_{t-1}] - i_t \} \tag{10}$$

subject to the capital accumulation given by (27).

4.6 The Banks

The banks in our model are structured in a manner that undertakes the business of intermediation through a loan disbursement division; deposit-mobilization division and a wholesale division. The deposit division champions mobilization of differentiated deposits products from patient households. The loan division champions the disbursement of differentiated loans products to impatient household and entrepreneurs. Banks in this set up operates in monopolistic competitive deposits and loans markets. As such, the loan and deposit divisions have the power to adjust interest rates on loans and deposits subject to both the demand, supply factors and adjustment costs. The wholesale division mobilizes funding from the deposit divisions and grants wholesale credits to the loan division as an internal transfer pricing mechanism. The wholesale division is responsible for managing the bank's asset and liability balance sheet composition with the overall aim of maximizing profits, subject to Basel capital and liquidity regulations.

4.6.1 The Bank's Treasury

The function of a bank's treasury is to manage the bank's capital position to keep the ratio ($\frac{K_t^b}{B_t}$) at its optimum level, given the existence of costs for the deviations. As a variation of the Gerali et al. (2010) model, the bank's treasury focuses on accumulating treasury bond assets as a public debt mechanism for cash-constrained Central Government. The treasury bonds accumulation equations are expressed by taking into consideration the Debt to GDP mechanics. The bank pays a quadratic cost (parameterized by K_{kb}) when the ratio $\frac{K_t^b}{B_t}$ moves away from its optimal value υ^b .

The bank's balance sheet consists of bank deposits (D_t) and equity (K_t^b), on the liability side, and loans (B_t) on the asset side. The capital accumulation equation is given by:

$$\pi_t K_t^b = (1-\delta^b)K_{t-1}^b(j) + j_{t-1}^{b,n}(j) \tag{11}$$

where j_t^b is realized income in the quarter and δ^b measures the resources used to manage the bank's capital position. The problem of profit maximization is to choose the volume of loans, treasury instruments and deposits that maximize the sum of the discounted cash flow (in real terms):

$$\max_{\{B_t,D_t\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \Big[\big(1+R_t^b\big)B_t - B_{t+1\pi_{t+1}} + \big(1+R_t^{tb}\big)TB_t - TB_{t+1\pi_{t+1}} + (1+R_t^{tn})TN_t - TN_{t+1\pi_{t+1}} - (D_{t+1\pi_{t+1}} - \big(1+R_t^d\big)D_t) + \big(K_{t+1}^b\pi_{t+1} - K^b\big) - \frac{k_{kb}}{2}\left(\frac{k_t^b}{B_t} - \upsilon^b\right)^2 k_t^b\Big] \tag{12}$$

subject to the restriction of bank balance sheets $B_t + TB_t + TN_t = D_t + K_t^b$ and assuming R_t^b (the loan rate), R_t^{tb} (the treasury bill rate) , R_t^{tn} (the treasury note yield rate) and R_t^d (the deposit rate) as given.

In retail, banks are monopolistic competitors in both the loan and the deposit markets.

4.6.1.1 Loans

The bank *j* gets several resources B_t (j) from its matrix, in real terms, at the rate R_t^b . Such loans are distinguished, without charge, to be resold (relent) to households' firms applying two different markups. The branch faces quadratic adjustment costs to provide intertemporal changes in their lending rates. These costs are parameterized by k_{bH} and k_{bE}, associated, respectively, for households and firms. Are proportional to the aggregate return of loans. The banking branch *j* aims to choose $\{r_t^{bH}$ (j), r_t^{bE} (j)$\}$, in order to maximize

$$E_0 max \sum_{t=0}^{\infty} \Lambda_{0,t}^P \Big[r_t^{bH}(j)b_t^I(j) + r_t^{bE}(j)b_t^E(j) - R_t^b B_t(j) - \big(1+R_t^d\big)D_t - \frac{k_{bH}}{2}\left(\frac{r_t^{bH}(j)}{r_{t-1}^{bH}(j)} - 1\right)^2 r_t^{bH} b_t^I - \frac{k_{bE}}{2}\left(\frac{r_t^{bE}(j)}{r_{t-1}^{bE}(j)} - 1\right)^2 r_t^{bE} b_t^E\Big] \tag{13}$$

subject to demands (31) and (33) and B_t (j) = b_t (j) = b_t^I (j) + b_t^E (j).

4.6.1.2 Deposits

Likewise, the bank branch *j* receives deposits d_t^b *(j)* from the households and transfers it to the bank treasury that pays interest rate r_t . Therefore, the problem in the deposit market in the branch will be

$$\max_{\{r_t^d(j)\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[r_t D_t(j) - r_t^d(j) d_t^P(j) - \frac{k_d}{2} \left(\frac{r_t^d(j)}{r_{t-1}^d(j)} - 1 \right)^2 r_t^d d_t \right] \quad (14)$$

subject to demand deposits (35) and $D_t(j) = d_t^P$ *(j)*, quadratic adjustment costs in terms of intertemporal changes in deposit rates are parameterized by κd and proportionate to the aggregate rate to be paid on deposits.

4.6.2 Domestic Debt Accumulation Equations

The domestic debt that the government treasury obtains from the banking sector is in the form of Treasury Notes and Treasury Bills. These have been modeled as below:

$$tn_t^b = \vartheta_t GDP_t + \varepsilon_t^{tn} - Adj_t^{TN} \quad (15)$$

$$tb_t^b = \xi_t GDP_t + \varepsilon_t^{tb} - Adj_t^{TB} \quad (16)$$

where $Adj_t^{TN/TB}$ indicates the adjustment costs for changing rates on treasury notes and bills.

4.6.3 Bank Profits

The bank profits are the sum of net gains in the treasury and retail unit. Excluding intra-group transactions, the expression of the profit is given by:

$$j_t^b = r_t^{bH} b_t^I + r_t^{bE} b_t^E + r_t^{TN} tn_t^b + r_t^{TB} tb_t^b - r_t^d d_t - \frac{k_{kb}}{2} \left(\frac{K_t^d}{B_t} - \nu^b \right)^2 - K_t^b - K_t^{TN} - K_t^{TB} - Adj_t^B \quad (17)$$

where Adj_t^B indicates the adjustment costs for changing rates on loans, treasury notes, and bills and deposits.

4.7 Monetary Policy

The central bank sets the interest rate r_t by Taylor's rule as follows:

$$(1 + r_t) = (1 + r)^{1-\phi_R} \left(\frac{\pi_t}{\pi_{t-1}} \right)^{\phi_\pi (1-\phi_R)} \left(\frac{Y_t}{Y_{t-1}} \right)^{\phi_y (1-\phi_R)} (1 + \varepsilon_t^r) \quad (18)$$

where ϕ_π and ϕ_y are the weights assigned to the stabilization of inflation and output, respectively, r is the nominal interest rate at a steady state and ε_t^R is an exogenous shock to monetary policy.

5. Empirical Model

This chapter provides the empirical aspects related to the procedure that will be used to obtain the posterior distribution of the structural underlying model described in Section 4. The model will be estimated using Bayesian methods, which require the specification of priors (beliefs). We will run the analysis using MATLAB 2015a, Software using Dynare version 4.6.4.

5.1 Bayesian Estimation

5.1.1 General Bayesian Theorem Formulation

Bayesian modelers recognize that "all models are false", rather than assuming they are working with the correct model. This perspective contrasts with the classical frequentist analytical methods that search for a single model with the highest posterior probability given the evidence.

To demonstrate how the general principles of Bayesian Theory works as below; we will use a simple example case of the interaction between two random variables, X and Y. As is in bayesian literature let *p(V)* represent a probability mass function or density, depending on whether the variables are discrete or continuous. The general rule of conditional probability will be as follows:

$$\mathrm{p}(X \mid \mathrm{Y}) = \frac{\mathrm{p}\,(\mathrm{X,Y})}{\mathrm{p}(\mathrm{Y})} \tag{19}$$

And can be used to generate the Bayes' Theorem as below:

$$p(X \mid \mathrm{Y}) = \frac{p(\mathrm{Y|X})p(X)}{p(\mathrm{Y})} \tag{20}$$

In statistical problem generalization, we start with a data vector y, that is presumed to be a sample from a probability model with an unknown parameter vector θ. We present the model using the likelihood function $L(\theta; y) = f(y, \theta) = \prod_{i=1}^{n} f(y_i \mid \theta)$, where $f(y_i \mid \theta)$ shows the PDF (probability density function) of y_i given θ. The next objective is to deduce the properties of θ based on the data y. In Bayesian theory, the model that is parameterized by θ is a random vector. We presume that θ has a probability distribution $p(\theta) = \pi(\theta)$, which is referred to as a prior distribution. Because both y and θ are random, we can apply Bayes Theorem to derive the posterior distribution of θ given data y.

$$p(\theta \mid \mathrm{y}) = \frac{p(\mathrm{y}|\theta)p(\theta)}{p(\mathrm{y})} = \frac{f(\mathrm{y};\theta)\pi(\theta)}{m(\mathrm{y})} \tag{21}$$

Where $m(\mathrm{y}) = p(y)$, known as the marginal distribution of y, is defined by

$$m(\mathrm{y}) = \int f(\mathrm{y};\theta)\pi(\theta)d\theta \tag{22}$$

Since the marginal distribution $m(\mathrm{y})$ does not depend on the parameter of interest θ, we, therefore, reduce our posterior distribution equation to:

$$p(\theta \mid \mathrm{y}) \propto L(\mathrm{y};\theta)\pi(\theta) \tag{23}$$

This equation is important in Bayesian statistics and says that the posterior distribution of model parameters is proportional to their likelihood and probability distribution. The above equation is often computationally in a more convenient log-scale form as per below:

$$In\{p(\theta \mid \mathrm{y})\} = l(\mathrm{y};\theta) + In\{\pi(\theta)\} - \mathrm{c} \tag{24}$$

Where $l(\cdot;\cdot)$ depicts the log-likelihood of the model. Dependent on the analytical approach used, the log-posterior $In\{p(\theta \mid \mathrm{y})\}$, the actual value of the constant $c = In\{m(y)\}$ may or may not be relevant. For credible statistical analysis, however, it is always assumed that c is finite.

The likelihood function can be computed via the state-space representation of the model together with the measurement equation linking the observed data and the state vector. The model state-space representation will be:

$$S_{t+1} = \Gamma_1 S_t + \Gamma_2 w_{t+1} \tag{25}$$

$$Y_t = \Lambda S_t + \mu_t \tag{26}$$

Where $S_t = \{x_t, y_t\}$ x_t and y_t is the equilibriums described by the matrices of the deep parameters, Y_t is the vector of observed variables, μ_t is the measurement error, matrices Γ_1 and Γ_2 are functions of the model's deep parameters and Λ defines the relationship between observed and state variables.

The likelihood function will be computed under the assumption of normally distributed disturbances by combining the state-space representation implied by the solution of the linear rational expectations model and the Kalman filter. Posterior draws will be obtained using MCMC methods. After obtaining an approximation of the mode of the posterior, we will rely on an RWMH algorithm to generate posterior draws, as discussed in Schorfheide (2014). Point estimates of θ will be obtained from the generated values by using various location measures such as mean or median. Similarly, measures of uncertainty will follow from the computation of the percentiles of the draws.

5.1.2 Specific Application of Bayesian Theorem to our Model Framework

The prior density $p(\Theta \mid M_R)$, which is equivalent to $p(\theta \mid y)$ in the general framework above; assumes that prior information about the parameter vector can be summarized by a joint probability density function. These have a Beta and Inverse Gamma distribution respectively.

The likelihood function describes the density of the observed data given the model and the parameter vector. It is estimated using the Kalman filter, which evaluates the likelihood function associated with the solution of the space-state system of the model.

This function can be represented recursively

$$\mathscr{L}(\Theta \mid y_T, \mathrm{M_R}) \equiv \mathrm{p}(y_0 \mid \Theta, \mathrm{M_R}) \prod_{\mathrm{t=1}}^{\mathrm{T}} p\,(y_t \mid Y_{t-1}, \Theta, \mathrm{M_R}) \tag{27}$$

Where $\mathscr{L}(\Theta \mid y_T, \mathrm{M_R})$ is the likelihood function and $\mathrm{p}(y_t \mid Y_{t-1}, \Theta, \mathrm{M_R})$ is the density conditional on the information available up to *t-1*.

$$\Theta = \begin{bmatrix} \kappa_p, \kappa_w, \kappa_i, \kappa_d, \kappa_{bE}, \kappa_{bH}, \kappa_{Kb}, \phi_\pi, \phi_R, \phi_y, l_p, l_w, a^h, \rho_z, \rho_a, \rho_j, \rho_{mE}, \rho_{mI}, \rho_d, \rho_{bH}, \rho_{bE}, \rho_{qk}, \\ \rho_y, \rho_l, \rho_{Kb}, \sigma_z, \sigma_a, \sigma_j, \sigma_{mE}, \sigma_{mI}, \sigma_d, \sigma_{bH}, \sigma_{bE}, \sigma_{qk}, \sigma_R, \sigma_y, \sigma_l, \sigma_{Kb}, \end{bmatrix}$$

Where Θ is the vector of model parameters.

The posterior distribution is given by Bayes' theorem.

$$\mathrm{p}(\Theta \mid y_T, \mathrm{M_R}) = \frac{\mathcal{L}\,(\Theta \mid y_T, \mathrm{M_R})\,\mathrm{p}\,(\Theta \mid \mathrm{M_R})}{\mathrm{p}(y_T \mid \mathrm{M_R})} \tag{28}$$

The term $\mathrm{p}(y_T \mid \mathrm{M_R})$ is the marginal density of the data and appears as a normalization constant in the denominator. The logarithm of the marginal density of the data can be interpreted as a function of maximized log-likelihood penalized by the dimension of the model.

The term $\mathrm{p}(\Theta \mid y_T, \mathrm{M_R})$, is the posterior density proportional to the product of the likelihood function and the prior.

$$\mathrm{p}(\Theta \mid y_T, \mathrm{M_R}) \propto \mathscr{L}(\Theta \mid y_T, \mathrm{M_R})\,\mathrm{p}\,(\Theta \mid \mathrm{M_R}) \equiv \mathbb{K}(\Theta \mid y_T, \mathrm{M_R}) \tag{29}$$

This equation is of fundamental interest because it summarizes everything that is known about Θ, after using the data. The posterior kernel $\mathbb{K}(\Theta \mid y_T, \mathrm{M_R})$, corresponds to the numerator of the posterior density.

To complete a Bayesian specification of the model, we choose priors for each of the parameters of Θ.

5.1.3 Choice of Priors

In Bayesian analysis, we seek a balance between prior information in a form of expert knowledge or belief (results from prior or earlier research or literature) and evidence from data at hand. Achieving the right balance is one of the difficulties in Bayesian modeling and inference. In general, we should not allow the prior information to overwhelm the evidence from the data, especially when we have a large data sample. A famous theoretical result, the Bernstein–von Mises theorem, states that in large data samples, the posterior distribution is independent of the prior distribution and, therefore, Bayesian and likelihood-based inferences should yield essentially the same results. On the other hand, we need strong enough support for weak evidence that usually comes from insufficient data. It is always good practice to perform sensitivity analysis to check the dependence of the results on the choice of a prior.

Bayesian inference starts from the prior distribution of the model's non-calibrated parameters. Priors density function reflect our beliefs about parameter values. The Bayesian estimation technique allows us to use this prior information from earlier studies at both the macro and micro levels. When evidence is weak or non-existent, we will impose more diffuse priors.

The Gamma Distribution will be defined for the parameters that are assumed to be positive (Real Numbers) which include *all the quadratic adjustments.* Therefore, the priors were completely harmonized, with their means set at a range of 0.1 to 2 in line with the literature, and with a standard deviation of 0.1 to 0.5 for all the parameters.

Θ with Gamma Distribution $= \left[\kappa_p, \kappa_w, \kappa_i, \kappa_d, \kappa_{bE}, \kappa_{bH}, \kappa_{Kb}\right]$

The Beta Distribution will be defined for the parameters bounded between zero and one which includes the shocks autoregressive parameters, wage and price indexation parameters, habit formation parameters, inflation, and bank interest rate stabilizer indices. There was no prior strong information related to the autoregressive parameters. Therefore, the priors were completely harmonized, with their means set at a range of 0.1 to 2 in line with the literature, and with a standard deviation of 0.1 to 0.5 for all the parameters.

$$\Theta \text{ with Beta Distribution} = \begin{bmatrix} \phi_{\pi}, \phi_{R}, l_p, l_w, a^h, \rho_z, \rho_a, \rho_j, \rho_{mE}, \rho_{mI}, \rho_d, \rho_{bH}, \rho_{bE}, \rho_{qk}, \\ \rho_y, \rho_l, \rho_{Kb} \end{bmatrix}$$

The Inverse Gamma Distribution will be used for parameters that are assumed to be positive, Real Numbers such as standard deviations of shocks. The mean will be set at 0.01 for all the shocks, which is the standard value in the macro literature. To ensure the success of the numerical optimization of the posterior kernel the prior mean will be set at the considerably low level of 0.01, for the remaining shocks. The standard deviations for all these priors were set at 0.05, which is usually used in the literature.

$$\Theta \text{ with Inverse Gamma Distribution} = [\sigma_z, \sigma_a, \sigma_j, \sigma_{mE}, \sigma_{mI}, \sigma_d, \sigma_{bH}, \sigma_{bE}, \sigma_{qk}, \sigma_R, \sigma_y, \sigma_l, \sigma_{Kb}]$$

5.2 Data and Sources

In the empirical analysis, we will use quarterly macroeconomic variables of the Malawian economy. Data comprises the period between the full quarters of 2004 and 2020. Sources of Data have been outlined in appendix 2.

Let $\boldsymbol{y_t} = [y_t]_{t=1}^{T}$ the set of observables

$$\boldsymbol{y_t} = \left(\log C_t, \log K_t, \log \pi_t, \log R_t, \log K_t^b, \log Loans_t, \log DD_t, \log BK_t, \log TNOTES_t, \log TBILLS_t\right)$$

It is assumed that the period t in the model corresponds to one quarter, y_t is the vector of observables, C_t is the Household final Consumption (Real Consumption), K_t is the Gross Capital Formation (Real Investments), π_t is the CPI inflation, R_t is the Monetary Policy Rate (Policy Rate), K_t^b is the aggregate bank capital, loans, Treasury Notes, Treasury Bills and Deposits. The data has been obtained from the Reserve Bank of Malawi and National Statistics Office in Malawi.

The parameters to estimate are contained in vector Θ.

$$\Theta = \begin{bmatrix} \kappa_p, \kappa_w, \kappa_i, \kappa_d, \kappa_{bE}, \kappa_{bH}, \kappa_{Kb}, \phi_\pi, \phi_R, \phi_y, l_p, l_w, a^h, \rho_z, \rho_a, \rho_j, \rho_{mE}, \rho_{mI}, \rho_d, \rho_{bH}, \rho_{bE}, \rho_{qk}, \\ \rho_y, \rho_l, \rho_{Kb}, \sigma_z, \sigma_a, \sigma_j, \sigma_{mE}, \sigma_{mI}, \sigma_d, \sigma_{bH}, \sigma_{bE}, \sigma_{qk}, \sigma_R, \sigma_y, \sigma_l, \sigma_{Kb}, \end{bmatrix}$$

The parameter vector Θ, is made up of the autocorrelation slopes and the standard deviations of the exogenous shocks that are a source of fluctuations in the general equilibrium model.

5.2.1 Interpolation of Quarterly GDP, Household Consumption, Capital Formation Data

The interpolation of annual data into quarterly data was done using the interpolator that we developed by borrowing the "Balance Sheet Accounting Approach" that was extracted from the *System of Macroeconomic Accounts Statistics: An Overview; IMF Pamphlet No.56*. If you have a continuous annual GDP series, it is then possible to generate quarterly GDP series in between the years using the "Balance Sheet Approach". The starting point is the Opening balance sheet as in the table below of which in our case, this will be the annual GDP of the preceding year; then our closing GDP for the last quarter in the following year will be the Closing balance sheet for that year as in the figure above.

The formula we have developed produces a "year-specific multiplier" that is then applied to the Opening balance sheet to produce a monthly series that reconciles back to the Closing balance sheet. Once the monthly series has been generated and reconciled; then the data is organized into quarterly series. The key reconciliation point to note is that the 12th month or last quarterly series will always be equal to the Closing balance sheet which in our case it is the following year's annual GDP series.

The developed interpolator is presented below in mathematical forms:

$$\left(\left(\frac{Closing\ GDP_t}{Opening\ GDP_t}\right)^{\left(\frac{1}{12}\right)}\right) - 1 \tag{30}$$

$$(December\ 2004\ GDP_t) * \left(\left(\left(\frac{December\ 2005\ GDP_t}{December\ 2004\ GDP_t}\right)^{\left(\frac{1}{12}\right)}\right) - 1\right) = January\ 2005\ GDP_t \tag{31}$$

$$(January\ 2005\ GDP_t) * \left(\left(\left(\frac{December\ 2005\ GDP_t}{December\ 2004\ GDP_t}\right)^{\left(\frac{1}{12}\right)}\right) - 1\right) = February\ 2005\ GDP_t \tag{32}$$

The process is repeated continuously to the last balance sheet date and thereafter the monthly generated series is organized in quarterly data. It is important to note that the interpolator generated above in equation 32 is already an addictive or subtractive interpolator depending on the year-on-year GDP series progression. So, the quarterly GDP as per the balance sheet approach will be series extracted in March, June, September, and December of each series for a particular year of interest.

5.3 Properties of the Model

To assess the goodness of the Bayesian estimators of a DSGE model, several tools can be used and generated at the end of the estimation. Among them, it is worth noting the univariate diagnosis of Monte Carlo Markov chains (MCMC), the diagnosis of multivariate convergence, the Blanchard-Kahn conditions, the pairings between the prior and posterior distributions.

The prior and posterior distributions in Appendix 5, Figure 1, show two important facts. On the one hand, most of the a priori distributions (red color) match the posterior distributions (blue dotted) adequately. This reflects the idea that the data used for the estimations contain enough information that meets the author's beliefs on the prior distributions of the parameters Pfeifer (2020). On the other hand, overall, the estimated parameters are significantly different from zero. This is true for all parameters including standard deviations of shocks.

About the univariate diagnosis of the convergence of MCMC chains, it should be noted the analysis was performed with 100,000 simulations of the Metropolis-Hastings (MH) algorithm. The acceptance ratios in the two chains averaged 24.64%, (chain 1 was 24.44% and chain 2 was 24.84%), which is quite satisfactory. If the results are conclusive, the two chains relating to each parameter should evolve at a constant pace and converge towards a common value. Figures 3 (appendix 5) clearly show that this requirement is met in the case of this study.

Finally, figure 2 in appendix 5 suggests that the calibrated values of the parameters provide non-explosive solutions to the model and that the Blanchard-Kahn conditions are satisfied because the estimated mode is at the maximum of the posterior likelihood for all the model settings.

Autocorrelation coefficients are assumed to have a Beta distribution with limits of [0,1]. It is also assumed that the standard deviation of the shocks imposes an Inverse Gamma with limits of [0, □]. Considering the standard literature, dogmatic priors are imposed over Standard Deviation parameters.

5.4 Calibration

As commonly done in the DSGE literature, several parameters will be calibrated from the onset, and not included in the estimation process. This procedure helps to deal with the identification problem from which DSGE models commonly suffer, which arises from the fact that the variables used in the estimation may contain little information about some of the parameters of interest. In small-scale models this problem is usually solved by carefully looking at each equation; but in medium or large-scale models like the one we have employed in this study, the task of looking at each equation is almost impossible. Furthermore, incorporating fixed parameters in the estimation process can be viewed as imposing a very strict prior, and therefore a consistent common practice with the Bayesian approach to estimation. The calibrated parameters are in Table 3 appendix 3.

The parameters that were chosen in the calibration strategy mainly pertain to three aspects:

(a) those crucial to determine the steady-state (those that can be easily identified from steady-state relationships among observable variables);
(b) those for which reliable estimates are available from other sources (in our case those parameters that characterize the Law of Motion of the exogenous processes);
(c) those whose values are crucial to replicate the main steady-state key ratios of the Malawian Economy (those that are endogenously determined).

However as indicated in the introduction, there have not been many papers written in this area from which we can draw priors.

Calibration can be considered an estimation strategy, Gregory and Smith (1987). This procedure allows us to assign values to the parameters of the general equilibrium model based on various sources. Some parameters reflect their historical values and others are our estimates. The subjective discount factor β, will be set to 0.9943, as per literature. As for the impatient households and entrepreneurs' discount factors β_I and β_E, we set them at 0.975, in the range suggested by Iacoviello (2005) and Iacoviello and Neri (2009). As for the loan to value (LTV) steady-state ratios, we set m^I and m^E at 0.70 in line with evidence for mortgages in Malawi.

The rest of the parameters are estimated per standard banking literature on DSGE.

Table 3: Calibrated Parameters

Parameter	Description	Value	Source
β_P	Patient household's discount factor	0.9943	Literature
β_I	Impatient household's discount factor	0.975	Literature
β_E	Entrepreneurs' discount factor	0.975	Literature
Φ	The inverse of the Frisch elasticity	1.0	Literature
μ	Share of unconstrained households	0.8	Literature
ε^h	Weigh of housing in the household's utility function	0.2	Literature
α	Capital share in the production function	0.25	Literature
δ	The depreciation rate of physical capital	0.025	Literature
ε^y	$\varepsilon^y/_{\varepsilon^y - 1}$ is the markup in the goods market	6	Literature
ε^l	$\varepsilon^l/_{\varepsilon^l - 1}$ is the markup in the labor market	5	Literature
m^I	Households LTV ratio	0.70	Malawi Banks Practice
m^E	Entrepreneurs' LTV ratio	0.70	Malawi Banks Practice
v^b	Target capital to loans ratio	0.10	Tier 1 – Basel Accord
ε^d	$\varepsilon^d/_{\varepsilon^d - 1}$ is the mark-up on deposit rate	-1.46	Literature
ε^{bH}	$\varepsilon^{bH}/_{\varepsilon^{bH} - 1}$ is the mark-up on loans to households	2.79	Literature
ε^{bE}	$\varepsilon^{bE}/_{\varepsilon^{bE} - 1}$ is the mark-up on loans to firms	3.12	Literature
δ^b	Cost of managing the bank's capital position	0.1049	Tier 1 – Basel Accord

6.0 RESULTS

This section presents the results obtained. Long before this presentation, some comments on the estimated parameters are presented first. Then, the factors driving business cycle fluctuations are analyzed from the simulations carried out on the model and thus estimated. Finally, in addition, cyclical fluctuations in Output are analyzed using two tools: the decomposition of the variance of the error and the decomposition of the historical variance, that is, that which is based on the quarterly data used.

6.1 APPLICATION OF THE MODEL

In this section we use the estimated results and propagation mechanics to address the research questions posed in the introduction. To investigates the extent to which credit-supply factors affect business cycle fluctuations in Malawi, and whether banks' balance sheet structure could also be a potential source of business cycle fluctuations through their firm level investments accumulation mechanism.

6.1.1 The role of a financial shock in the Business Cycle in Malawi

To study the relative importance of the shocks in the model we performed a historical decomposition of the dynamics of the for Malawi. This decomposition was obtained by fixing the parameters of the model at the posterior mode and then using the Kalman smoother to obtain the values of the innovations for each shock. The aim of the exercise is twofold: on the one hand, we want to investigate how our financially-rich model interprets the credit supply frictions in Malawi and thus learn from the model which shocks were mainly responsible for the variation in output and credit supply. On the other hand, to the extent that the overall story told by the model is consistent with the common public opinion about the origins and causes of the credit supply frictions in Malawi.

For this exercise, we have divided the 16 shocks that appear in the model into three groups. First, there is a "macroeconomic" group , "banking/financial group" and “monetary policy group”.

The macroeconomic shock group consists of shocks to the production technology (e_A_e); shocks to intertemporal preferences (e_z); to price and wage markups (e_i); to the investment-specific technology (e_qk).

Banking or Financial group shock group consists of shock to the loan-to-value ratios on loans to firms (e_me); the loan-to-value ratios on loans to households (e_mi); shock to bank balance sheet loan book – firms (e_mk_be); shock to balance sheet loan book – household (e_mk_bh); shock to deposits (e_mk_d); shock to mark up on bank interest rates (e_r_ib); shock to domestic debt portfolio (e_tnotes); shock to domestic debt portfolio (e_tbill); shock to reference rate (e_r_ref); shock to bank profits (e_j); shock to bank capital (e_eps_K_b) and shock to output (e_y)

The monetary policy shock group consists of the residual shocks apart from Macroeconomic and Financial/Banking Isolated shocks

Figure 12: Historical Shock Decomposition of main macro variables: Dynamic Effects of Respective Shocks on Output (GDP)

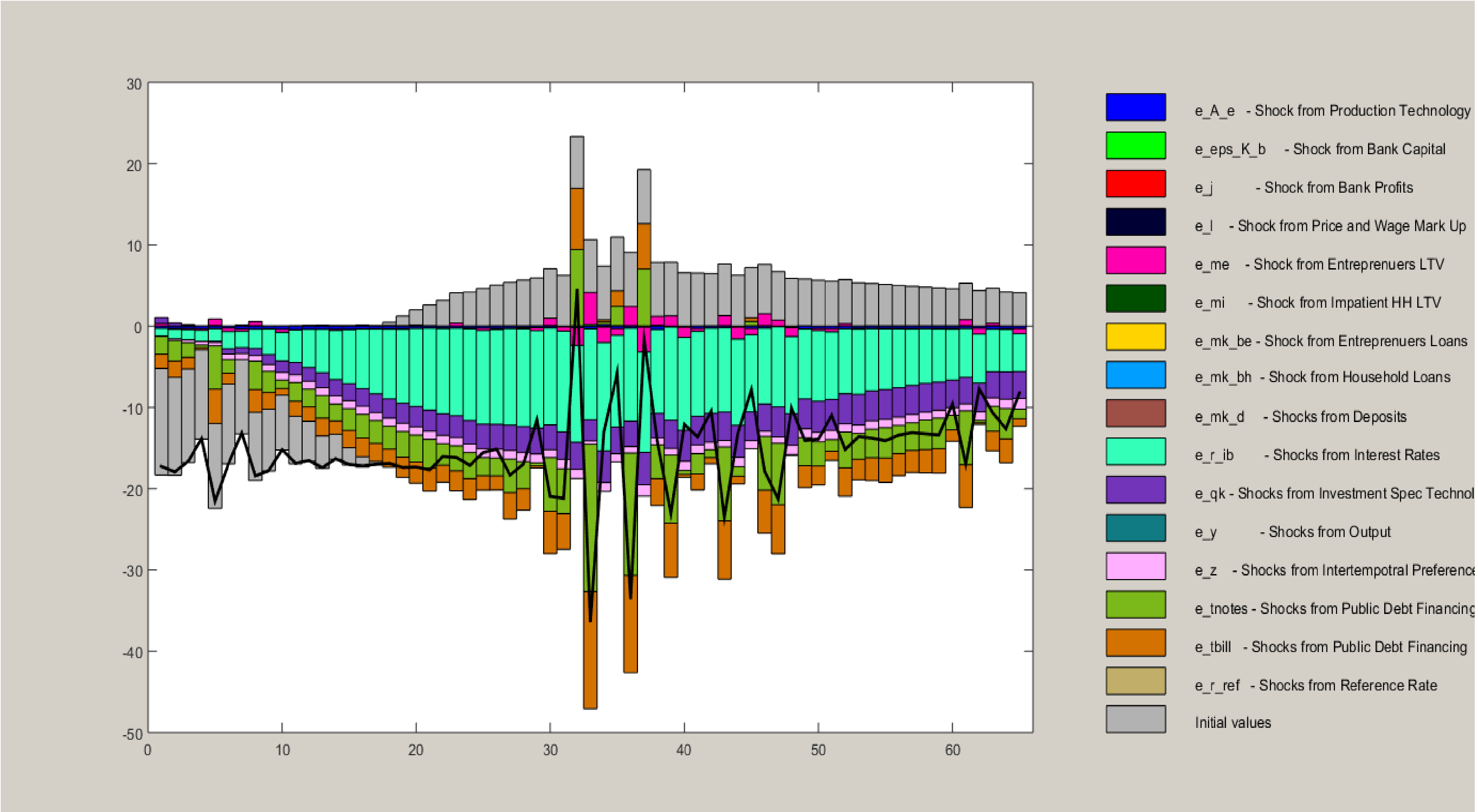


Figure 13: Decomposition of Variance Conditional Forecast Errors (%)

Period 1	**e_A_e**	**e_eps_K_b**	**e_j**	**e_l**	**e_me**	**e_mi**	**e_mk_be**	**e_mk_bh**	**e_mk_d**	**e_r_ib**	**e_qk**	**e_y**	**e_z**	**e_tnotes**	**e_tbill**	**e_r_ref**	**Totals**
interestPol	1.58	0.01	0	0	0.34	0	0	0	0	45.21	0.13	0	0.16	33.06	19.51	0	100
interestH	7.68	0.13	0	0	0.04	0.03	0	0.02	0.16	6.8	0.12	0	5.97	49.71	29.33	0	100
interestF	7.98	0.13	0	0	0.04	0.04	0.02	0	0.16	5.06	0.12	0	6.01	50.59	29.85	0	100
inflation	15.05	0.02	0	0	0	0	0	0	0.03	79.19	0.03	0.01	0.8	3.06	1.81	0	100
loansH	1.77	0.02	0	0	0.09	97.21	0	0	0	0.51	0.02	0	0.01	0.23	0.14	0	100
loansF	2.44	1.64	0	0	51.51	0.03	0.01	0	0.05	16.97	26.51	0	0.84	0	0	0	100
output	0.16	0.01	0	0	0.73	0	0	0	0	0.4	0.35	0	0.07	61.81	36.47	0	100
consumption	1.65	0.17	0	0	7.85	0.02	0	0	0	24.69	7.07	0	57.6	0.6	0.35	0	100
investment	0.55	0.15	0	0	0.1	0	0	0	0	2.74	96.44	0	0	0	0	0	100
deposits	1.44	0.52	0	0	1.22	95.77	0	0	0	0.15	0.49	0	0	0.26	0.15	0	100
interestDep	4.47	0.08	0	0	0.07	0	0	0	0.01	41.82	0	0	1.29	32.86	19.39	0	100
bankcapital	0.63	95.82	0	0	0	0	0	0	0	3.31	0	0	0.03	0.13	0.08	0	100
interestTNOTES	1.55	0.1	0	0	0.63	1.21	0	0	0.01	2.07	2.69	0	4.47	56.97	30.3	0	100
interestTBILL	1.63	0.1	0	0	0.69	1.23	0	0	0.01	2.1	2.87	0	4.55	57.01	29.81	0	100
Period 4	**e_A_e**	**e_eps_K_b**	**e_j**	**e_l**	**e_me**	**e_mi**	**e_mk_be**	**e_mk_bh**	**e_mk_d**	**e_r_ib**	**e_qk**	**e_y**	**e_z**	**e_tnotes**	**e_tbill**	**e_r_ref**	**Totals**
interestPol	1.36	0.02	0	0	0.73	0	0	0	0.01	46.94	0.3	0	0.42	31.58	18.64	0	100
interestH	0.42	0.04	0	0	0.02	0.01	0	0	0.07	93.77	0.17	0	1.67	2.41	1.42	0	100
interestF	0.46	0.04	0	0	0.02	0.01	0	0	0.07	93.67	0.17	0	1.71	2.42	1.43	0	100
inflation	3.9	0.04	0	0	0	0.01	0	0	0.03	89.52	0.03	0	0.81	3.56	2.1	0	100
loansH	7.46	0.05	0	0	0.08	89.3	0	0	0	2.64	0.03	0	0.03	0.26	0.15	0	100
loansF	0.58	0.34	0	0	3.21	0.03	0	0	0.04	90.9	2.57	0	0.62	1.07	0.63	0	100
output	0.17	0.04	0	0	1.08	0	0	0	0	0.42	0.47	0	0.38	61.27	36.16	0	100
consumption	0.69	0.05	0	0	1.04	0.01	0	0	0.01	48.54	2.43	0	45.4	1.15	0.68	0	100
investment	0.38	0.11	0	0	0.9	0	0	0	0.01	23.19	74.63	0	0.01	0.49	0.29	0	100
deposits	4.82	1.16	0	0	0.8	62.14	0	0	0.03	29.14	0.45	0	0.01	0.9	0.54	0	100
interestDep	1.95	0.13	0	0	0.19	0.01	0	0	0.03	82.61	0.4	0	2.33	7.78	4.59	0	100
bankcapital	1.64	63.33	0	0	0.07	1.08	0	0	0.07	23.96	0.04	0	0.09	6.08	3.64	0	100
interestTNOTES	2.77	0.21	0	0	10.32	0.02	0.01	0	0.02	68.58	12.16	0	2.61	2.06	1.18	0.06	100
interestTBILL	2.77	0.21	0	0	10.32	0.02	0.01	0	0.02	68.53	12.23	0	2.61	2.05	1.16	0.06	100

Figure 13: Decomposition of Variance Conditional Forecast Errors (%) - Continued

Period 8	**e_A_e**	**e_eps_K_b**	**e_j**	**e_l**	**e_me**	**e_mi**	**e_mk_be**	**e_mk_bh**	**e_mk_d**	**e_r_ib**	**e_qk**	**e_y**	**e_z**	**e_tnotes**	**e_tbill**	**e_r_ref**	**Totals**
interestPol	1.07	0.03	0	0	0.54	0	0	0	0.02	59.12	0.22	0	0.42	24.26	14.32	0	100
interestH	0.18	0.01	0	0	0.01	0.01	0	0	0.04	94.67	0.05	0	0.73	2.71	1.6	0	100
interestF	0.18	0.01	0	0	0.01	0.01	0	0	0.04	94.66	0.05	0	0.74	2.7	1.59	0	100
inflation	2.27	0.04	0	0	0	0	0	0	0.03	91.06	0.02	0	0.65	3.72	2.2	0	100
loansH	10.61	0.11	0	0	0.08	71.67	0	0	0.02	16.27	0.16	0	0.04	0.66	0.39	0	100
loansF	0.28	0.12	0	0	0.85	0.02	0	0	0.03	93.28	1.43	0	0.31	2.32	1.37	0	100
output	0.18	0.06	0	0	1.08	0	0	0	0	0.57	0.63	0	0.61	60.92	35.95	0	100
consumption	0.28	0.02	0	0	0.37	0.01	0	0	0.02	69.55	1.08	0	25.44	2.03	1.2	0	100
investment	0.49	0.09	0	0	0.67	0	0	0	0.02	47.52	49.05	0	0.01	1.35	0.8	0	100
deposits	4.01	0.5	0	0	0.33	24.64	0	0	0.05	66.07	0.54	0	0.03	2.4	1.42	0	100
interestDep	0.58	0.06	0	0	0.05	0.01	0	0	0.03	91.73	0.1	0	0.91	4.1	2.42	0	100
bankcapital	0.49	20.27	0	0	0.04	0.4	0	0	0.11	68.76	0.02	0	0.22	6.08	3.62	0	100
interestTNOTES	1.74	0.09	0	0	2.98	0.01	0	0	0.03	82.17	8.15	0	1.06	2.37	1.39	0.02	100
interestTBILL	1.74	0.09	0	0	2.98	0.01	0	0	0.03	82.12	8.21	0	1.06	2.36	1.38	0.02	100
Period 16	**e_A_e**	**e_eps_K_b**	**e_j**	**e_l**	**e_me**	**e_mi**	**e_mk_be**	**e_mk_bh**	**e_mk_d**	**e_r_ib**	**e_qk**	**e_y**	**e_z**	**e_tnotes**	**e_tbill**	**e_r_ref**	**Totals**
interestPol	0.98	0.02	0	0	0.43	0	0	0	0.02	66.4	0.2	0	0.34	19.87	11.73	0	100
interestH	0.42	0.01	0	0	0.02	0.01	0	0	0.04	93.86	0.07	0	0.39	3.27	1.93	0	100
interestF	0.43	0.01	0	0	0.02	0.01	0	0	0.04	93.85	0.07	0	0.39	3.26	1.93	0	100
inflation	1.77	0.03	0	0	0.01	0	0	0	0.03	91.53	0.05	0	0.47	3.83	2.26	0	100
loansH	9.54	0.33	0	0	0.08	45.8	0	0	0.03	41.3	0.52	0	0.06	1.47	0.87	0	100
loansF	0.66	0.07	0	0	0.48	0.01	0	0	0.03	87.92	6.16	0	0.17	2.83	1.67	0	100
output	0.18	0.07	0	0	1.06	0	0	0	0	1.84	0.88	0	0.74	59.89	35.34	0	100
consumption	0.19	0.02	0	0	0.18	0.01	0	0	0.02	80.47	0.55	0	14.11	2.8	1.65	0	100
investment	0.83	0.08	0	0	0.47	0	0	0	0.02	63.37	31.73	0	0.05	2.18	1.28	0	100
deposits	2.51	0.2	0	0	0.16	8.4	0	0	0.04	82.31	1.54	0	0.02	3.03	1.79	0	100
interestDep	0.61	0.04	0	0	0.04	0	0	0	0.03	92.28	0.1	0	0.49	4.03	2.38	0	100
bankcapital	0.15	2.55	0	0	0.01	0.05	0	0	0.05	90.85	0.02	0	0.26	3.81	2.25	0	100
interestTNOTES	1.43	0.07	0	0	1.41	0	0	0	0.03	84.3	7.71	0	0.47	2.88	1.7	0.01	100
interestTBILL	1.42	0.07	0	0	1.4	0	0	0	0.03	84.23	7.8	0	0.47	2.88	1.69	0.01	100

Figure 13: Decomposition of Variance Conditional Forecast Errors (%) - Continued

Period 32	e_A_e	e_eps_K_b	e_j	e_l	e_me	e_mi	e_mk_be	e_mk_bh	e_mk_d	e_r_ib	e_qk	e_y	e_z	e_tnotes	e_tbill	e_r_ref	Totals
interestPol	1.05	0.03	0	0	0.41	0	0	0	0.02	67.49	0.29	0	0.37	19.08	11.26	0	100
interestH	0.65	0.01	0	0	0.02	0.01	0	0	0.03	93.17	0.28	0	0.48	3.36	1.98	0	100
interestF	0.64	0.01	0	0	0.02	0.01	0	0	0.03	93.17	0.28	0	0.49	3.35	1.98	0	100
inflation	1.81	0.04	0	0	0.02	0	0	0	0.03	91.26	0.2	0	0.5	3.85	2.27	0	100
loansH	9.28	0.5	0	0	0.09	40.81	0	0	0.03	45.23	1.06	0	0.39	1.64	0.97	0	100
loansF	1.15	0.12	0	0	0.48	0.01	0	0	0.02	75.63	18.19	0	0.28	2.59	1.53	0	100
output	0.18	0.07	0	0	1.05	0	0	0	0	2.75	1.22	0	0.75	59.1	34.87	0	100
consumption	0.26	0.02	0	0	0.17	0.01	0	0	0.02	81.45	0.71	0	12.64	2.96	1.75	0	100
investment	1.31	0.13	0	0	0.47	0.01	0	0	0.02	63.49	30.55	0	0.33	2.32	1.37	0	100
deposits	2.53	0.22	0	0	0.19	5.73	0	0	0.04	81.13	5.01	0	0.23	3.1	1.83	0	100
interestDep	0.8	0.04	0	0	0.04	0.01	0	0	0.03	91.8	0.31	0	0.53	4.05	2.39	0	100
bankcapital	0.46	1.35	0	0	0.02	0.03	0	0	0.04	91.71	0.02	0	0.2	3.88	2.29	0	100
interestTNOTES	1.65	0.1	0	0	1.14	0	0	0	0.03	80.88	11	0	0.57	2.91	1.71	0.01	100
interestTBILL	1.65	0.1	0	0	1.13	0	0	0	0.03	80.73	11.17	0	0.57	2.9	1.71	0	100

Also, from the same tables above it can be seen that Household Loans and Loans to Entrepreneurs and firms are hugely affected by interest rates and shocks coming from collateral administration as the model assumed a Loan to Value Ratio (LTV) of 70%.

Figure 12 shows the results of the exercise for some macro variables. Concerning output, the results of the historical decomposition suggest that when we model banks we notice that it’s a mixture of banking or financial shocks and macroeconomic shocks that were primary drivers behind both business cycle fluctuations and credit supply in the Malawi economy. These shocks explain about 48 percent of the slowdown in economic activity up to period 30.

Chief among the banking sector shocks that were prominent in influencing output fluctuations were shocks from public debt financing. This is not surprising considering that Banks in Malawi just like many parts of the world hold a significant portion of non-loan book assets. As of December 2020, in Malawi banks held about 39% of the total banking sector assets in treasury instruments, both for liquidity purposes and overly yield attractive fiscal public debt financing instruments.

This in effect crowds out private sector consumption and investment as economic agents' impatient households or non-Ricardian, Entrepreneurs, and Firms together with the Government compete for the same available credit supply by the Banking Sector. But what attracts banks to build such significant portfolios of Public Debt Induced Assets is the fact that portfolios with the Central Government carry zero risk weights for Credit Risk purposes and hence they preserve the banks' capital and also because the Central Government due to inadequate fiscal funding needs financing usually drives the treasury yields up to an extent that the yield on treasuries is almost closer to the yields on consumer or investment financing but since they are zero risk weighted that consumer loans portfolios. Banks find it rewarding and capital preserving to finance the accumulation of Public Debt linked assets.

This is the main avenue in which crowding-out effects happen in the Malawian economy and constrains credit supply to the wider economy.

As seen in the tables above public debt financing interest rates transmission contributes to 79.04% variability in interest rates charged to Households and 80.44% variability in interest rates charged to Firms in the short run. Meaning the unsustainability of public debt has real crowding out effects for Households and Firms, this crowding out comes in the form of investment opportunities trade-off opportunities for banks. For every excess funds above regulatory liquidity threshold management, banks are more likely induced to invest only 20.96% to loans to households and 19.56% to firms. This is the measurable degree of crowding out that the study shows.

The other main culprit behind the fluctuations in business cycles is negative shocks from interest rates. These are also prominent across the periods from period 1 to period 60. This confirms the public outcry that in the Malawian market, interest rates are too high to effectively incentive output growth.

The other contributor to output fluctuations as seen from the graph is negative shocks from investment-specific technology, which are coming in between high-interest rates and crowding out effects from public debt financing. This leaves not enough resources to finance investments that have the potential to increase or augment output growth.

The other negative influence on output are smaller shocks from intertemporal preferences; depicting the consumption behavior of economic agents that feed into output; the more consumption is directed on non-output enhancing goods, the more negative will that shock influence output.

And from Figure 13 above it can also be seen that shocks from banking sector profits, household loans, and entrepreneurs' lending do not have adverse effects on output nor are they featuring heavily in the decomposition of the shocks. Meaning mainly that apart from the Bank's active accumulation of Public Debt Assets, the rest of the Banking Sector balance sheet doesn't adversely affect the fluctuations of output in Malawi.

7.0 Conclusion and Policy Recommendation

Our study establishes that banking sector shocks emanating from financing public debt play a significant role in explaining variations in output in Malawi both in the short and long run. We also found that these shocks from public financing shocks crowd-out private sector credit supply and hence push interest rates up in the face of liquidity-constrained Central Government.

Our study also finds that shocks from banking sector profits, household loans, and entrepreneurs lending do not have adverse effects on output nor are they featuring heavily in the decomposition of the shocks that explain the fluctuation of output in Malawi. This generally means that apart from the Bank's active accumulation of public debt assets, the rest of the banking sector balance sheet variables do not directly adversely affect the fluctuations of output in Malawi, which is quite contrary to public perception of the banking sector.

We also found that interest rates indeed negatively affect both consumption and investments. We found that demand for household and entrepreneur loans was highly affected by shocks coming from collateral settings. Indeed, in Malawi, banks demand high collateral ratios for them to advance credit to households and firms.

The findings of our study are quite important for policymakers. Since is undeniable that banks play a very important financial intermediation role and, they are a conduit through which the Central Bank monetary policy transmission uses to affect the asset composition of the Bank's balance sheets at any given point. Banks also play a very important role in allocating scarce resources between savers and borrowers. The main finding of our study is that public debt instruments accumulation by banks had a pronounced effect on output fluctuation in Malawi during the period of the study; in other words, banks are more inclined to hold treasury instruments than supply credit to households and firms. This is encouraged by high yields and zero risk attached to the accumulation of public debt for credit risk-weighted assets purposes.

But since we noted in our study that the public debt shocks negatively affect output; it is important for authorities to examine the way they finance the fiscal budget gaps in Central Government financing other than bonds creation. This might mean reducing wasteful consumptive recurrent expenditures. The main reason why public debt shocks are negatively affecting output is that the resources from treasury bonds do not support real output growth augmenting investments that have potential of stimulating the growth of the tax base. When the Central Government reduces the quantum of fiscal funding gap using the banking channel, banks will be encouraged to supply credit to the rest of the economy in growth-oriented sectors.

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Appendix 1

Technical Appendix - Setting the Model Equations – Selected Equations

Households Block of the Model

$$\max_{\{c_t^I, h_t^I, d_t^I\}} E_0 \sum_{t=0}^{\infty} \beta_p^t \left[(1 - a^p)\varepsilon_t^z \log\left(c_t^p(i) - a^p c_{t-1}^p\right) + \varepsilon_t^h log h_t^p(i) - \frac{l_t^p(i)^{1+\phi}}{1+\phi}\right], \tag{A.1}$$

Subject to

$$c_t^p(i) + q_t^h\left(h_t^p(i) - h_{t-1}^p(i)\right) + d_t^p(i) \leq w_t^p l_t^p(i) + \frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p(i) + t_t^p(i) \tag{A.2}$$

Step 1 - Setting up a Lagrangian from the Objective function in 1 and budget constraint in 2

Let $f(x,y) = \max_{\{c_t^I, h_t^I, d_t^I\}} E_0 \sum_{t=0}^{\infty} \beta_p^t \left[(1 - a^p)\varepsilon_t^z \log\left(c_t^p(i) - a^p c_{t-1}^p\right) + \varepsilon_t^h log h_t^p(i) - \frac{l_t^p(i)^{1+\phi}}{1+\phi}\right]$ and

$$g(x,y) = c = c_t^p(i) + q_t^h\left(h_t^p(i) - h_{t-1}^p(i)\right) + d_t^p(i) \leq w_t^p l_t^p(i) + \frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p(i) + t_t^p(i)$$

Therefore, the Lagrangian function, after introducing the Lagrangian Multiplier λ shall be

$$\mathcal{L}(x,y,\lambda) = f(x,y) - \lambda(g(x,y) - c) \tag{A.3}$$

Which in full is presented in equation 4

$$\mathcal{L}\left(\beta_p^t(1 - a^p)\varepsilon_t^z \log\left(c_t^p(i) - a^p c_{t-1}^p\right) + \beta_p^t \varepsilon_t^h log h_t^p(i) - \beta_p^t \frac{l_t^p(i)^{1+\phi}}{1+\phi}, \lambda\right) = \Big[\beta_p^t(1 - a^p)\varepsilon_t^z \log\left(c_t^p(i) - a^p c_{t-1}^p\right) + \beta_p^t \varepsilon_t^h log h_t^p(i) - \beta_p^t \frac{l_t^p(i)^{1+\phi}}{1+\phi}\Big] - \lambda\Big[c_t^p(i) + q_t^h\left(h_t^p(i) - h_{t-1}^p(i)\right) + d_t^p(i) - w_t^p l_t^p(i) + \frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p(i) + t_t^p(i),\Big] \tag{A.4}$$

Step 2 – Obtain FOC from LF by differentiating the LF in 4 concerning c_t^p, h_t^p, and d_t^p

$$\frac{\partial \mathcal{L}(x,y,\lambda)}{\partial c_t^p} = f_1'(x,y) - \lambda g_1'(x,y) = 0 \quad \text{(A.4a)}$$

$$\frac{\partial \mathcal{L}(x,y,\lambda)}{\partial h_t^p} = f_2'(x,y) - \lambda g_2'(x,y) = 0 \quad \text{(A.4b)}$$

$$\frac{\partial \mathcal{L}(x,y,\lambda)}{\partial d_t^p} = f_3'(x,y) - \lambda g_3'(x,y) = 0 \quad \text{(A.4c)}$$

We will have four partial derivatives of the Lagrangian for our unconstrained consumption and housing functions and presented in the objective function and our budget constraint equation, and at the optimal choices these will be as follows:

Taking the derivate of the: $(1 - a^p)\varepsilon_t^z \log\left(c_t^p(i) - a^p c_{t-1}^p\right) - \lambda_t^p c_t^p$ gives the FOC below:

Since the $\frac{\partial ln(x,y,\lambda)}{\partial c_t^p} = \frac{1}{c_t^p}$ therefore:

$$\lambda_t^p = \varepsilon_t^z \frac{(1-a^p)}{c_t^P - a^P c_{t-1}^P} \quad \text{(A.5)}$$

Taking the derivate of the: $\varepsilon_t^h log h_t^p(i) - \lambda_t^p \left[q_t^h \left(h_t^p(i) - h_{t-1}^p(i)\right)\right]$ gives the FOC below

$$\lambda_t^p q_t^h = \frac{\varepsilon_t^h}{h_t^p} + \beta^P E_t\left[\lambda_{t+1}^p q_{t+1}^h\right] \quad \text{(A.6)}$$

Taking the derivate of the: $\lambda_t^p \left[\frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1}^p(i)\right]$ gives the FOC below

$$\lambda_t^p = \beta^P E_t\left[\lambda_{t+1}^p \frac{(1+r_{t-1}^d)}{\pi_t}\right] \quad \text{(A.7)}$$

Repeating the above procedures for impatient households using their objective function and budget constraints. Drawing up the Lagrangian Function and taking FOC will yield the below

$$\lambda_t^I = \varepsilon_t^z \frac{1-a^P}{c_t^I - a^I c_{t-1}^I} \quad \text{(A.8)}$$

$$\lambda_t^I q_t^h = \frac{\varepsilon_t^h}{h_t^I} + \beta^I E_t[\lambda_{t+1}^I q_{t+1}^h + s_t^I m_t^I q_t^I \pi_{t+1}] \quad \text{(A.9)}$$

$$\lambda_t^I = \beta^I E_t\left[\lambda_{t+1}^I \frac{(1+r_t^{bH}}{\pi_{t+1}}\right] \quad \text{(A.10)}$$

$$\pi_t^{w^s} = \frac{W_t^s}{W_{t-1}^s} \pi_t. \quad \text{(A.11)}$$

The MODEL block for households is made up of equations 5, 6, 7, 8, 9, 10 being FOC, household budget and borrowing constraints, and equation 11 for wage determination.

Entrepreneurs Block the Model

Repeating the above procedures for Entrepreneurs using their objective function and budget constraints. Drawing up the Lagrangian Function and taking FOC will yield the below

$$\lambda_t^E = \frac{1-a^E}{c_t^E - a^E c_{t-1}^E} \tag{A.12}$$

$$\lambda_t^E q_t^k = E_t\{s_t^E m_t^E q_{t+1}^k \pi_{t+1}(1-\delta) + \beta_E \lambda_{t+1}^E [r_{t+1}^k u_{t+1} + q_{t+1}^k(1-\delta) - \psi(u_{t+1)})]\} \tag{A.13}$$

$$r_t^k = \xi_1 + \xi_2(u_t - 1) \tag{A.14}$$

$$w_t^k = (1-\alpha)\frac{y_t^E}{x_t}\frac{\mu}{l_t^{E,P}} \tag{A.15}$$

$$w_t^I = (1-\alpha)\frac{y_t^E}{x_t}\frac{1-\mu}{l_t^{E,I}} \tag{A.16}$$

$$\lambda_t^E = s_t^E(1+r_t^{bE})\beta_E E_t\left[\lambda_{t+1}^E \frac{(1+r_t^{bE})}{\pi_{t+1}}\right] \tag{A.17}$$

The MODEL block for Entrepreneurs is made up of equations 12 to 14 including Entrepreneurs' budget constraints, and production technology equations.

Capital Producers Block of the Model

The problem of capital producers is:

$$max\ E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E \{q_t^k[k_t - (1-\delta)k_{t-1}] - i_t\} \tag{A.18}$$

Subject to the capital accumulation equation below:

$$k_t = (1-\delta)k_{t-1} + \beta_E E_t\left[1 - \frac{K_i}{2}\left(\frac{i_t \varepsilon_t^{qk}}{i_{t-1}}\right)^2\right] i_t \tag{A.19}$$

Setting a Lagrangian and solving for the price of capital; the FOC equation for the price of capital q_t^k , given by,

$$1 = q_t^k\left[1 - \frac{K_i}{2}\left(\frac{i_t\varepsilon_t^{qk}}{i_{t-1}} - 1\right)^2 - k_i\left(\frac{i_t\varepsilon_t^{qk}}{i_{t-1}} - 1\right)\frac{i_t\varepsilon_t^{qk}}{i_{t-1}}\right] + \beta_E E_t\left[\frac{\lambda_{t+1}^E}{\lambda_t^E} q_{t+1}^k \varepsilon_{t+1}^{qk} k_i \left(\frac{i_{t+1}\varepsilon_{t+1}^{qk}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right] \tag{A.20}$$

The MODEL block for capital producers is made up of equations 13 and 14.

Banks Block of the Model

Repeating the above procedures for Entrepreneurs using their objective function and budget constraints. Drawing up the Lagrangian Function and taking FOC will yield the below

$$R_t^b = r_t - k_{kb}\left(\frac{k_t^b}{B_t} - \upsilon^b\right)\left(\frac{k_t^b}{B_t}\right)^2$$

$$\pi_t K_t^b = (1-\delta^b)K_{t-1}^b(j) + j_{t-1}^{b,n}(j)$$

FOC for a deposit and loan branch

$$1 - \varepsilon_t^d + \varepsilon_t^{bs}\frac{r_t}{r_t^d} - k_d\left(\frac{r_t^d}{r_{t-1}^d} - 1\right)\frac{r_t^d}{r_{t-1}^d} + \beta_p E_t\left[\frac{\lambda_{t+1}^P}{\lambda_t^P}k_d\left(\frac{r_{t+1}^d}{r_t^d} - 1\right)\left(\frac{r_{t+1}^d}{r_t^d}\right)^2\frac{d_{t+1}}{d_t}\right] = 0 \quad \text{(A.21)}$$

$$1 - \varepsilon_t^{bs} + \varepsilon_t^{bs}\frac{R_t^b}{r_t^{bs}} - k_{bs}\left(\frac{r_t^{bs}}{r_{t-1_t}^{bs}} - 1\right)\frac{r_t^{bs}}{r_{t-1}^{bs}} + \beta_p E_t\left[\frac{\lambda_{t+1}^s}{\lambda_t^s}k_{bs}\left(\frac{r_{t+1}^{bs}}{r_t^{bs}} - 1\right)\left(\frac{r_{t+1}^{bs}}{r_t^{bs}}\right)^2\frac{b_{t+1}^s}{b_t^s}\right] = 0 \quad \text{(A.22)}$$

Domestic Debt Accumulation Equations

The domestic debt that the government treasury obtains from the banking sector is in the form of Treasury Notes and Treasury Bills. These have been modeled as below:

$$tn_t^b = \vartheta_t GDP_t + \varepsilon_t^{tn} - Adj_t^{TN} \quad \text{(A.23)}$$

$$tb_t^b = \xi_t GDP_t + \varepsilon_t^{tb} - Adj_t^{TB} \quad \text{(A.24)}$$

Bank Profit Function

We have added Public Debt mechanics to the Bank profit function as a deviation from Gerali's (2010) model.

$$j_t^b = r_t^{bH}b_t^I + r_t^{bE}b_t^E + r_t^{TN}tn_t^b + r_t^{TB}tb_t^b - r_t^d d_t - \frac{k_{kb}}{2}\left(\frac{K_t^d}{B_t} - \nu^b\right)^2 - K_t^b - K_t^{TN} - K_t^{TB} - Adj_t^B$$
(A.25)

Model Reference Rate Mathematical Derivation

Following the general outcry on how banks set the pricing of loans in the country as discussed in the introduction section. On 1st June 2019, the Central Bank and Bankers Association in Malawi agreed on the implementation of a reference rate that was believed to bring so much transparency to how loans are priced. On the part of the implementation, the banking sector was given three months transitioning period. The reference rate is an average multiplicand of the variables (previous month) in the table below and their given weights.

Table 1: Reference rate weights

Variable	Weighting
Lombard Rate	64.80%
All types of Treasury Bills Rate	10.00%
Interbank Rates	25.00%
Savings Deposits Rate	0.20%
Totals	100.00%

Source: Bankers Association of Malawi

The reference rate now serves as a uniform base lending rate for all banks in the country. The banks then add a risk premium on top of the reference rate to come up with an effective lending rate. The risk premium is also set within a band of only up to 10%.

In this paper, the authors have developed the mathematical Benchmark reference rate to reflect the current setup as adopted by the Monetary Authorities and Banks in mathematical terms.

The Benchmark reference rate can be written by a mathematical function below:

$$f(x) = R_t^* = \alpha_t + \xi_t LMR_{t-1} + \frac{\lambda_t}{1-effLRR_{1-1}} AVGTBR_{t-1} + \psi_t AVGIBR_{t-1} + \eta_t AVGSVR_{t-1} + \upsilon_t \tag{A.26}$$

And $R_t^* > 0$ for all t

Where R_t^* is the applicable month central bank approved reference rate and the shock υ_t is an *i.i.d* process with $\upsilon_t \sim N(0, \sigma)$

And the remaining variables are defined as below:

α_t is the maximum allowable spread to be added to the reference rate by Commercial Banks. The maximum spread is 11%. *So technically speaking this variable captures Expected Credit Losses (ECL), Unexpected Losses (UE), Operational Costs (OC), and Liquidity costs (LC).*

ξ_t is the current weighting given to Lombard Rate (LMR) in the current Reference rate calculation Matrix;

λ_t is the current weighting given to an average of all types of Treasury Bills (AVGTBR) in the current Reference rate calculation Matrix which is multiplied by the reciprocal of effective Liquidity Reserve Requirement Ratio $\frac{\lambda_t}{1-effLRR_{1-1}}$;

ψ_t is the current weighting given to average Interbank Lending Rates (IBR) in the current Reference rate calculation Matrix;

η_t is the current weighting given to average bank-wide Savings Rates (SVR) in the current Reference rate calculation Matrix;

Equation (24) becomes the current lending rate in Malawi with α_t as the Central Bank Maximum Allowable Spread.

<u>Derivation of a Dynamic Reference Rate Model</u>

From the general formulation of the reference rate equation, the equation is transformed to:

To make the reference rate function more robust all the weights must be represented in the form of elasticities.

$$R_t^* = \alpha_t + \sigma_{LMR_{t-1}} LMR_{t-1} + \sigma_{AVGTBR_{t-1}} AVGTBR_{t-1} + \sigma_{AVGIBR_{t-1}} AVGIBR_{t-1} + \sigma_{AVGSVR_{t-1}} AVGSVR_{t-1} \beta^M + \upsilon_t \quad \text{(A.27)}$$

And $R_t^* > 0$ for all t

Where R_t^* is the applicable month central bank approved reference rate and the shock υ_t is an *i.i.d* process with $\upsilon_t \sim N(0, \sigma)$

And the remaining variables are defined as below:

$\sigma_{LMR_{t-1}} = \frac{1}{1-\xi_t}$ is the elasticity of the monetary policy variable reflecting policy direction;

$\sigma_{AVGTBR_{t-1}} = \frac{1-effLRR_{t-1}}{1-\lambda_t}$ is the elasticity of Average Short Term and Long-Term Money Market Instruments subject to an augmenting LRR constraint;

$\sigma_{AVGIBR_{t-1}} = \frac{1}{1-\psi_t}$ is the elasticity of Average Inter Bank Borrowing rates, reflecting the tightness of liquidity in the Market;

$\sigma_{AVGSVR_{t-1}} = \frac{1}{1-\eta_t}$ is the elasticity of Savings Deposits;

β^M is the degree of habit formation or changes in the Savings Culture of Malawians.

In the model, we have used two reference rate equations 21 and 23. Equation 23 captures all public debt dynamic effects in loan pricing. Equation 23 is important as it is the basis of outstripping the public debt crowding effects.

$$R_t^* = \alpha_t + \sigma_{LMR_{t-1}} LMR_{t-1} + \sigma_{AVGTNOTES_{t-1}} AVGTNTS_{t-1} + \sigma_{AVGTBR_{t-1}} AVGTBR_{t-1} + \sigma_{AVGIBR_{t-1}} AVGIBR_{t-1} + \sigma_{AVGSVR_{t-1}} AVGSVR_{t-1} \beta^M + \upsilon_t \qquad \text{(A.28)}$$

<u>Appendix 2</u>

Data Used and Sources

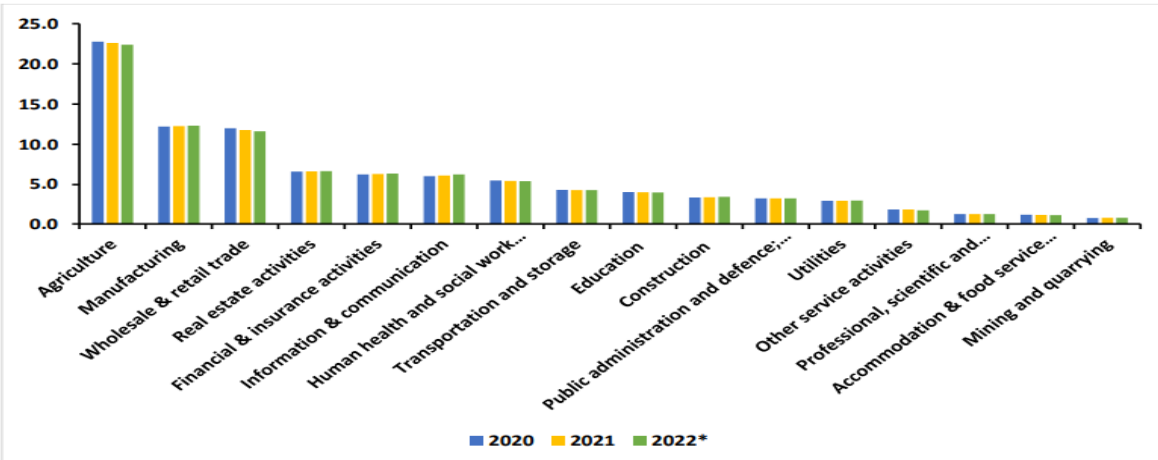
Below, we present the chosen variables with their respective sources:

1. Output – GDP: Source: National Statistical Office (NSO) and IMF World Economic Outlook Database;

2. Household final consumption (in MWK million) – Real Consumption: Source: National Statistics Office (NSO);
3. Gross Fixed Capital Formation (in MWK million) – Real Investment: Source: National Statistics Office (NSO) and IMF World Economic Outlook Database;
4. Housing loans to households (in MWK million). Source: Reserve Bank of Malawi (RBM);
5. Loans to firms (in MWK million). Source: Reserve Bank of Malawi (RBM);
6. Deposits, Savings, and Other (in MWK million). Source: Reserve Bank of Malawi (RBM);
7. Consumer Price Index (CPI) as a proxy of price inflation. Source: National Statistics Office (NSO);
8. Quarterly interest rate of deposits to households. Source: Reserve Bank of Malawi (RBM);
9. Referential Interest Rate quarterly average, index for lending to households, plus annual interest rate Source: Reserve Bank of Malawi (RBM);
10. Quarterly interest rate for loans to firms. Source: Reserve Bank of Malawi (RBM);
11. Policy Rate (quarterly). Source: Reserve Bank of Malawi (RBM);
12. Treasury Notes: Source: Reserve Bank of Malawi (RBM);
13. Treasury Bills: Source: Reserve Bank of Malawi (RBM);
14. Bank Capital: Source: Reserve Bank of Malawi (RBM);

Appendix 3 - GDP, Banking Balance Sheets, Distribution of Credit

Figure 1: Sectoral Contribution to GDP (Percent)



Source: National Statistical Office, Reserve Bank, Ministry of Finance and Economic Affairs

Figure 2: Distribution of Private Sector Credit by Industry (Percent)

Sector	2020	2021				2022
	IV	I	II	III	IV	I
Agriculture, forestry, fishing and hunting	18.8	19.9	18.2	16.8	15.8	15.9
Manufacturing	13.3	11.5	13.5	13.5	12.2	9.8
Wholesale and retail trade	24.2	22.5	23.2	21.0	22.2	22.5
Community, social and personal services	18.3	30.9	29.1	31.5	32.7	33.5
Other sectors[1]	29.5	19.6	20.1	21.7	21.1	22.3
Provisions for losses	-4.2	-4.3	-4.1	-4.4	-3.5	-4.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Note: [1]*Other sectors include Transport, storage and communications; Restaurants and hotels; Construction; Electricity, gas, water and energy; Financial Services; Real Estate; Mining and quarrying and others.*
Source: *Reserve Bank of Malawi*

Figure 3: Consolidated Malawian Banks' Statement of Financial Positions

Assets and Liabilities of Banks (MK'Bn)	**2016**	**2017**	**2018**	**2019**	**2020**
Type of Assets					
Cash and Dues from Other Banks	276.30	315.20	234.40	177.80	307.10
Secutirities and Investments	**386.10**	**615.80**	**680.30**	**791.70**	**893.20**
Treasury Bills	190.90	260.60	348.10	388.60	364.40
Money Market Deposits	2.70	25.60	32.10	35.20	18.20
Interbank Loans	34.30	50.50	23.70	30.50	24.10
Repurchase Agreements	100.90	180.50	143.00	108.70	69.20
All other short term investments	18.30	28.80	18.20	17.60	26.80
Local Registered Stocks	3.90	5.60	22.50	58.50	100.00
Government Bonds	2.20	21.70	61.10	62.90	75.20
Local Government Bonds	6.60	13.00	7.50	10.20	96.20
Equity Investments (MSE)	3.20	5.20	-	-	-
Other securities	23.10	24.30	24.10	79.50	119.10
Total Loans and Leases (net of IFRS 9 ECL)	**417.70**	**422.10**	**491.20**	**609.90**	**702.40**
Other Assets	159.60	219.20	264.70	310.70	385.30
Total Assets	**1,239.70**	**1,572.30**	**1,670.60**	**1,890.10**	**2,288.00**
Type of Liabilities					
Deposits	809.10	995.50	1,088.10	1,175.20	1,422.40
Liabilities to Other Banks	20.10	67.00	67.20	43.00	52.10
Other Liabilities	200.10	253.80	248.20	356.80	453.60
Total Equity Capital	210.40	256.00	267.10	315.10	359.90
Total Liabilities and Equity Capital	**1,239.70**	**1,572.30**	**1,670.60**	**1,890.10**	**2,288.00**
Check	-	-	-	-	-

Source: Reserve Bank of Malawi, note for 2019 and 2020 the variances between total assets and liabilities were allocated to other assets

Figure 4: Distribution of Assets and Liabilities of Malawi Banking Sector (Percent)

Assets and Liabilities of Banks (%)	**2016**	**2017**	**2018**	**2019**	**2020**
Type of Assets					
Cash and Dues from Other Banks	22%	20%	14%	9%	13%
Secutirities and Investments	**31%**	**39%**	**41%**	**42%**	**39%**
Treasury Bills	49%	42%	51%	49%	41%
Money Market Deposits	1%	4%	5%	4%	2%
Interbank Loans	9%	8%	3%	4%	3%
Repurchase Agreements	26%	29%	21%	14%	8%
All other short term investments	5%	5%	3%	2%	3%
Local Registered Stocks	1%	1%	3%	7%	11%
Government Bonds	1%	4%	9%	8%	8%
Local Government Bonds	2%	2%	1%	1%	11%
Equity Investments (MSE)	1%	1%	0%	0%	0%
Other securities	6%	4%	4%	10%	13%
Total Loans and Leases (net of IFRS 9 ECL)	**34%**	**27%**	**29%**	**32%**	**31%**
Other Assets	13%	14%	16%	16%	17%
Total Assets	**100%**	**100%**	**100%**	**100%**	**100%**
Type of Liabilities					
Deposits	65%	63%	65%	62%	62%
Liabilities to Other Banks	2%	4%	4%	2%	2%
Other Liabilities	16%	16%	15%	19%	20%
Total Equity Capital	**17%**	**16%**	**16%**	**17%**	**16%**
Total Liabilities and Equity Capital	**100%**	**100%**	**100%**	**100%**	**100%**
Check	-	-	-	-	-

Source: Authors Computation from Figure 3

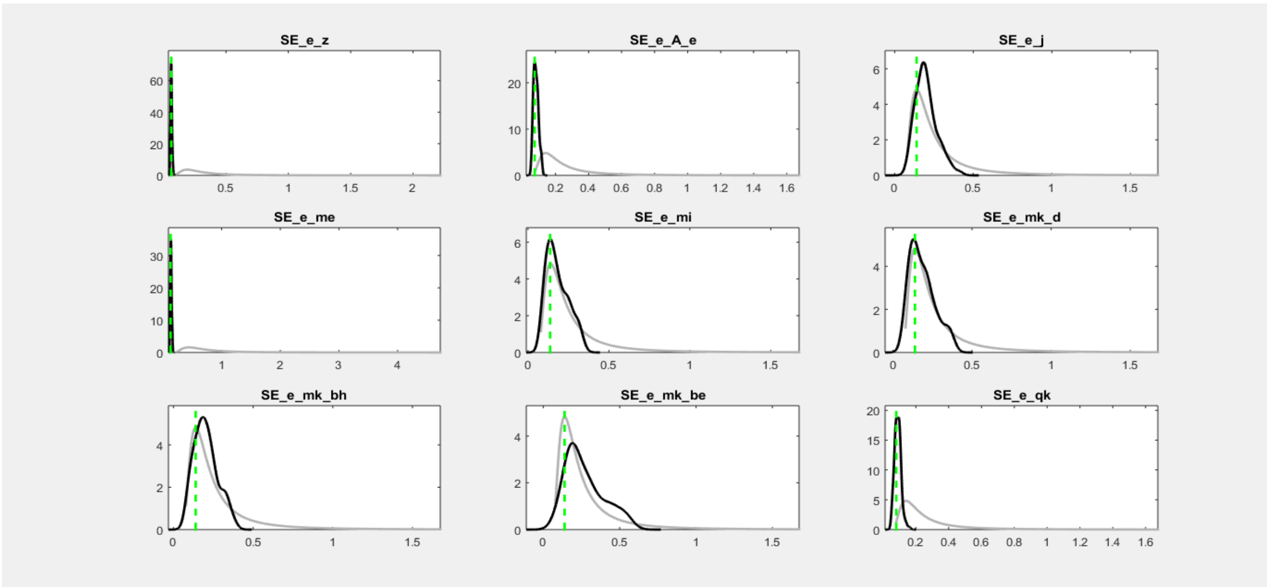
Figure 5: Distribution of Assets and Liabilities of Malawi Banking Sector (Percent)

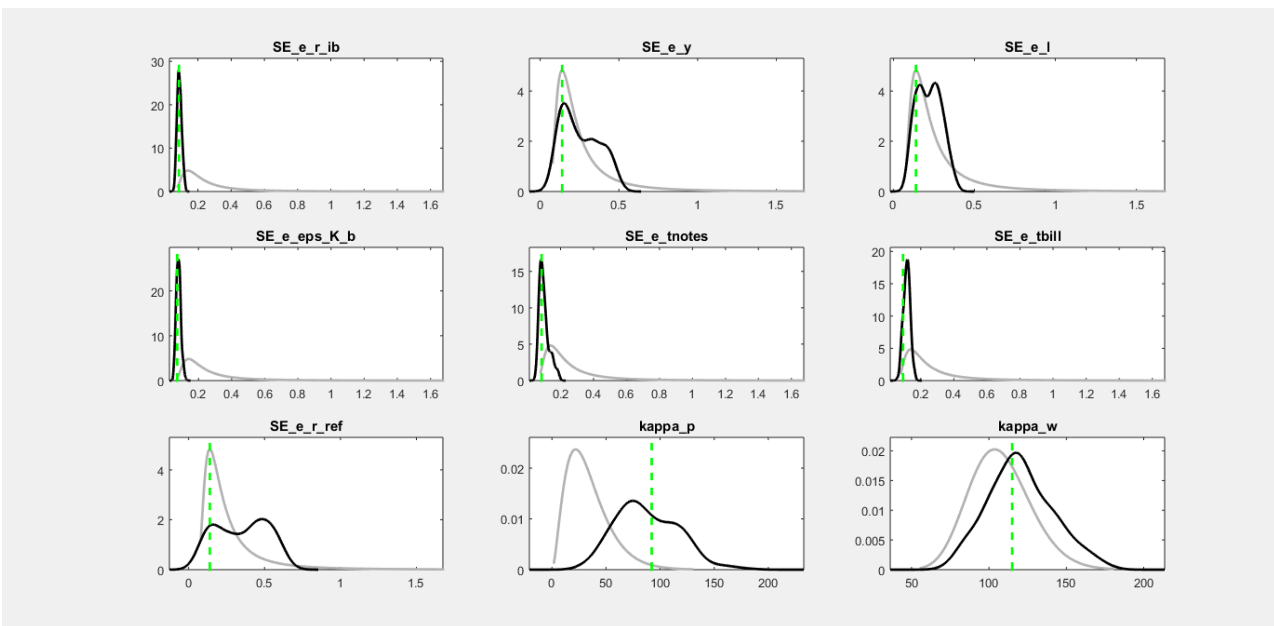
Sector (MK'bn)	2016	2017	2018	2019	2020
Wholesale and retail trade	101.90	101.30	112.70	146.80	168.20
Agriculture, forestry, fishing and hunting	81.90	97.90	94.30	122.80	120.80
Manufacturing	75.20	69.60	87.80	88.40	85.40
Community, social and personal services	58.50	44.30	47.40	72.80	120.30
Other sectors	23.80	32.50	43.40	53.70	72.10
Transport, storage, and communications	28.80	16.90	12.90	19.40	18.60
Financial services	14.20	16.90	12.90	19.40	18.60
Electricity, gas, water and energy	4.60	15.20	33.40	44.80	44.90
Construction	13.40	14.80	15.90	19.70	27.50
Restaurants and hotels	11.70	13.50	18.50	20.00	22.90
Credit/debit cards	1.30	1.70	-	-	-
Real estate	1.30	1.70	7.80	11.20	13.80
Mining and quarrying	0.80	1.30	1.40	2.70	0.80
IFRS 9 Expected Credit Losses	**0.30**	**(5.50)**	**2.80**	**(11.80)**	**(11.50)**
Totals	**417.70**	**422.10**	**491.20**	**609.90**	**702.40**

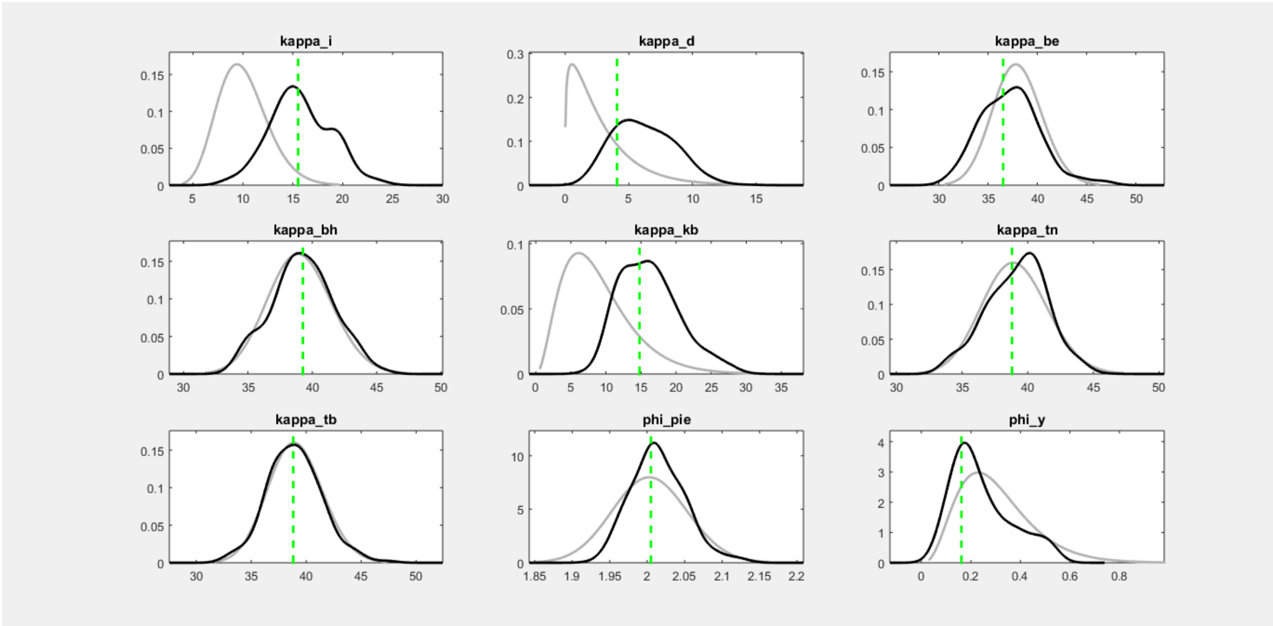
Sector (%)	2016	2017	2018	2019	2020
Wholesale and retail trade	24%	24%	23%	24%	24%
Agriculture, forestry, fishing and hunting	20%	23%	19%	20%	17%
Manufacturing	18%	16%	18%	14%	12%
Community, social and personal services	14%	10%	10%	12%	17%
Other sectors	6%	8%	9%	9%	10%
Transport, storage, and communications	7%	4%	3%	3%	3%
Financial services	3%	4%	3%	3%	3%
Electricity, gas, water and energy	1%	4%	7%	7%	6%
Construction	3%	4%	3%	3%	4%
Restaurants and hotels	3%	3%	4%	3%	3%
Credit/debit cards	0%	0%	0%	0%	0%
Real estate	0%	0%	2%	2%	2%
Mining and quarrying	0%	0%	0%	0%	0%
IFRS 9 Expected Credit Losses	**0%**	**-1%**	**1%**	**-2%**	**-2%**
Totals	**100%**	**100%**	**100%**	**100%**	**100%**

Appendix 5 – Selected Graphs

Figure 1 - Prior and posterior marginal distributions



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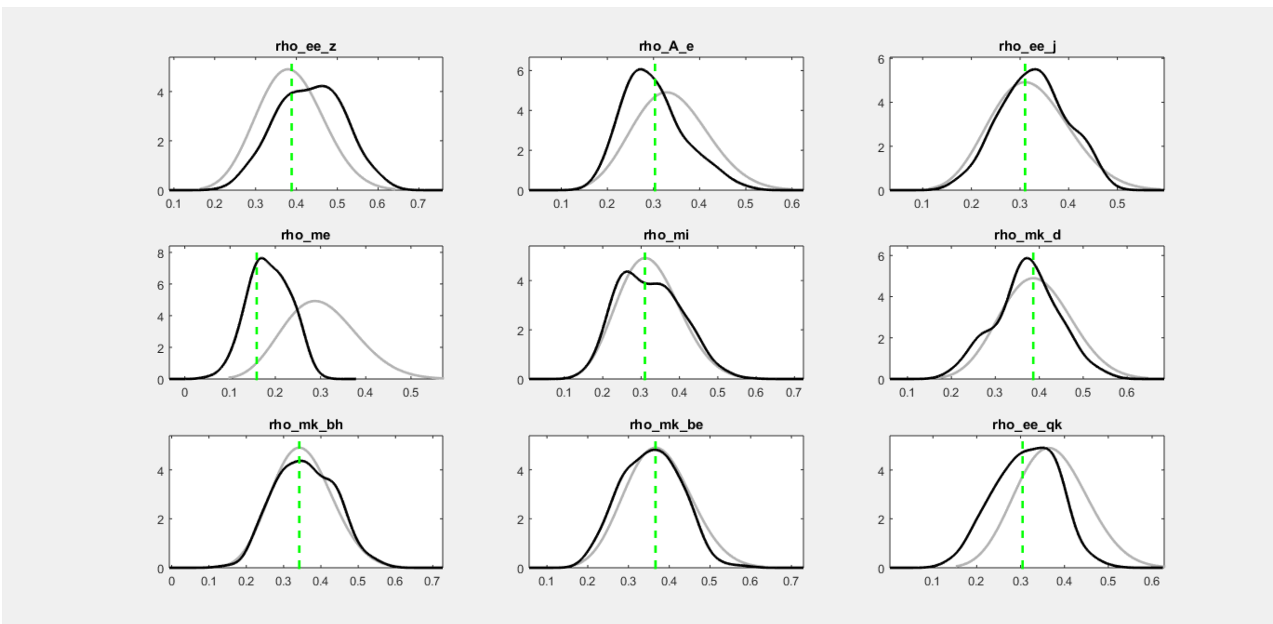
phi_y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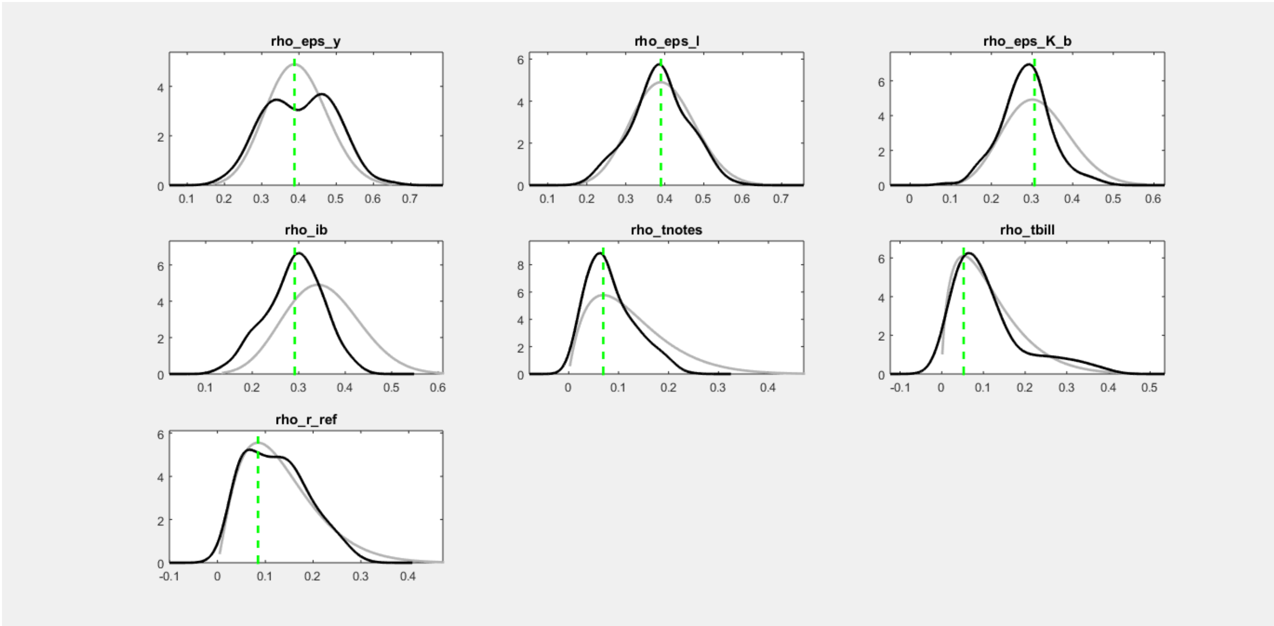
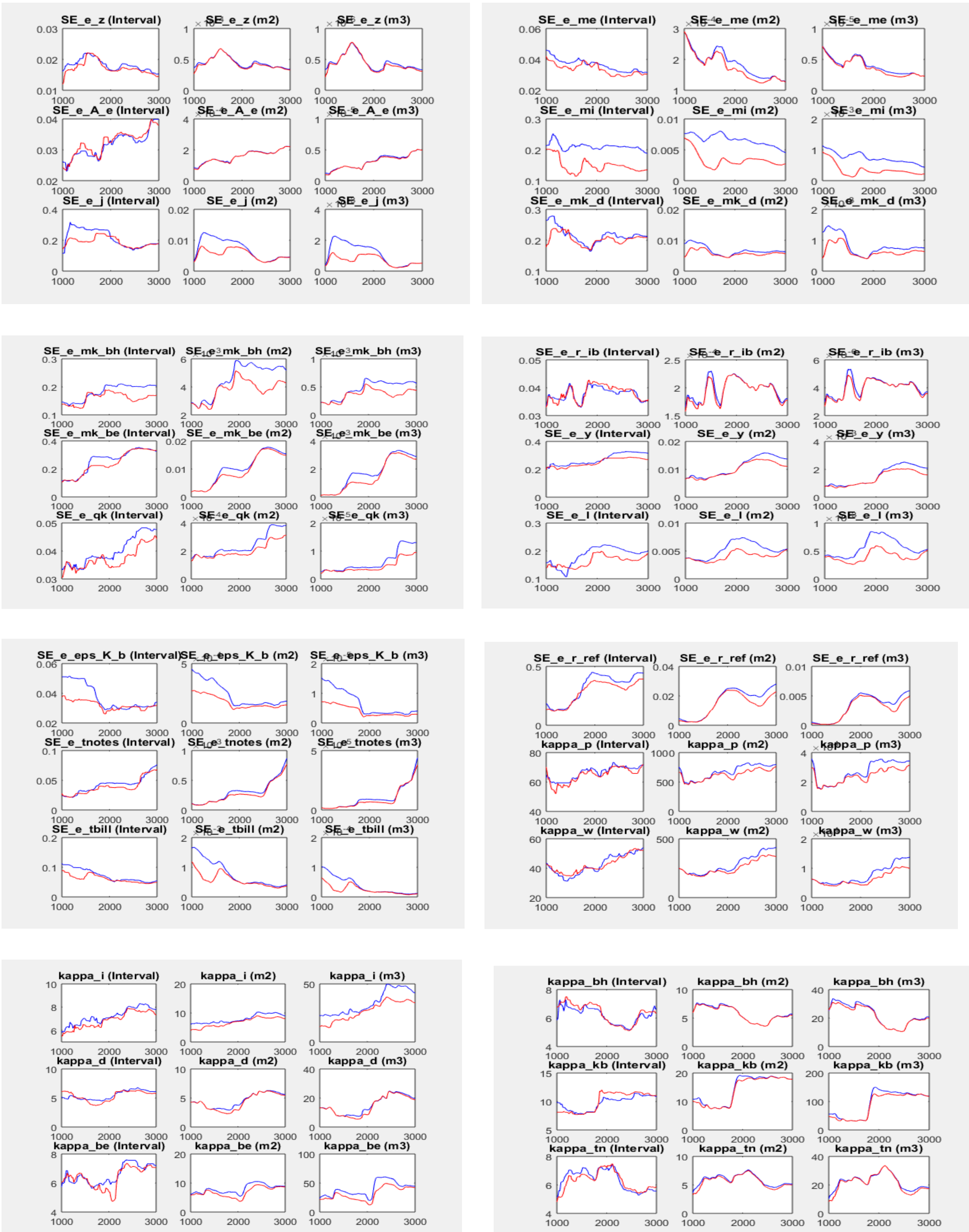
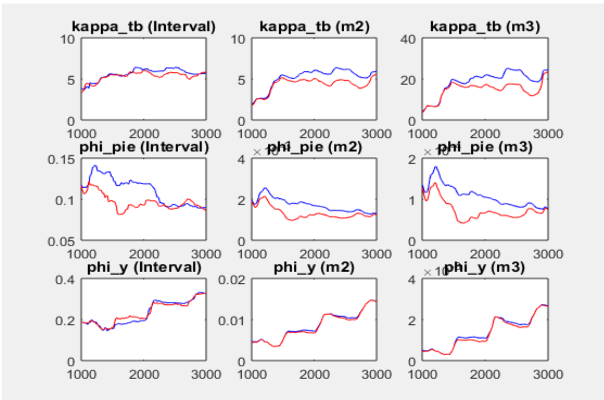


Note: **The marginal posterior densities are based on 10 chains, each with 100,000 draws Metropolis algorithm. The grey line represents the Prior distribution and the black line represents the Posterior Distribution.**

Figure 2 - Posterior Mode Check

Figure 3 - MCMC Univariate Convergence Diagnostics

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kappa_tb (m2)
kappa_tb (m3)
phi_pie (Interval)
phi_pie (m2)
phi_pie (m3)
phi_y (Interval)
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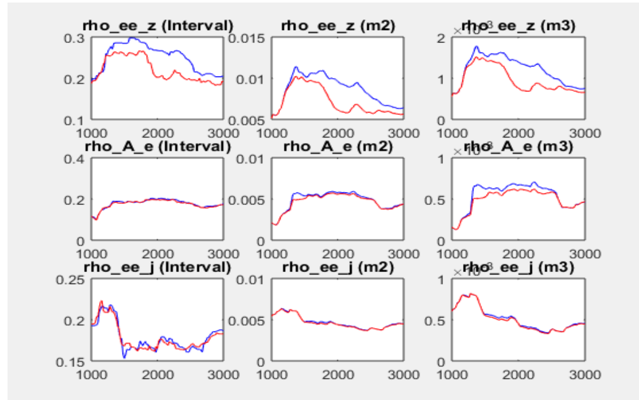
phi_y (m3)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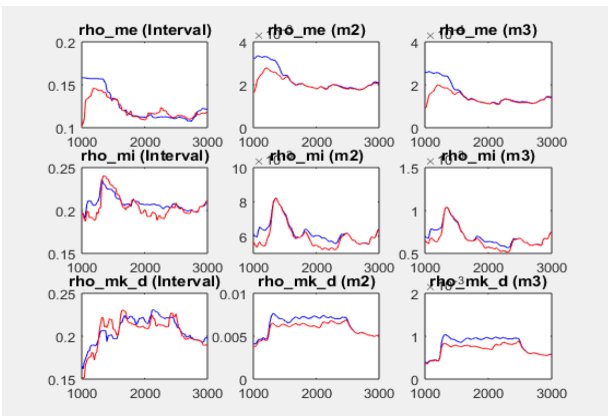
rho_ee_z (m2)
rho_ee_z (m3)
rho_A_e (Interval)
rho_A_e (m2)
rho_A_e (m3)
rho_ee_j (Interval)
rho_ee_j (m2)
rho_ee_j (m3)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rho_me (m2)
rho_me (m3)
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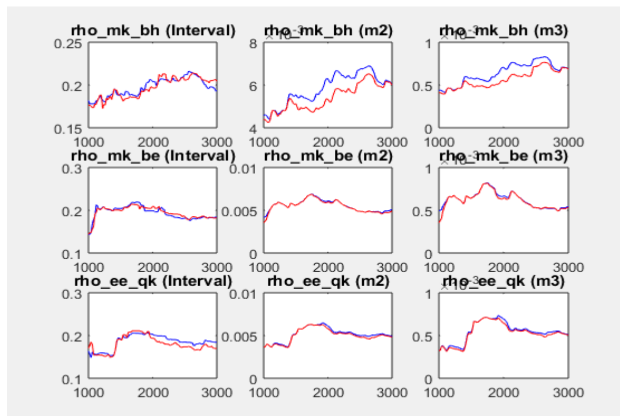
rho_mi (m3)
rho_mk_d (Interval)
rho_mk_d (m2)
rho_mk_d (m3)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rho_mk_bh (m3)
rho_mk_be (Interval)
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rho_mk_be (m3)
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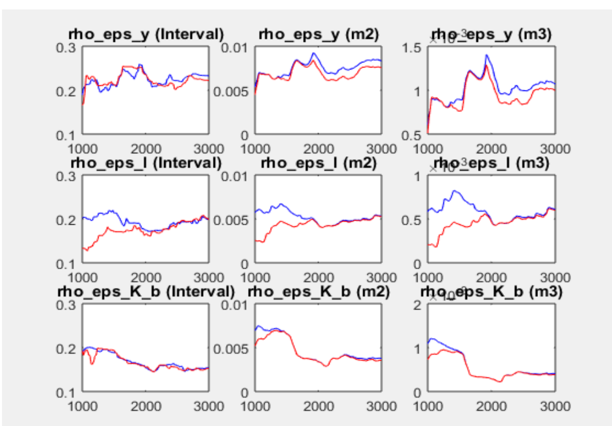
rho_ee_qk (m2)
rho_ee_qk (m3)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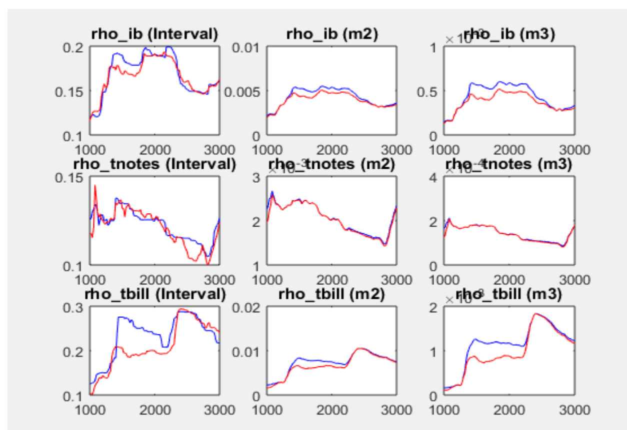
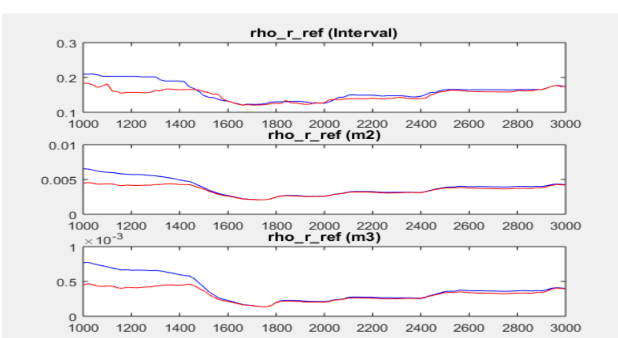
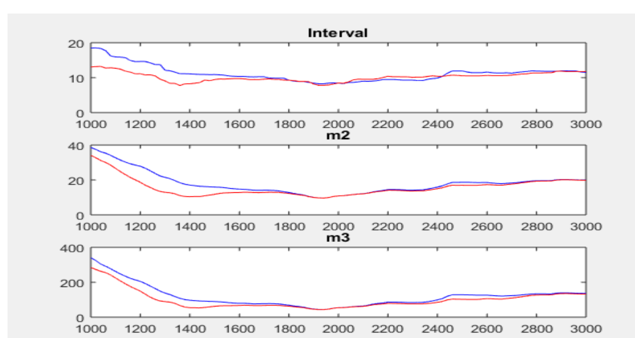
rho_eps_y (m2)
rho_eps_y (m3)
rho_eps_l (Interval)
rho_eps_l (m2)
rho_eps_l (m3)
rho_eps_K_b (Interval)
rho_eps_K_b (m2)
rho_eps_K_b (m3)


rho_ib (Interval)
rho_ib (m2)
rho_ib (m3)
rho_tnotes (Interval)
rho_tnotes (m2)
rho_tnotes (m3)
rho_tbill (Interval)
rho_tbill (m2)
rho_tbill (m3)


rho_r_ref (Interval)
rho_r_ref (m2)
rho_r_ref (m3)


Interval
m2
m3