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Abstract
In the last few years, macroeconomic modelling has emphasised the role of credit market frictions in magnifying and transmitting nominal and real disturbances and their implication for macro-prudential policy design. In this paper, we construct a modest New Keynesian general equilibrium model with active banking sector. In this set-up, the financial sector interacts with the real side of the economy via firm balance sheet and bank capital conditions and their impact on investment and production decisions. We rely on the financial accelerator mechanism due to Bernanke et al. (1999) and combine it with a bank capital channel as demonstrated by Aguiar and Drumond (2007). We calibrate the resulting model from the perspective of a low income economy reflecting the existence of relatively high investment adjustment cost, strong fiscal dominance, and underdeveloped financial and capital markets where the central bank uses money growth in stabilizing the national economy. Then we examine the impulse response of selected endogenous variables to shocks stemming from the fiscal authority, the monetary policy process, and technological progress. The findings are broadly consistent with previous studies that demonstrated stronger role for credit market imperfections in amplifying and propagating monetary policy shocks. Moreover, we also compare the trajectory of the model economy under alternative monetary policy instruments. The results suggest that the model with money growth rule generates higher volatility in output and inflation than the one with interest rate rule.

Keywords
Firm net worth, bank equity, monetary policy transmission, macro-prudential regulation, business cycle

JEL Codes
E32, E44, E50, C68

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1 Introduction

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

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

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

One important force behind the screening and filtering barriers erected by lenders is that agency problems can operate through the size of the borrowing firm.[1] Size can affect the capital structure of the firm because of the role of scale economies in reducing asymmetric information, degree of risk exposure, the extent of transaction costs, and access to market facilities. Smaller firms receive less capital or pay higher rates as it is relatively more expensive for them to solve informational problems with their potential creditors. This implies that the effect of size on financing structure should be more pronounced among start-ups as new firms are more informationally dense than their established counterparts. Moreover, to the extent that firm size is inversely correlated with risk, bankruptcy costs, and market barriers, this would discourage smaller firms from accessing outside financing options. Consequently, in light of these frictions and imperfections, the capital structure of firms and financial intermediaries could be vastly different from the one predicted by the MM principle.

Size is particularly relevant in the context of low income countries where small and micro enterprises (SMEs) have great potential in terms of employment creation as well as in their contribution to GDP but face significant barriers against access to finance.[2] The World Bank report on small and micro enterprise financing in Ethiopia (WB, 2015) confirms this observation. The report shows that in both manufacturing and service sectors, job creation is higher among established and older firms than under young businesses, suggesting a lack of competitiveness and innovation in the private sector. The retail and service sectors were also more important than manufacturing in job creation and employment. Regarding financial constraints, the report indicates small firms struggle the most in getting access to credit, smaller and young firms are more likely to be rejected for a loan or a line of credit, and that SMEs are discouraged or willingly distance themselves from applying for loans due to prohibitive collateral requirements. The report also identifies a 'missing link' in which small firms are disproportionately affected compared with micro, medium, and large enterprises.[3]

In light of the practical credit market impediments faced by smaller firms, we construct a DSGE model with financial frictions to understand how limited business net worth affects the terms and

[1] See Cassar (2004) for more detail on financing issues affecting business start-ups. Additionally, owner characteristics (level of education or experience), asset structure or collateral, legal organization (presence or absence of limited liability) and other factors can shape financing structure.
[2] For instance, under the five-year Growth and Transformation Plan (GTP), the government of Ethiopia recognized the industrial potential embedded in SMEs and it was expected they would generate more than 3 million jobs between 2010/11 and 2014/15.
[3] According to this report only 1.9 percent of small firms have loan or line of credit while the corresponding figures for micro, medium and large firms are 6, 20.5, 35.5 percent, respectively.

conditions of credit contract as well as subsequent investment and production decisions. We consider frictions stemming both from the demand and supply side of credit markets.

2 Small and Micro Enterprises in Ethiopia

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

The aforementioned gaps have been addressed in the revised 2011 federal MSE development strategy paper, which relies on the level of paid up capital and the size of labour employment. It also classifies SMEs by industry in addition to the size of seed money and asset stock. According to the new definition, micro enterprises are those business establishments that absorb at least five employees and their total asset value not exceeding Birr 100,000 if the firm is in the industrial sector (manufacturing, construction, and mining) or Birr 50,000 for a firm operating in the service sector (retailing, ICT, maintenance, and hotel and tourism). Similarly, businesses are considered small if they employ between six and thirty people with their maximum asset value being Birr 100,001-1,500,000 for manufacturing firms and Birr 50,001-500,000 for firms engaged in providing services.

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

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

Like elsewhere in Africa, small and micro enterprises in Ethiopia face significant challenges in their access to finance. Beck and Cull (2014) based on World Bank enterprise survey data from over 100 countries observe that African firms are more likely to identify financing issues as the most important constraint on their operation and growth than enterprises outside the continent. More than 25 percent of the surveyed enterprises in Africa rated the affordability and availability of finance as the most important barrier. Specific findings consolidate this observation, especially for Ethiopia. For instance, Kuntchev et al. (2014) find that around half of the surveyed enterprises in Ethiopia are fully credit constrained. This is substantially higher when compared with the figures for other countries in the region: Eritrea (8.2%), Mauritius (8.5%), Kenya (11.7%), Rwanda (17.6%), Uganda (19.3%), Burundi (20.6%), Tanzania (22.3%), Madagascar (22.6%), Malawi (25.2%), and Mozambique (30.9%)[4].

Even though SMEs have enormous potential to contribute to GDP and employment, lack of credit has been a major obstacle for such businesses to start, survive, and grow. In some cases, credit is totally unavailable, and in others, it proves to be insufficient or extremely costly. Since most SMEs lack the ability to post collateral or to offer equivalent guarantee, the formal banking system is not willing to extend loans to them--or when the credit line is available--there is a kind of "poverty premium" attached to it to compensate for the possible default of the borrowers. This reinforces the proverbial vicious circle of impoverishment in which high interest rates discourage SMEs from undertaking or expanding profitable projects which in turn overshadows the prospect of timely loan repayment.

In view of the difficulty that SMEs face, the government of Ethiopia has developed a comprehensive small business support strategy document (FSMEDSP, 2011) that promises to provide an integrated package of financial and non-financial assistance to small and micro firms to spur entrepreneurship. The support covers firms through their different stages of life cycle from start up through growth to maturity. Assistance to SMEs includes technology extension and human resource development; market linkages through sub-contracting, franchising, and outsourcing; the provision of sales facilities; and most importantly credit and finance support services. The credit support scheme is aimed at strengthening the financial position of SMEs by improving their financial skills and saving culture, offering credit guarantee arrangements that involve regional governments, microfinance institutions, and SMEs. It also facilitates machinery-leasing services in which the dominant state owned commercial bank (CBE) works jointly with microcredit organizations. In this leasing system, the beneficiaries are expected to save 40% of the value of the

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

machine while the bank finances the remaining 60%. Such arrangements are very useful as they enable SMEs to get bank loans without collateral and to mitigate a long-standing capital/asset insufficiency problem.

3 Literature Review

Despite their popularity as the workhorse for monetary policy scenario analysis, standard New Keynesian general equilibrium models had devoted insignificant role to financial market frictions in magnifying and driving macroeconomic volatility.[5] These models replicate business cycle properties only with heavy reliance on extensive and persistent shocks whose existence cannot easily be verified and explained (Brazdik et al., 2012). In this paper, we introduce explicit roles for both business and financial market rigidities that facilitates the amplification and propagation of real and nominal shocks affecting the economy.[6]

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

On the demand side, Bernanke and Gertler (1989) and Bernanke et al. (1999) constitute the foundation by incorporating information asymmetry in credit markets as a source of agency costs influencing investment-spending behaviour among firms. This approach formulates a basis for the interaction of financial and real markets as a result of firm borrowing costs being driven by endogenous changes in its net worth. This link is particularly strong when the economy is stuck below its capacity. In recession, for instance, demand shortfall negatively affects revenue and consequently firm profit and equity[7] fall substantially. The attendant increase in leverage ratio (or decrease in net worth) aggravates the already existent agency problem and creditors respond by raising the finance premium on their loans. The higher external financial premium reduces the

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

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

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

demand for capital investment which, in turn, further undermines the net worth position and survivability of the firm. This self-reinforcing mechanism is known as the "financial accelerator" and illustrates the pro-cyclical nature of adverse changes in business net worth and their impact on the ability of firms to access external funding opportunities.

The financial accelerator principle implicitly assumes that producers can get unlimited amount of funding at the prevailing lending rate subject to the strength of their balance sheet structures (banks demand no guarantee that the loan be repaid in full). In this setting, the external risk premium only affects their capacity to borrow without facing the possibility of credit rationing or some other quantitative restrictions imposed by lenders. Kiyotaki and Moore (1997) consider collateral constraints that facilitate the magnification of business cycle volatility and persistence as a result of dynamic association between credit prices and quantities.

In the past, the vast majority of the literature focused its attention on credit market imperfections affecting firms while the role of banking was understated or totally ignored. Incorporating the financial sector permits an important role for the supply side of the credit market by activating banks' liquidity and capital structures, which creates a two-way bridge between banking services and the broader non-financial economic activity. Consequently, introducing an active banking sector creates a double-agency-cost problem between banks and their shareholders on the one hand and between borrowers and creditors on the other.[8] Van den Heuvel (2002), Markovic (2006), Aguiar and Drumond (2007), Christensen and Dib (2008), and Dib (2010), among others, have rationalized how capital sufficiency regulations imply a breakdown of the Modigliani-Miller principle: the bank's credit supply policy is a function of its capital structure, lending opportunities, and market interest rates. For instance, a sharp fall in bank capital—from cancellation of large non-performing loans or other adverse shocks—will force the bank to reduce the supply of credit because of regulatory capital requirement or the punitive cost of attracting new capital. A similar argument can be deployed regarding the role of insufficient bank liquidity in amplifying tight monetary policy measures and other negative shocks affecting the broader economy.

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

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

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

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

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

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

In addition to the net worth channel, demand-side financial imperfections have also been identified to originate from collateral constraints. Brzoza-Brzezina et al. (2010)[9] compare the relative significance of the two channels in an extended medium scale New Keynesian model calibrated to the Polish economy. They compare the collateral constraint framework of Kiyotaki and Moore (1997) with the external finance premium setup of Carlstrom and Fuerst (1997) and Bernanke et al. (1999). They rely on business cycle accounting, moment matching, and impulse response analyses to see the qualitative and quantitative performance of the two models. Their results indicate that both models with financial frictions add volatility to the baseline New Keynesian framework, with the external finance premium showing significantly stronger internal propagation mechanism than its collateral constraint counterpart. In terms of business cycle accounting, they find superior performance of the models with financial frictions to the baseline specification, with the model under collateral constraint offering moments closely resembling those filtered from actual data.

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

Recently, there have been growing tendencies to model banking activity as a potential source of economic fluctuations. For instance, Meh and Moran (2009), using a general equilibrium framework, show that bank capital can be an important channel for the transmission of shocks in view of moral hazard problems between banks and investors that provide loanable funds. Other works emphasizing the role of bank balance sheets in intensifying and transmitting exogenous shocks include Gertler and Karadi (2011), Van den Heuvel (2011)[10], Hafstead and Smith (2012), and Hollander and Liu (2013), among others. Though much of the focus has been on bank equity, there have been efforts to incorporate the importance of liquidity under a general equilibrium framework. This might involve assigning roles to interbank markets as in Carrera and Vega (2012) or studying the impact of reserve requirements as in Areosa and Coelho (2013).

The vast majority of studies on financial market imperfections are devoted to advanced industrial economies and to some extent to emerging blocks while there appears to be scant interest in low-income countries, especially those in Sub-Saharan Africa. One contribution is by Babilla (2014) who uses a mix of calibration and Bayesian estimation of a modified small open dynamic stochastic general equilibrium model for the West African Economic and Monetary Union (WAEMU). The paper evaluates the effectiveness of bank lending channel in the propagation of monetary policy measures within a currency union where financial intermediation is dominated by oligopolistic banks. Consistent with the evidence for advanced and emerging countries, the paper finds that including financial market distortions improves the performance of the model. Unlike Fukunaga (2002), who finds deteriorating net worth in response to positive technology shock, here positive productivity shock improves firm net worth and investment despite an increase in the external finance premium.[11]

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

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

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

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

4 Model

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

4.1 Entrepreneurs

Every period the entrepreneur purchases the required capital stock which will be combined with labour to produce goods the next period. Thus, at time t entrepreneur j purchases homogenous capital for use at t+1, K_{t+1}^{j}. The return to capital is affected by both systemic risk and risk that is specific to the firm. The ex post gross return on capital for firm j is $\omega_{t+1}^{j} R_{t+1}^{K}$, where ω_{t+1}^{j} is an idiosyncratic shock specific to firm j's return and R_{t+1}^{K} is the ex post aggregate return to capital. The idiosyncratic disturbance (ω^{j}) is independently and identically distributed both across entrepreneurs and over time, with a continuous and once-differentiable cumulative distribution function (c.d.f), $F(\omega)$, over a non-negative support, and with expected value equal to unity.

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

$$\mu = \omega_{t+1}^{j} R_{t+1}^{K} Q_t K_{t+1}^{j},$$

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

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

$$\bar{\omega}_{t+1}^{j} R_{t+1}^{K} Q_t K_{t+1}^{j} = Z_t L_{t+1}^{j} \tag{1}$$

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

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

$$(1 - F(\bar{\omega}_{t+1}^{j})] \mathrm{Z}_{t+1}^{i} L_{t+1}^{j} + (1-\mu)\int_{0}^{\bar{\omega}_{t+1}^{j}} \omega_{t+1}^{j} R_{t+1}^{K} Q_t K_{t+1}^{j} f(\omega) d\omega = R_{t+1}^{F} (Q_t K_{t+1}^{j} - N_{t+1}^{j}), \tag{2a}$$

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

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

$$\left\{ [1 - F(\bar{\omega}_{t+1}^{j})] \bar{\omega}_{t+1}^{j} + (1-\mu)\int_{0}^{\bar{\omega}_{t+1}^{j}} \omega_{t+1}^{j} f(\omega) d\omega \right\} R_{t+1}^{K} K_{t+1}^{j} = R_{t+1}^{F} (Q_t K_{t+1}^{j} - N_{t+1}^{j}) \tag{2b}$$

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

$$\underbrace{1 - F(\bar{\omega}_{t+1}^{j})] \bar{\omega}_{t+1}^{j} + \int_{0}^{\bar{\omega}_{t+1}^{j}} \omega_{t+1}^{j} f(\omega) d\omega}_{\Gamma(\omega)} - \underbrace{\mu \int_{0}^{\bar{\omega}_{t+1}^{j}} \omega_{t+1}^{j} f(\omega) d\omega}_{\mu\Theta(\omega)}$$

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

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

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

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

$$\begin{aligned} &E_t\{\frac{[1-\Gamma(\bar{\omega}_{t+1})](1+R^K_t)}{1+R^F_{t+1}} \\ &+\frac{1-F(\bar{\omega}_{t+1})}{1-F(\bar{\omega}_{t+1})-\mu\Theta(\bar{\omega}_{t+1})}\left[\frac{1+R^K_t}{1+R^F_{t+1}}(\Gamma(\bar{\omega}_{t+1})-\mu\Theta(\bar{\omega}_{t+1})-1\right]\}=0 \end{aligned} \tag{3}$$

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

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

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

$$\frac{Q_t K^j_{t+1}}{N^j_{t+1}} = \Xi\left(\frac{E_t(R^K_{t+1})}{R^F_{t+1}}\right),$$

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

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

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

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

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

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

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

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

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

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

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

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

where $\mu \Theta(\overline{\omega}_t) R_t^K Q_{t-1} K_t$ represent the total default monitoring costs and $\Theta(\overline{\omega}_t) = \int_0^{\overline{\omega}_t} \omega_t^j f(\omega) d\omega$. Equations (6) and (7) indicate that the net worth of firms is influenced by their earnings net of interest expenses to the bankers.

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

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

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

4.2 Banks

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

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

The banks problem involves:

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

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

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

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

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

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

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

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

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

Return on Capital

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

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

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

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

4.3 Capital Producers

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

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

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

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

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

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

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

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

4.4 Entrepreneurs

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

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

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

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

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

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

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

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

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

4.5 Retailers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$=p_{t-1}+\pi_{t}+(1-\beta\theta)mc_{t}+\beta\theta(\overline{p}_{t+1}-p_{t})$$

$$\overline{p}_{t}-p_{t-1}=\pi_{t}+\beta\theta E_{t}\pi_{t+1}+(1-\beta\theta)mc_{t} \tag{28}$$

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

$$\pi_{t}=\beta(1-\theta)E_{t}\pi_{t+1}+\theta\pi_{t-1}+z_{\pi}mc_{t} \tag{29}$$

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

4.6 Households

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

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

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

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

The autonomous household choices over the optimal amount of consumption, labour supply, and deposits in each period give rise to the following set of first order conditions (FOCs) of the household utility optimization problem[12]:

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

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

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

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

where Ψ_t is the Lagrange multiplier.

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

5 Analysis

5.1 Calibration

The non-stochastic discount factor β is set to 0.98 while the constant risk aversion parameter is fixed at 3 which together imply a stead state consumption deposit ratio of 0.22 as depicted in the household first order equation (31). We choose a value of 4 for the elasticity of labour supply. The price rigidity parameter is 0.75 which suggests that prices remain unchanged for at least four quarters. The gross mark up of retail goods over wholesale counterparts is assumed to be 10 per cent consistent with the limited monopoly power of small firms in less innovative low income economies.

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

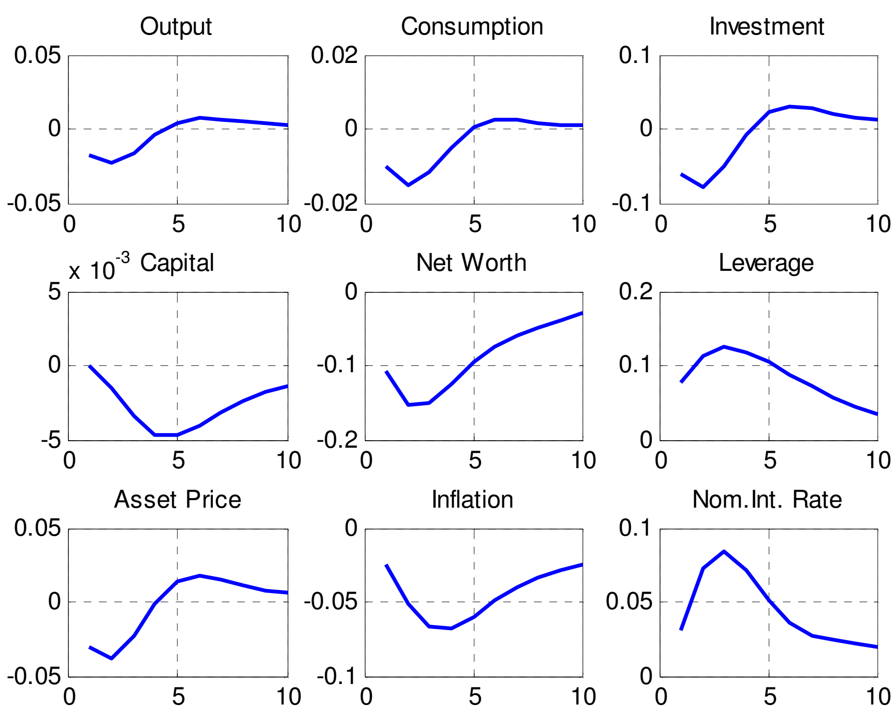
The steady state values for components of GDP are calibrated based on empirical data for the Ethiopian economy. Accordingly, we fix the investment, consumption, and government spending ratios to GDP at 0.18, 0.60, and 0.22, respectively. The quarterly capital depreciation rate δ is equal to 0.025 which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

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

5.2 Simulation Results

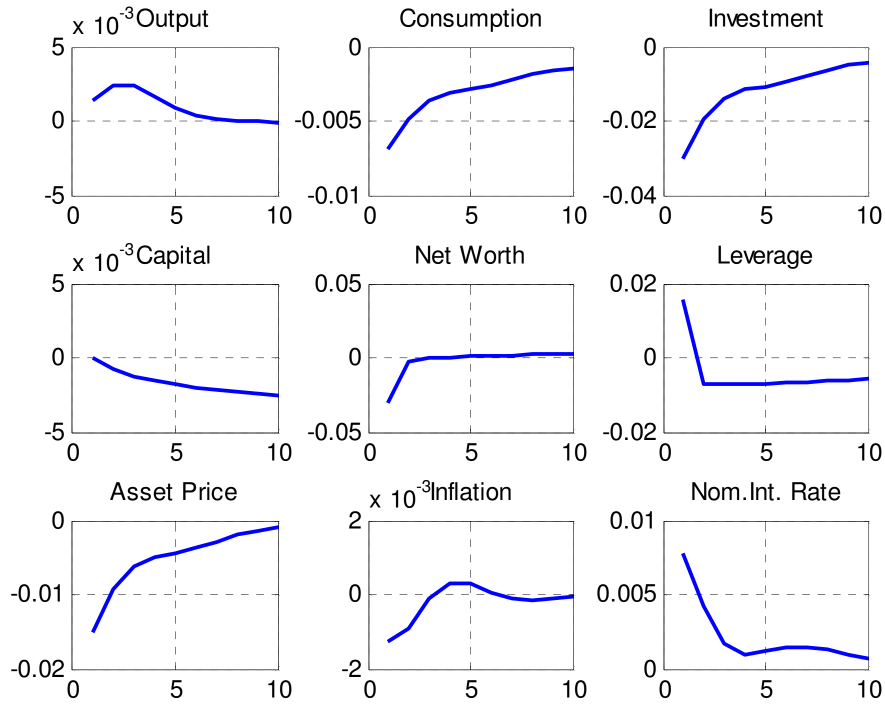
In this section I present the simulation results in which we examine endogenous developments in the model economy in response to exogenous shocks stemming from the monetary policy process, the fiscal authority and technological progress. Figure 1 displays the reaction of selected variables to unanticipated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

Figure 1: Impulse Response to Negative Monetary Policy Shock



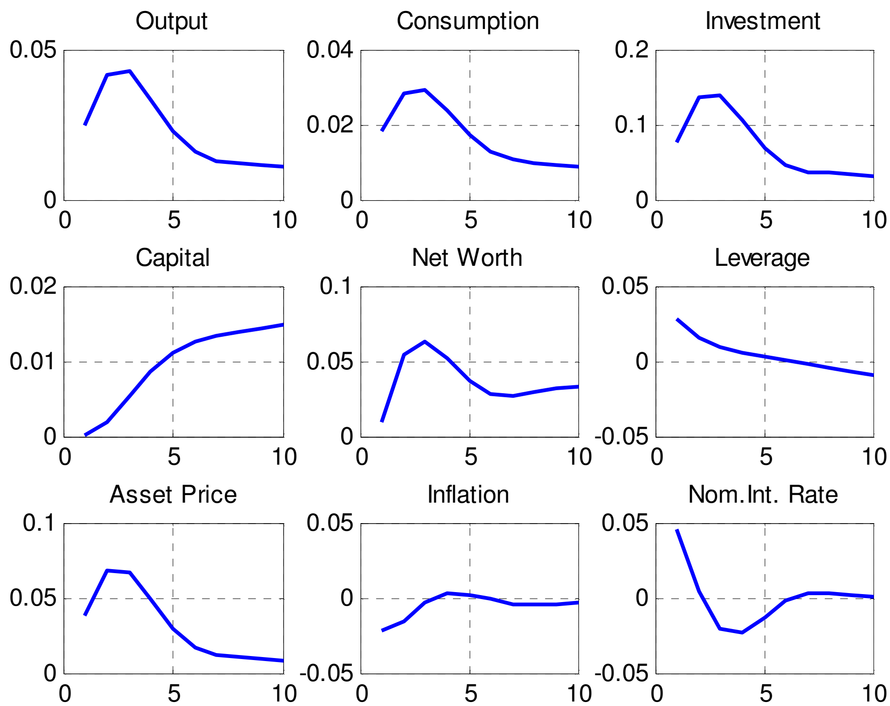
Monetary tightening also causes a fall in inflation and asset prices. The drop in asset prices reduces the net worth of entrepreneurs which raises their leverage. This opens up an asset price channel for monetary policy transmission mechanism which is absent in standard new Keynesian models without credit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

Figure 2: Impulse Response to Positive Fiscal Shock



The fiscal authority can influence national economic outcomes through a combination of tax and transfer policies. Even though we do not explicitly model the effect of taxation on investment and household spending, there is considerable consensus among macroeconomists that large and growing spending by the government limits the availability of credit to private players. As shown in Figure 2 above, an increase in government spending raises the interest rate which in turn drives down private consumption and investment in the short run. But the contribution of the fiscal authority more than offsets the fall in private consumption and investment spending and consequently aggregate output increases. Consistent with the results from negative monetary policy shocks, net worth, capital stock, and asset prices fall on impact in the wake of an increase in the nominal interest rate triggered by heightened public expenditure programmes. Inflation initially falls as the increased output from fiscal contribution places downward pressure on prices; however, over time, the public sector competes with households and entrepreneurs for limited resources and this causes inflation to pick up in the medium run. This suggests a significant crowding out effect in the long run where the fall in private spending more than offsets the increase in GDP from fiscal contribution.

Figure 3: Impulse Response to Positive Productivity Shock

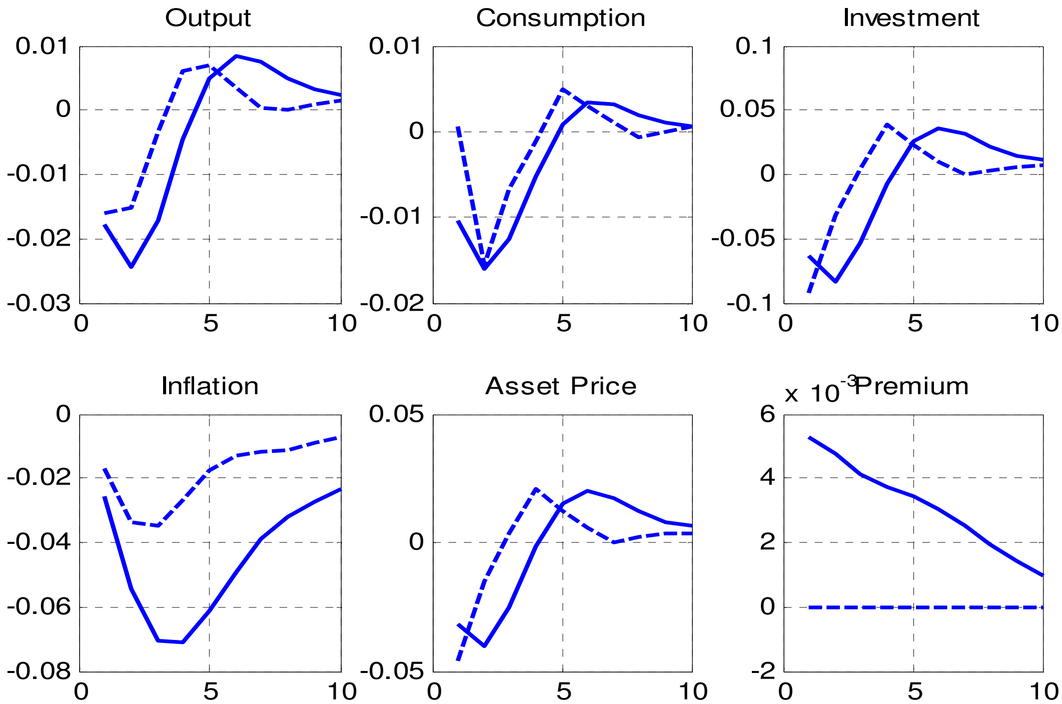


Finally, Figure 3 presents the endogenous response of the model economy to an exogenous total productivity shock. An improvement in the productive capacity of the economy generates expansion in output, capital stock, private consumption and investment spending which persists for more than two years after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

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

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

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



In Figure 4 I show the relative responses of selected endogenous variables to a one-off quarterly monetary policy shock equal to 0.05 standard deviation. It is clear that the results are significantly different for the two models. In the model with financial distortions, unexpected increase in the policy rate lifts the cost of raising fresh capital for financial intermediaries which they translate into higher external premium for loan applicants. By contrast, when the role of frictions is switched off, there is no difference among the policy rate, the required rate of return on bank loans, and the rate of return on equity investment. This is summarised by the flat impulse response of the external finance premium. Consistent with conventional empirical evidence, monetary tightening is accompanied by a decline in inflation, output, consumption, investment, and asset prices. But the degree of contraction is deeper and more persistent in the model where supply and demand side financial market imperfections have been considered. These results are broadly in line with previous findings that suggest stronger amplification of monetary policy shock in the real economy as a result of the interaction between corporate balance sheet and bank capital channels. Markovic (2006), Aguiar and Drumond (2007), and Zhang (2009) report that the effects of unanticipated central bank policy measures are amplified and propagated much more strongly with double agency cost problems in the financial markets.

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

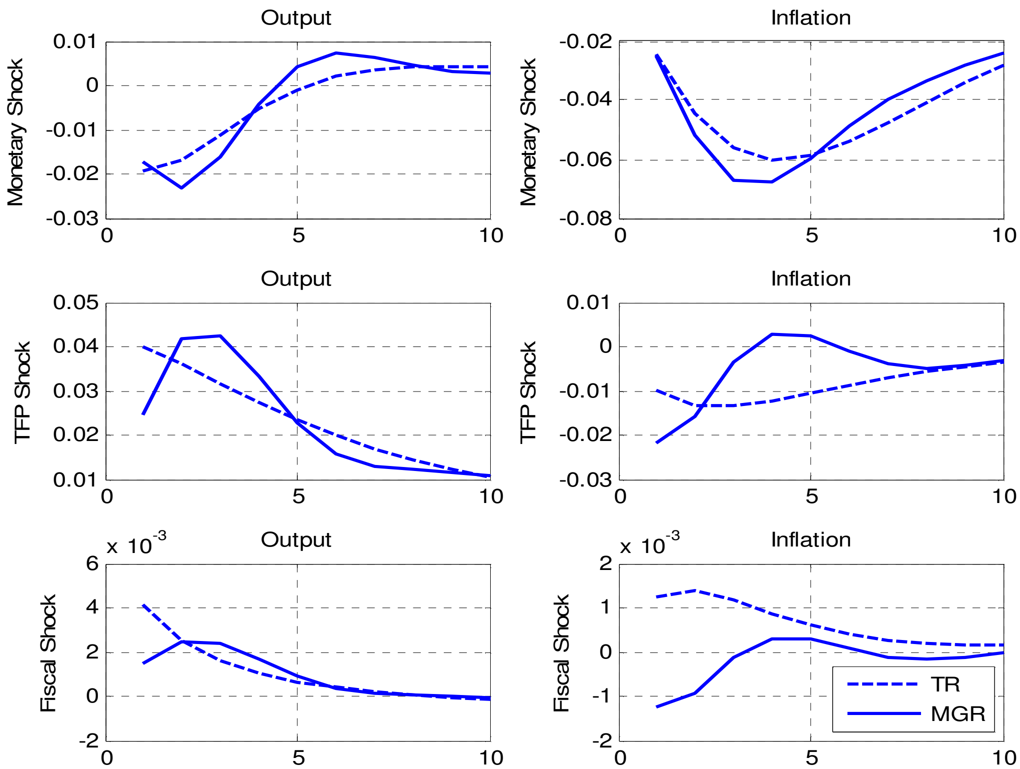


Figure 5 presents the responses of output and inflation to shocks under alternative monetary policy regimes. The qualitative aspects of the results are more or less preserved. For instance, contractionary monetary policy (a rise in the policy rate or a fall in money supply) leads to noticeable reduction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

6. Conclusion and Policy Implications

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

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

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

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Appendix A

First Order Conditions and Definitions

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

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

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

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

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

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

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

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

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

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

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

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

$$C_t^{-\sigma} = \Psi_t \tag{A13}$$

$$\Psi_t = \beta E_t R_{t+1}^D \Psi_{t+1} + D_t^{-\sigma} \tag{A14}$$

$$\Psi_t = \beta\{E_t \Psi_{t+1} R_{t+1}^S + \mathrm{cov}_t(R_{t+1}^S, \mathrm{C}_{t+1}^{-\sigma}\} \tag{A15}$$

$$(H_t^h)^{\varphi} = \Psi_t W_t^h \tag{A16}$$

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

$$\mu_t^m = \rho_m \mu_{t-1}^m - k_{i,\pi}\pi_t - k_{i,\mathrm{y}} y_t - v_t^{\varepsilon} \tag{A17}$$

$$\mu_t^m = m_t - m_{t-1} + \pi_t \tag{A18}$$

$$m_t = y_t - \rho_i r_t^n \tag{A19}$$

$$g_t = ARg_{t-1} + v_t^g \tag{A20}$$

Appendix B

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

Appendix C

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

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

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

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

Remember that $\Gamma(\bar{\omega})$ and $\Theta(\bar{\omega})$ are standard normal cumulative density functions and they are related to each other through $\Gamma(\bar{\omega}) = \Phi(z-\sigma) + \bar{\omega}[1-\Phi(z)]$ where $\Theta(\bar{\omega}) = \Phi(z-\sigma)$. Since it is assumed that the idiosyncratic shock is log-normally distributed with mean $-0.5\sigma^2$ and variance σ^2, it has the following log-normal probability and cumulative density functions, respectively:

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

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

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