Credit Market Segmentation and Macroprudential Regulation



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Abstract

This paper analyses the implications of credit market segmentation in the form of a formal and informal sector, for the effectiveness of bank-specific macroprudential regulation. It features a simple DSGE model involving households, formal financial intermediaries and firms. The novelty of the model lies in the quantitative rationing of credit by formal intermediaries, wherein a fraction of firms in the economy fail to get any loan from the formal sector, and have to directly approach the households for their borrowing. To understand the dynamics of this framework, I study the effects of negative shocks to the net worth of formal intermediaries, on certain macroeconomic and financial variables. I then analyse the effects of increasing the Capital Requirement Ratio in the presence of these shocks, on the volatility of aggregate credit and output, which are used as indicators of stability. In order to demonstrate the possible differences arising out of credit market segmentation, I compare the results obtained with the counterfactual case of an economy with no such segmentation. There are two interesting observations made in the analysis. Firstly, in the presence of segmentation, the response of relevant variables to a negative financial shock is more persistent. Secondly, increase in CRR as a stabilization tool is less effective in the case of segmented credit markets, and might even lead to an increase in credit and output volatility if executed beyond a reasonable level.

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Chapter 1

Introduction

The main object of interest in this study is the credit market segmentation arising from the quantitative rationing of credit by formal financial intermediaries. Quantitative rationing here refers to the refusal by the formal sector to provide *any* credit to a section of the firms. Many of the emerging economies in the world do not have cheap and easily available alternatives to formal intermediaries (mainly banks), because of their lesser developed financial markets. Therefore if a section of firms in these economies are quantitatively rationed by the banks, they have to seek informal sources of credit at much higher costs. By focusing on the specific case of India, I aim to analyse the effectiveness of Capital Requirement Ratio, which is a banking sector specific macroprudential regulation, in the presence of this alternative costly source of credit.

Macroprudential regulation has actively been used in India and many other emerging economies, since before the onset of the Global Financial Crisis. This has proven to be a sensible strategy given the volatility experienced by many of the emerging markets in the past three decades. To begin with, it is important to define what macroprudential regulation aims to achieve in my model. In the real world, the primary objective of these regulations can be seen in two lights. They can be viewed as preventive measures for potential future crises. Alternatively, they can be viewed as stabilization tools enacted to prevent excess financial volatility without excessively hampering growth. Both these objectives are mutually interrelated, albeit not technically equivalent. In this study I analyse macroprudential regulation as a financial stabilization tool. If the financial sector is fundamentally different in the EMEs as compared to advanced economies, the response of important variables to the same regulation may significantly differ. Given this possibility, studying macroprudential regulation for emerging economies using the models created to mirror the financial sector in advanced economies might lead to incorrect conclusions.

I therefore attempt to create a framework which can capture the type of credit market segmentation observed in India and other similar economies. To begin with, I analyse the general dynamics of the model through Impulse Response Functions of the main macroeconomic and financial variables, to a negative shock to the bank balance sheets. I find that in the presence of segmentation, the response of the variables to the negative shock shows greater persistence. This implies that negative financial realizations in segmented economies can have longer lasting adverse effects.

Following this, I utilise the model to compare the effect of an increase in the Capital Requirement Ratio (CRR) in an economy with no quantitative rationing of credit (and hence no segmentation) to a case with significant segmentation. I focus on the changes in the volatility of aggregate credit and output in response to changes in the CRR. I carry out these simulations in the presence of a single financial shock in the economy in order to better understand and delineate the meaning of the results. I find important differences in the results for the two types of economies. In the presence of segmentation, an increase in Capital Requirement Ratio has a lower effect on the volatility of the variables in question. Interestingly, if increased beyond a reasonable level, the CRR is actually associated with an increase in the volatility of these variables. These results are explained by the reduced co-movement of formal and informal lending as CRR increases. On the basis of this analysis, I conclude that the influence of credit market segmentation on the real economy can be significant, and must be taken into account even when devising policy which applies only to the formal financial intermediaries.

The presence of the informal credit sector is central to the analysis in this paper. Therefore, at the very outset, it is important to define the purview of this sector. Sometimes the term informal has been used interchangeably with the shadow banking sector. In this study however, there is a distinction between the two. Shadow banks refer to financial intermediaries whose members are subject to less regulatory oversight than the traditional banks. For the advanced economies, much literature has been devoted to the co-existence of traditional and shadow banks. In emerging economies such as India, shadow banks are subject to more stringent regulation and obtain most of their funding from the traditional banks. Hence, at least for this study, they can be considered a part of the formal financial intermediaries.

The informal credit sector in this context refers to all the institutional and non-institutional structures that provide credit in the absence of well-defined contracts. An important implication of this is that these sources do not require collateral, which is generally a prerequisite for formal sector loans. Given the absence of well-defined

contracts, the interest rates charged in the informal sector are much higher than those in the formal sector. Irrespective of these higher costs, many of the firms which fail to get access to cheaper formal funds on account of a dearth of good quality collateral, turn to the informal markets because of their urgent requirement for working capital. Examples of institutional sources of informal sector credit include moneylenders and chit funds.

Since activities of the informal sector are extremely difficult to measure and document, there have been very few studies in this area. However, it is well established that this sector is non-trivial for India as well as many other emerging markets of the world. It is therefore increasingly important to attempt an understanding into how these features of the financial sector interact with some large scale financial regulations.

I analyse the questions laid out in this chapter through the lens of a Dynamic Stochastic General Equilibrium Framework featuring households, banks and firms. In order to create a situation where some firms are rationed by the banks, I introduce heterogeneity in the working capital requirements of the firms. Informal loans in the model refer to the direct lending by the households to the rationed firms. Since households are unable to enforce contracts, informal rates are much higher than the formal ones.

Chapter 2

Literature Review

Boissay (2001)[5] provided an important distinction between price rationing and quantity rationing of credit. He defined price rationing as a situation where all the firms in the economy get the credit they desire, but at a rate that includes the external market premium. In contrast to this, he focused on the scenario of quantity rationing where the demand for credit by some of the borrowers is turned down, even if they are willing to pay the interest rate of the contract.

Quantity Rationing of Credit: The idea of quantitative rationing of credit is not new. A closely related and widely cited paper by Kiyotaki and Moore (1997)[12] focuses on this very friction. In fact, the basic workings of rationing in my framework closely follow the method introduced in their paper, with collateral being of primary importance. It is assumed that there exists a pre-commitment problem with respect to lending. This means that the borrowers cannot always be forced to repay their debts. Therefore, the lenders will only be willing to lend if there exists sufficient collateral with the borrowers to cover the cost of the loan in the case of default. While my model follows the same logic to introduce rationing of credit, there is one important difference. In Kiyotaki and Moore (1997)[12] all the borrowers are essentially identical. This means that all the borrowers are quantitatively rationed to an extent, by the lender. Instead, I follow Boissay (2001)[5] in including a simple idiosyncratic shock to the working capital requirement of the individual firms, to create a scenario where a section of the firms in the economy simply fail to get a loan from the formal banks.

My paper differs from the study by Boissay (2001)[5] in a few important ways. Firstly, his model does not explicitly feature a banking sector. Hence it is not possible to analyse bank-specific macroprudential regulation. Secondly, in his model, the firms which fail to obtain loans have zero production in that period. In doing so he focuses on the under-utilization of factors and resultant underproduction arising due

to quantitative rationing. My objective in introducing quantitative rationing of a section of the firms is to necessitate the demand for the highly expensive alternative to formal credit, in the form of the informal sector. This rationing therefore gives rise to segmentation in my model.

Banking Sector: I take the help of the Gertler and Karadi (2011)[7] framework to model the formal financial intermediaries. Gertler and Karadi (2011)[7] introduce an agency problem between the households and the banks, which endogenously limits the banks ability to obtain funds from the households. This agency problem arises from the possibility of the banks running away with a portion of the overall deposits. As a result, the depositors provide these intermediaries with funds subject to the constraint that the future discounted value of the net worth of the banks is greater than or equal to the value of the funds that can be appropriated by them. My paper differs slightly in modelling the banks, in that they do not have the option of running away with the depositors funds. There is instead an exogenous constraint imposed by the regulator on these institutions, determining the minimum regulatory capital requirement. This constraint introduces a friction in the financial sector whose extent is determined by the regulatory authority.

Capital Requirement Ratio and Credit Rationing: Agur (2011)[1] extends the Stiglitz and Weiss (1981)[21] model of credit rationing to study the trade off between financial stability and credit rationing, for changes in the Capital Requirement Ratio. His model includes a probability of bank default which is endogenous and falls with a rise in the CRR. This rise in CRR however, is also associated with a rise in credit rationing, leading to a trade off. There are two important differences between his paper and the current study. Firstly, in his analysis, an increase in the CRR leads to a fall in the bank lending rates, because it improves the capitalisation of the banks, which are then hypothesised to choose less risky loans. In my analysis, an increase in CRR has the opposite effect on the lending rates[1]. Secondly, while Agur focuses on the trade off between stability and rationing, I study how an increase in rationing can lead to an increase in the volatility of aggregate credit and output, thus reducing the effectiveness of the CRR.

Segmentation of Credit Markets: Rubio (2017)[18] carries out an analysis similar to this study. Instead of an informal credit market, she considers the effects of the presence of a shadow banking sector in a DSGE framework. She follows the methodology used in Iocoviello (2015)[10], which is also inspired by the Kiyotaki

[1] A related paper by Thakor (1996)[22] also involves an increase in lending rates with an increase in CRR

Moore framework. There are however important differences between her paper and the current study. Firstly, in Rubio (2017)[18] even the borrowing from the shadow banking sector is subject to collateral constraints unlike in my model where borrowing from the informal sector is in the absence of any collateral, leading to much higher interest rates. Secondly, in her model the liquidation technology is symmetric for both the formal and the shadow banking sectors. Therefore, these provide similar alternatives to the borrowers in terms of the costs, and the borrowers optimize between the two to maximise their utility function. In my model, only the firms that fail to get credit from the cheaper financial sector approach the informal sector for credit. Lastly, I follow a different technique in modelling the banks- Rubio (2017)[18] considers banks as agents separate from the households which maximise their consumption in the form of dividends, while I use the Gertler Karadi approach in modelling the sector.

Segmentation between the Formal and Informal Credit Sector: Although different in methodology, Ngalawa and Viegi (2013)[16] share the objective of my study in including an informal credit sector alongside the formal sector in a DSGE framework to analyse implications for policy. They follow the argument of information asymmetry analysed by Stiglitz and Weiss (1981)[21] to explain rationing of firms by the formal sector, and study monetary policy in this context. While they provide a very simple and useful framework for analysing the effects of segmentation, the extent of credit rationing is exogenous to their model and the fraction of total firms which are rationed, does not vary with the macroeconomic and financial conditions of the economy. This endogenous mechanism is central to the analysis in the current paper.

Chapter 3

Evidence of Credit Market Segmentation in India

In this section I provide some evidence of significant presence of quantitative rationing of credit, and the heavy dependence of a section of firms in the Indian economy on informal credit. The financial sector in India is till date heavily dominated by conventional deposit taking banks. In 2013, bank credit as a share of total credit disbursed to the non-financial private sector stood at 92% [1]. However, the proportion of bank (and NBFC) credit to the GDP in India is only 46% as compared to the average of 67.7% for emerging economies and 138.5% for advanced economies. The limited reach of the banking sector is thus evident. This can be attributed to various costs and challenges involved in the sector- such as heavy regulations, dearth of good quality collateral and significant information asymmetries. All these factors imply thin profit margins for banks. This results in significant credit rationing and magnified effects of negative realizations to the bank balance sheets on the real economy. Given that the bond market in the economy is not completely developed, and international borrowing only restricted to larger firms, the residual credit demand by the rationed, faster growing, smaller and riskier firms is fulfilled by the informal credit sector [2].

From the perspective of formal lenders, most of the smaller firms in the Indian economy are characterized by acute information asymmetry and a lack of sufficient collateral. Because of these factors, advancing loans to these smaller entities is deemed to be riskier. Hence in looking at the evidence for quantitative rationing of credit in the Indian economy, I focus primarily on the Micro, Small and Medium Enterprise (MSME) sector. The MSME Sector has been crucial in the growth story of India.

[1] Mohanty and Rishabh (2016) [15]
[2] Kletzer (2012) [13]

A recent Ministry of MSME Report[3] stated that there are close to 55.8 million such enterprises and they employ approximately 124 million people across the country. In all, the MSME sector accounts for about 31 percent of the Indian GDP and 45 percent of the total Indian exports[4]. In 2017, the International Finance Corporation of the World Bank Group, prepared a report[5] detailing the financial landscape of the Micro, Small and Medium Enterprises in India. This report strongly underscored the prior held belief that there exists significant unmet demand for finance from the formal credit sector, as a result of which these enterprises are forced to look towards informal sources of credit at much higher interest rates.

3.1 Main Findings of the IFC (2018) Report

The study found that a primary reason for the significant rationing in the MSME sector is the lack of quality collateral available with the firms. Most of MSME firms (85%) are not registered formally, and hence little information is available about them. Given the lack of useful information on these firms, banks are very hesitant in advancing credit to these businesses unless sufficient collateral is available. I use this agency problem in my model, wherein the firms borrowing have the option to run away with the loans, implying that loans are only provided in situations where the value of collateral exceeds the value of the loan.

The main reason for seeking informal credit is that almost all of the informal loan products are unsecured, and hence the only option for the MSMEs which lack immediate access to sufficient collateral. Yang et al. (2014)[23], found that these smaller businesses prefer the certainty of short term financing, even at the cost of very high interest rates and the resultant heavy repayment burdens that informal sector borrowing entails.

Over the years these enterprises have become increasingly dependent on debt for their functioning with their debt demand increasing from INR 26 trillion (USD 520 Billion) in 2010 to 69.3 trillion (USD 1.07 Trillion) in 2017. As shown in Figure 3.1, of this total debt demanded, only 16%, or INR 10.9 Trillion (USD 168 Billion) is financed by the formal sources of credit in the economy. Banking institutions service INR 9.4 Trillion (USD 144 Billion) of the total INR 10.9 Trillion formal sector credit. The rest of the INR 58.4 Trillion (USD 898 Billion), constituting 84% of the total

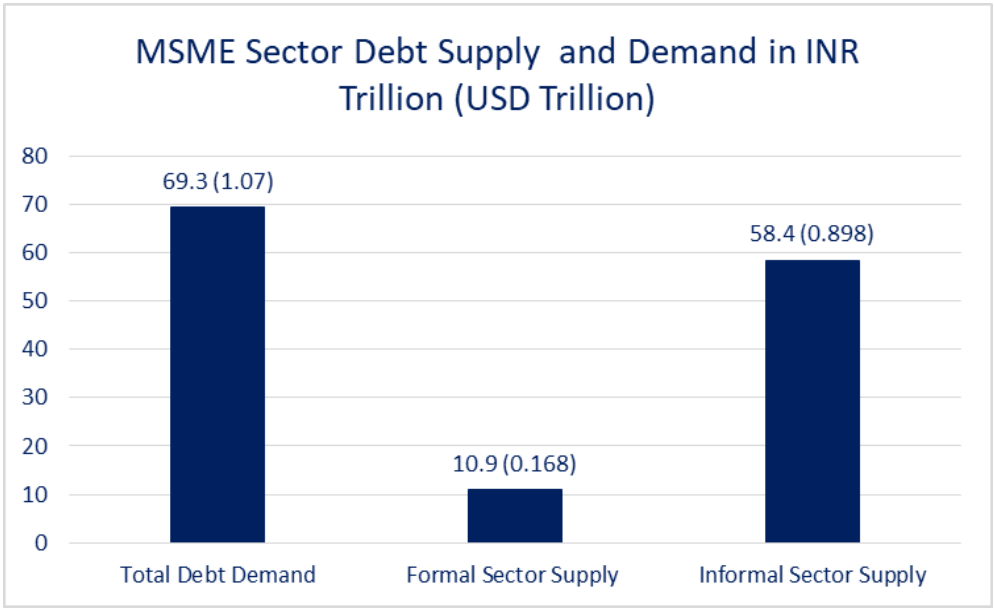
[3]Ministry of MSME-Annual Report 2014-15 accessed at https://msme.gov.in/sites/default/files/MSME

[4]Ministry of MSME- Annual Report, 2016-17 available at https://msme.gov.in

[5]Financing India's MSMEs, IFC, World Bank Group (2018) avaiable at https://www.ifc.org/

debt demanded, is fulfilled by the informal sources in the economy. Even though the informal credit sector plays such a dominant role in the provision of credit to these smaller businesses, the exact sources are extremely difficult to ascertain. Within the informal sector, institutional sources of credit mainly consist of Moneylenders and Chit-funds.

Figure 3.1:

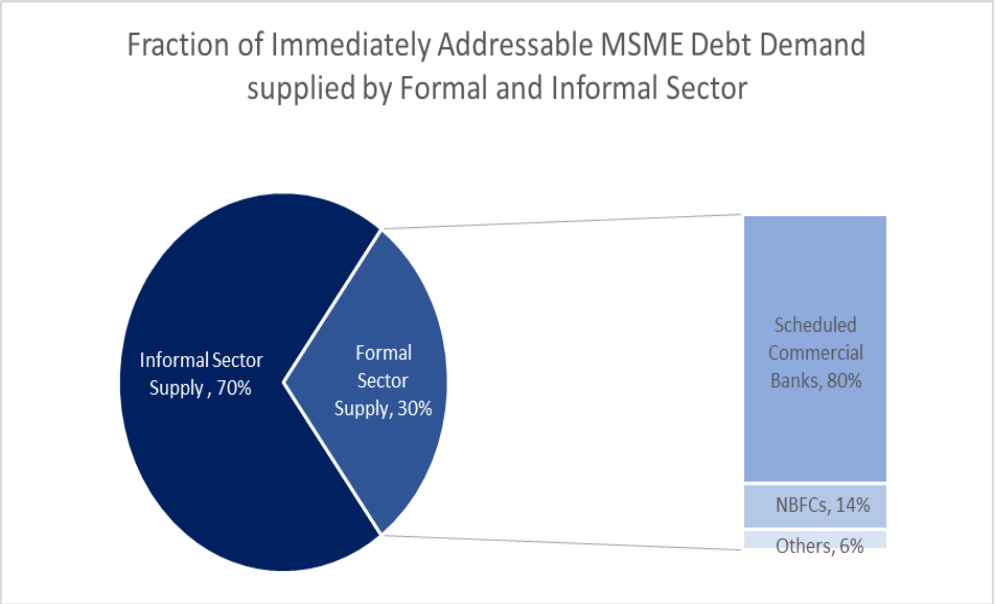


Source: *Financing India's MSMEs*, *IFC*, *World Bank Group* (2018)

Another important consideration is whether these two sectors are exclusive in terms of the firms they service. If that were the case, then changes in formal sector specific macroprudential policy should not affect the informal sector demand. The IFC study addresses this issue, finding (as shown in Figure 3.2) that of the total INR 69.3 Trillion (USD 1.07 Trillion) debt demand by MSMEs, only a fraction is demanded by firms which exclusively seek informal loans, or may be too sick or young to avail formal sector loans. Even if we exclude this from the total MSME debt demand, INR 36.74 Trillion (USD 0.57 Trillion) worth of informal sector debt supply is immediately addressable by the formal sector depending on the availability of sufficient collateral and supply of formal credit in the economy. This finding goes to show that the formal and the informal sectors are anything but exclusive. Hence, policy makers need to be aware of the possible implications of both monetary and macroprudential policies on

the supply of credit by the formal sector and the resultant change in the degree of segmentation in the economy.

Figure 3.2:



Source: *Financing India's MSMEs, IFC, World Bank Group* (2018)

Chapter 4

Model

I develop a simple Dynamic Stochastic General Equilibrium model with credit market segmentation. There are three types of agents in the economy- Households, formal financial intermediaries (banks) and firms. I explicitly model a banking sector to analyse the effects of financial shocks, which are represented by shocks to the balance sheet of the banks, and to compare the implications of bank-specific macroprudential regulation for economies with and without segmentation.

In order to produce in the period t, I assume that the firms need some working capital goods for which they need to borrow. This working capital requirement is assumed to be proportional to the firm size while being independent of the productivity parameter a_t. Denoting the working capital requirement of a firm i at time t by $\varphi_{i,t}$, I assume $\varphi_{i,t} = \Theta_i k_t^{\alpha} l_t^{(1-\alpha)}$, where Θ_i is the firm specific idiosyncratic shock realised at the beginning of every period. This shock introduces heterogeneity in the working capital requirement of the individual firms, and is assumed to follow a uniform distribution, with $\Theta_i \in [0, 1]$.

The key friction lies between the banks and firms, and arises from the possibility that after obtaining the loan and completing production, the firms may run away without honouring their debt. As a result of this possibility, the banks only lend to firms for which the liquidation value of the assets (some fraction of the total firm asset value), is greater than the eventual repayment value of the loan. The firms that fail this basic requirement are turned away by the formal sector and have to approach the informal sector for their borrowing.

I assume that only the banks are capable of enforcing these collateral contracts and hence the interest rates charged in the informal credit sector depend on the probability of loan default. This probability of loan default increases with an increase in the total volume of informal lending.

4.1 Households

There exist a continuum of identical households of measure unity, each characterized by an intertemporal utility function which is separable in consumption and leisure. The households invest in capital to be used in the next period for production, lend a portion of their total income to the banks in the form of deposits, and also lend directly to the rationed firms in the economy. This last component represents informal sector lending in the model.

Each household consists of a fraction (1-f) of workers and the remaining fraction f of bankers. Workers provide labour as an input in production for the firms, for which they receive wages. These wages are returned to the households as income. Similarly, for the bankers, all profits (net earnings) are eventually transferred back to the households.

4.1.1 Timing of events for Households

At the end of the period t,

- Households carry out investment, adding to the stock of capital goods
- Then an economy wide financial shock occurs
- Post this shock the firms hire labour and rent capital from the households
- Finally the households decide on consumption, deposits to the formal financial intermediaries and the informal sector loans. Note that at this point the households have enough information to know the aggregate demand for informal sector loans since the idiosyncratic shock does not affect the aggregate demand.
- Period t ends and period t+1 begins
- The firm specific idiosyncratic shock occurs. Post this shock, the firms approach the formal or informal sector depending on the realization of the shock

4.1.2 Household's Optimization Problem

Each household maximizes its lifetime utility subject to its budget constraint and the law of motion for the stock of capital. This optimization problem is as given below:

$$max_{(k_{t+1},l_t)_{t=\tau,..}} E_\tau max_{(d_{t+1},L^i_{t+1},c_t)_{t=\tau,..}} E_{\tau+1} \sum_{t=\tau}^{t=+\infty} \beta^{t-\tau} \Big[U(c_t) + V(l_t) \Big] \tag{4.1}$$

subject to:

$$c_t + d_{t+1} + L^i_{t+1} + i_t \leq (1 + r_t)d_t + (1 + R^i_t)q(L^i_t)L^i_t + w_t l_t + R^k_t k_t + \Pi_t \tag{4.2}$$

with

$$i_t = k_{t+1} - (1 - \delta)k_t \tag{4.3}$$

where E_t is expectation conditional on the information available at time t. U and V are the instantaneous utility functions of consumption and labour respectively. These utility functions are well behaved in the sense that $U'(C_t) > 0, U''(C_t) < 0, V'(1 - l_t) > 0$ and $V''(1 - l_t) < 0$. d_{t+1} stands for the deposits made by the households in the banks at the end of period t. Similarly, L^i_{t+1} signifies the informal sector lending by the households directly to the firms. r_t and R^i_t denote the interest rates that the households receive on their deposits and informal loans respectively. $q(L^i_t)$ is a function signifying the probability of loan recovery. This probability of recovery is assumed to be inversely related to the aggregate volume of informal sector loans given out by the household. Finally, following conventional notation, w_t stands for wage rate, R^k_t stands for rental rate, and Π_t is the profits of the firms.

Maximising (4.1) subject to (4.2) and (4.3), with respect to $c_t, d_{t+1}, L^i_{t+1}, i_t, k_{t+1}$ we can get the first order conditions:

$$U'(c_t) = \beta(1 + r_{t+1})U'(c_{t+1}) \tag{4.4}$$

$$\frac{V'(l_t)}{w_t} = U'(c_t) \tag{4.5}$$

$$1 + r_t = (1 + R^i_t)\Big(q(L^i_t) + q'(L^i_t)L^i_t\Big) \tag{4.6}$$

$$R^k_t = r_t + \delta \tag{4.7}$$

Equation (4.4) is the intertemporal consumption Euler equation and Equation (4.5) is the labour supply equation. Equation (4.6) is of some importance to the dynamics in this model, since it states that in equilibrium, the deposits made to the formal intermediaries provide the same return to the households as their informal lending adjusted by the probability of loan recovery.

4.2 Banks

Banks have a simple role in the economy: they intermediate funds from the households to the firms. In terms of this intermediation,they differ from the households because they are assumed to specialise in enforcing collateral contracts.

Unlike the framework in Gertler and Karadi (2011)[7] or Gertler and Kiyotaki (2010)[8], the banks do not carry out maturity transformation. In fact, their lending consists of working capital loans made to the firms at the beginning of a period which are duly returned at the end of the period. This is done to ensure maximum simplicity. Even though I lose out on some of the important features from Gertler and Karadi (2011)[7], the basic setup still helps me capture the balance sheet structure of the banks and their risk averse nature. The explicit modelling of balance sheet becomes helpful when undertaking analysis on Capital Requirement Ratio.

4.2.1 Timing of events for Banks

- At the end of period t, after the realization of the financial shock, the banks receive the deposits from the households and the revenue from loans advanced in the previous period.
- At the beginning to period t+1 the idiosyncratic shock occurs, and the banks lend to the firms which possess sufficient amount of collateral and turn away the rest.

4.2.2 Balance Sheet Identity

The balance sheet identity of the banks is standard: assets equal total of equity and liabilities. In this simplistic model, the assets consist of working capital loans made by the banks to the firms. And the liabilities are the deposits that the banks obtain from the households.

$$n_t + d_t = L_t^f \tag{4.8}$$

Here, n_t refers to the net worth or equity available to the individual bank at the beginning of the period t, and L_t^f refers to the lending by the bank. As before, d_t denotes the household deposits in Banks.

4.2.3 Regulatory Constraint on the Bankers

An important financial friction is introduced through a minimum regulatory capital constraint imposed on the bankers. This constraint requires the discounted value of the bankers' future net worth to be greater than or equal to a fraction of their

current assets. This fraction is determined by the regulatory authority and serves as the channel through which macroprudential policy is exercised[1].

$$V_t \geq \theta L_t^f \tag{4.9}$$

In this equation, θ is an exogenous parameter which determines the Capital Requirement Ratio, i.e. the ratio of current bank net worth to loans. This parameter can therefore be seen as a proxy for CRR, with an increase in the parameter representing an increase in the capital requirement for the banks.

4.2.4 Banker's Optimization Problem

The banker's optimisation problem (detailed derivation in the appendix A) is to maximise the present discounted value of its future net worth subject to its budget constraint. Following related literature (for example Gertler and Karadi (2011)[7] or Gertler et al. (2012)[9]). I assume that the banker survives for the next period with i.i.d probability σ and is forced to exit with probability $1-\sigma$. Once the banker exits it transfers the retained earnings to the households and becomes a worker. This aspect is introduced so as to ensure the banker does not accumulate enough net wealth to be able to disburse loans solely out of its equity. In essence this banker exit captures the dividend payout to the households.

It is assumed that the banker is more impatient than the household and hence the stochastic discount factor for the banker is given by:

$$\Lambda_{t,t+1} = \epsilon \frac{MU_{Ct+1}}{MU_{Ct}}$$

Where $\epsilon \leq \beta$, i.e. the bankers discount factor is assumed to be lower than the discount factor for the households. This is done to ensure the interest rate spread matches the realistic level for India.

Formally, the banker chooses $\{L_t^f, d_t\}$ to solve the following problem:

$$V(n_t) = max\Big[(1-\sigma)\{E_t\Lambda_{t,t+1}\Big((1+R_t^f)L_t^f - (1+r_t)d_t\Big)\} + \sigma\{E_t\Lambda_{t,t+1}[V_{t+1}(n_{t+1})]\}\Big] \tag{4.10}$$

Subject to the budget constraint:

$$L_t^f + (1+r_{t-1})d_{t-1} \leq (1+R_{t-1}^f)L_{t-1}^f + d_t \tag{4.11}$$

[1]Pietrunti (2017)[17] analyses a similar regulatory constraint on the bankers

The budget constraint of the banks simply points out that the revenue of the bank, consisting of payment from previous period loans, and current period deposits always has to exceed the expenditures, which comprise present period loans and interest payments on previous period deposits.

And subject to the regulatory constraint imposed by the regulator:

$$V_t \geq \theta L_t^f \tag{4.12}$$

Combining the budget constraint (4.11) with the balance sheet identity (4.8), we get the law of motion of net worth for the individual banker as follows,

$$n_{t+1} = (1 + R_t^f)L_t^f - (1 + r_t)d_t \tag{4.13}$$

Following related literature (Akinci and Queralto (2016)[2]), I guess that the value function is linear in net worth $V_t = \gamma_t n_t$. Here γ_t can be understood as the marginal value of an extra unit of net worth.

Using this, I can rewrite the value function as:

$$V_t = max_{L_t^f} E_t \Big\{ \Lambda_{t,t+1} \Omega_{t+1} n_{t+1} \Big\} \tag{4.14}$$

where Ω_t stands for $1 - \sigma + \sigma\gamma_t$.

I maximise this equation subject to the constraint (4.12). The first order condition with respect to L_t^f and the complementary slackness condition with μ_t as the lagrange multiplier, read as:

$$E_t \Big[\Lambda_{t,t+1} \Omega_{t+1} (R_t^f - r_t) \Big] = \theta \mu_t \tag{4.15}$$

$$\mu_t [\gamma_t n_t - \theta L_t^f] = 0 \tag{4.16}$$

4.2.5 Capital Requirement Ratio

Given that the regulatory constraint (4.12) on the bankers is always binding, we can express the Capital Requirement Ratio as the ratio of net worth to bank lending:

$$CRR = \frac{n_t}{L_t^f} = \frac{\theta}{\gamma_t} \tag{4.17}$$

If we substitute the law of motion of net worth into the F.O.C, we can obtain the expression for the marginal value of net worth as (full derivation provided in the appendix A):

$$\gamma_t = \frac{1}{1-\mu_t}\left[E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(1+r_t)\Big\}\right] \tag{4.18}$$

Replacing this in equation (4.17), we get:

$$CRR : \frac{\theta(1-\mu_t)}{E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(1+r_t)\Big\}}$$

or

$$CRR : \frac{\theta - E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(R^f_t - r_t)\Big\}}{E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(1+r_t)\Big\}} \tag{4.19}$$

Therefore, an increase in the value of θ corresponds to an increase in the value of the Capital Requirement Ratio. Since the modelling of the banking sector in this paper is the same for the economies with and without segmentation, the steady state CRR will be the same in both types of economies for a given value of the θ.

4.2.6 Aggregate Law of Motion

As in Gertler and Karadi (2011) [7], I assume that the endowment to the new entering bankers is proportional to the previous period lending. This endowment is given as ωL^f_{t-1}, where ω is a very small value ensuring new banks have some funds to begin with, but does not affect the workings of the model. To conclude the section on banks, I finally provide the aggregate law of motion for the banking sector net worth:

$$N_{t+1} = \sigma\Big[(R^f_t - r_t)L^f_t - (1+r_t)N_t\Big] + (1-\sigma)[\omega L^f_t] - z_{t+1} \tag{4.20}$$

where z_{t+1} is a mean zero shock meant to capture the unexpected adverse realizations to the aggregate net worth of the banking sector.

The aggregate net worth of the bankers is crucial to the analysis undertaken in the model. The extent of quantitative rationing in the economy, and hence the extent of under-investment by the firms is dependent on the health of the bank balance sheet. Any adverse realizations to the aggregate net worth of banks or tightening of macro-prudential regulations can thus lead to an increase in the lending interest rate, which eventually leads to greater rationing of firms.

4.3 Firms

The modelling of firms follows standard literature, with the only distinguishing characteristic being the heterogeneity in the working capital requirements of the individual firms. This aspect is necessary to introduce some demand for the costly informal sector loans.

4.3.1 Timing of events for firms

- At the end of period t, the financial shock for the period t+1 is realised. Post this shock, the firms hire labour l_{t+1} and rent capital k_{t+1} from the households for the period t+1.

- Once this is done, the labour and capital markets close and the period t ends. At the beginning of the period $t+1$, after the realization of the idiosyncratic shock Θ_i, the firm approaches the formal or informal sector to finance its working capital requirement given by $\varphi_{i,t+1}(\Theta_i) = \Theta_i k_{t+1}^{\alpha} l_{t+1}^{(1-\alpha)}$.

4.3.2 Collateral

In this model, the end of period depreciated capital and the cash flow of the firm constitute its collateralizable assets. However, an important consideration here is that only a fraction of these assets can be used as collateral. There can be two possible interpretations of this fraction: firstly, it can be seen as the liquidation value of the firm assets. This liquidation value conveys the level of financial development in a country, where a more financially developed country with strictly enforceable contracts would be characterized by a higher liquidation value of the same assets. Secondly, this can also be perceived as the regulatory loan to value ratio, which is now commonly used in many economies of the world as a prudential measure. In this model and in the subsequent analysis, I use it specifically in the former sense, with a lower liquidation value signifying a lower level of financial development in the economy. This fraction determines the broad level of credit market segmentation in the model. I calibrate it to match the level of segmentation estimated for the Indian economy. While the liquidation value sets the broad level of segmentation, macroprudential regulation in the form of CRR, and the associated endogenous variables determine the exact level.

4.3.3 Borrowing Constraints

A bank would only lend to a firm if:

$$\Theta_i k_t^{\alpha} l_t^{1-\alpha}(1+R_t^f) \leq \chi(1-\delta)k_t + \psi y_t$$

or

$$\Theta_i \leq min\left\{\chi\frac{1-\delta}{1+R_t^f}\left(\frac{k_t}{l_t}\right)^{1-\alpha} + \psi\frac{a_t}{1+R_t^f}, 1\right\} \equiv \overline{\Theta}_t \tag{4.21}$$

Interpretation:

The components of Equation (4.21) play an important role in the functioning of the model. χ and ψ denote the fraction of depreciated capital and cash flow that can be used as collateral. Θ_i is the firm specific idiosyncratic shock observed publicly at the beginning of every period and follows a uniform distribution with $\Theta_i \in [0,1]$. $\overline{\Theta}_t$ can be interpreted as the lending benchmark for the banks. Simply stated, banks refuse to advance loans to firms for whom the realised shock Θ_i is greater than this benchmark $\overline{\Theta}_t$. This means that the banks will refuse to provide credit to $1-F(\overline{\Theta}_t)$ fraction of the firms in the economy, where $F(\overline{\Theta}_t) \equiv P(\Theta \leq \overline{\Theta}_t)$. Since I assume a uniformly distributed firm specific shock, this equals $1-\overline{\Theta}_t$. We can interpret $1-\overline{\Theta}_t$ as the intensity or extent of credit rationing in the economy. Looking closely at the equation (4.21), we can observe a few important details. A positive technology shock (not included in this study) or an increase in the capital-to-labour ratio lead to an increase in $\overline{\Theta}_t$ whereas an increase in the bank lending rate has the opposite effect on the concerned variable.

Therefore, the extent of credit rationing in the economy is positively related to the formal sector bank lending rate and negatively related to the technology parameter and capital-to-labour ratio. Intuitively, it is sensible for one to expect a greater proportion of the firms being unable to avail formal sector loans because of higher lending rates, lower end of period cash flow or capital. Since capital is a collateralizable asset in our model, it plays a dual role for the firms, as an input for production and as a tangible asset which can be used to avail formal sector loans.

4.3.4 Firm's Optimization Problem

The firms make their capital and labour decisions after the realization of the economy wide aggregate financial shock but before the realization of the firm specific idiosyncratic shock. This means that at the time of making labour and capital decisions, a

firm does not know whether it will be able to avail formal sector loans. Therefore, in taking these decisions, it assigns a probability to being eligible for the formal sector loans and a probability to having to approach the informal sector at much higher rates.

Let Π denote the firm's profit. Then the static problem of the firm is as follows,

$$max_{l_t,k_t}\Pi_t = \Big[a_t - F(\overline{\Theta}_t)E(\overline{\Theta}_t)(1+R_t^f) - (1-F(\overline{\Theta}_t)E(\underline{\Theta}_t))(1+R_t^i)\Big]k_t^{\alpha}l_t^{1-\alpha} - w_t l_t - R_t^k k_t \tag{4.22}$$

Here, $E(\overline{\Theta}) \equiv \int_0^{\overline{\Theta}} \Theta dF(\Theta)$ is the average value of the firm specific working capital shock for firms which manage to get formal loans. $E(\underline{\Theta}) \equiv \int_{\overline{\Theta}}^{1} \Theta dF(\Theta)$ on the other hand, is the average value of the shock for firms which have to seek informal sector loans. $F(\overline{\Theta}_t) \equiv P(\Theta \leq \overline{\Theta})$ is the probability of being able to access the formal sector. Since I have assumed the firm specific shock to be uniformly distributed, $E(\overline{\Theta}) = \frac{\overline{\Theta}}{2}$,$E(\underline{\Theta}) = \frac{1+\overline{\Theta}}{2}$ and $F(\overline{\Theta}_t) = \overline{\Theta}_t$.

It is assumed that the firms take $\overline{\Theta}_t$ as given, meaning that they do not internalize the effect of their factor demands on the intensity of credit rationing measure. Allowing for internalization leads to slightly higher capital and lower labour without any notable change in the dynamics, also at the cost of increased complexity. Since simplicity is an objective, I do not allow for this internalisation.

The firm F.O.Cs with respect to capital and labour respectively are as follows:

$$\Big[a_t - \frac{\overline{\Theta}_t}{2}\overline{\Theta}_t\Big(1+R_t^f\Big) - \Big(\frac{1+\overline{\Theta}_t}{2}\Big)\Big(1-\overline{\Theta}_t\Big)\Big(1+R_t^i\Big)\Big]\alpha k_t^{(\alpha-1)}l_t^{(1-\alpha)} = R_t^k \tag{4.23}$$

$$\Big[a_t - \frac{\overline{\Theta}_t}{2}\overline{\Theta}_t\Big(1+R_t^f\Big) - \Big(\frac{1+\overline{\Theta}_t}{2}\Big)\Big(1-\overline{\Theta}_t\Big)\Big(1+R_t^i\Big)\Big](1-\alpha)k_t^{(\alpha)}l_t^{(-\alpha)} = w_t \tag{4.24}$$

If there is a negative shock to the aggregate bank net worth, the required rate of return on bank loans increases. This leads to an increase in the intensity of credit rationing $1-\overline{\Theta}_t$. With an increase in rationing, the probability of having to approach the more expensive informal sector increases. This results in a fall in the factor demand of the firms, leading to lower production.

4.3.5 Modelling of the Economy without Credit Market Segmentation

I use an economy with no credit market segmentation as a counterfactual in the subsequent analysis. This case can be seen as representing an advanced economy in the real world where there is no/little dependence on informal sources of credit. As stated in the introduction, I include all the other alternative sources of credit in the economy such as NBFCs under the definition of formal financial intermediaries since they operate in the presence of well defined contracts, which is the basis for the segmentation considered.

The modelling of the economy with no credit market segmentation involves setting the benchmark $\overline{\Theta}_t$ to 1. This means that all the firms in the economy, irrespective of their working capital requirements manage to secure loans from the formal financial intermediaries. Given availability of this cheaper credit, informal lending falls to zero, and the household's contribution to the lending in the economy is solely through their deposits in formal financial intermediaries.

4.4 Resource Constraint

The total output produced in any given period is used for consumption, investment and for the working capital requirements of the firms in the next period. Since the financial shock is realised at the end of period t before the capital and labour decisions are made, the aggregate lending for the next period is known. The resource constraint for the economy (derived in the appendix A) is as follows:

$$c_t + i_t + 0.5k_{t+1}^{\alpha} l_{t+1}^{1-\alpha} = Y_t \tag{4.25}$$

where $0.5k_{t+1}^{\alpha} l_{t+1}^{1-\alpha}$ constitutes the aggregate lending consisting of $\frac{\overline{\Theta}_{t+1}}{2}\overline{\Theta}_{t+1} k_{t+1}^{\alpha} l_{t+1}^{1-\alpha}$ aggregate formal loans, and $\left(\frac{1+\overline{\Theta}_{t+1}}{2}\right)\left(1-\overline{\Theta}_{t+1}\right) k_{t+1}^{\alpha} l_{t+1}^{1-\alpha}$ aggregate informal loans.

Chapter 5

Calibration and Functional forms

5.1 Functional Forms

The functional forms of the utility function for the household and the production function for the firms are as follows:

$$U(c_t, l_t) = u(c_t) + v(l_t) = \ln(c_t) + \eta \ln(1 - l_t) \tag{5.1}$$

$$Y_t = a_t k_t^{\alpha} l_t^{1-\alpha} \tag{5.2}$$

Apart from these, the functional form assigned to the probability of loan recovery is:

$$q(L_t^i) = 1 - \iota(L_t^i)^2 \tag{5.3}$$

This probability is assumed to be a quadratic function of the total volume of informal sector loans, hence it falls at a greater rate as the volume of informal sector loans rises. Since informal sector lacks well defined contracts, it is fair to assume that greater the volume of the loan, greater the probability of default.

5.2 Calibration

Table 5.1 provides the parameter values. One time period in the model signifies a quarter. I assign the standard value of 0.33 to the capital share α [1]. Similarly, the depreciation rate δ, has also been assigned the standard value of 0.025. The value of

[1] Saxegaard et al. (2010)[20], along with much of the related literature, use this value for the Indian economy.

labour supply elasticity η is set at 0.7 in order to ensure labour hours constitute one-half of the overall time in the steady state and to obtain a labour supply elasticity of 1 (derived in appendix A), following the value of elasticity considered in Rubio (2017)[19] and much of the related literature.

β is set at 0.985 so as to ensure a steady state value of the annual real interest rate of 6% to match the average value from 1978-2017 for India[2]. The bank discount rate ϵ on the other hand is set at a lower value of 0.8 to match the high interest rate spread in India. Given the simplistic structure of my banking model, I need a low value of the discount factor to generate sufficient spread. With this value of the bank discount factor, I obtain a spread of 0.5-1.5% and hence a steady state value of the lending rate within 2-3%, denoting an annual rate of 8-12%. I carry out a robustness check for a higher value of this discount factor in the appendix B and find that qualitatively, it does not change the results of the subsequent analysis.

Unlike the formal sector, concrete estimates of the informal sector interest rate are not available. I base the value of these rates on the findings of related literature, for example the IFC report (2018), estimates that the annual informal rates start from around 36% and go all the way up to 200%. Literature in microeconomics studying the informal sector in India, for example Bhatacharjee and Rajeev (2010)[4], find that even though there is a lot of dispersion, most informal loans are given at rates ranging from 48-60%. Batini et al. (2010)[14] also find that the informal sector rates are much higher than the formal sector rates, and those charged by institutional moneylenders may exceed 75% per year. I therefore calibrate the value of ι in equation (5.3) to obtain a steady state quarterly interest rate of 12-13% and hence an annual rate of 48-52%, with the exact value determined by the level of CRR. I analyse the robustness of results to alternative calibrations of ι in the appendix B. In this instance as well, I find that this calibration does not affect the qualitative nature of the results.

For the banks, the parameter σ denoting their survival rate is set at 0.931. This implies that the expected survival of the banks is $\frac{1}{1-0.931}$ or around 15 quarters (3.75 years). Intuitively, this can be thought of as the average time across dividend payouts, and is within the range usually considered in related literature. Following Gerlter and Karadi (2011)[7], I set the value of the proportional transfer to entering banks to a minute 0.002, so as not to affect results but also allow the entering banks to begin their operations.

Finally, within the firm specific parameters, the values of χ and ψ, which denote the share of capital and cash flow that can be used as collateral are assigned a value of

[2]IMF data

0.12 in order to ensure 23-25% of the firms in the economy are rationed by the formal sector. This value is chosen according to the IFC study, which estimates around 80% of the firms in the MSME sector are rationed. This sector constitutes 31% of the total Indian GDP, hence the estimate of $\sim 23 - 25\%$ rationing. Since there is no specific reason to assume one of the two firm assets is a more efficient form of collateral than the other,the fraction has been assumed to be the same for both capital and cash flow. Finally, the technology parameter has been assigned a value of 1.2, to ensure that even the firms having to depend on informal loans have an incentive to produce.

Table 5.1: Calibration

Households and Firms		
Parameter	Symbol	Value
Discount Factor	β	0.985
Capital Share	α	0.33
Depreciation rate	δ	0.025
Labour Supply Elasticity	η	0.7
Share of capital that can be used as collateral	χ	0.12
Share of cash flow that can be used as collateral	ψ	0.12
Informal loan recovery parameter	ι	0.5
Technology Parameter	a	1.2
Formal Financial Intermediaries		
Parameter	Symbol	Value
Regulatory Requirement on Bank lending and associated CRR	θ	(0.031 to 0.061) $\Rightarrow$ CRR values: (10.5 to 19.5%)
Bank Discount Factor	ϵ	0.8
Survival Rate	σ	0.931
Proportional Transfer to entering bankers	ω	0.002

Chapter 6

Model Analysis and Impulse Response Functions

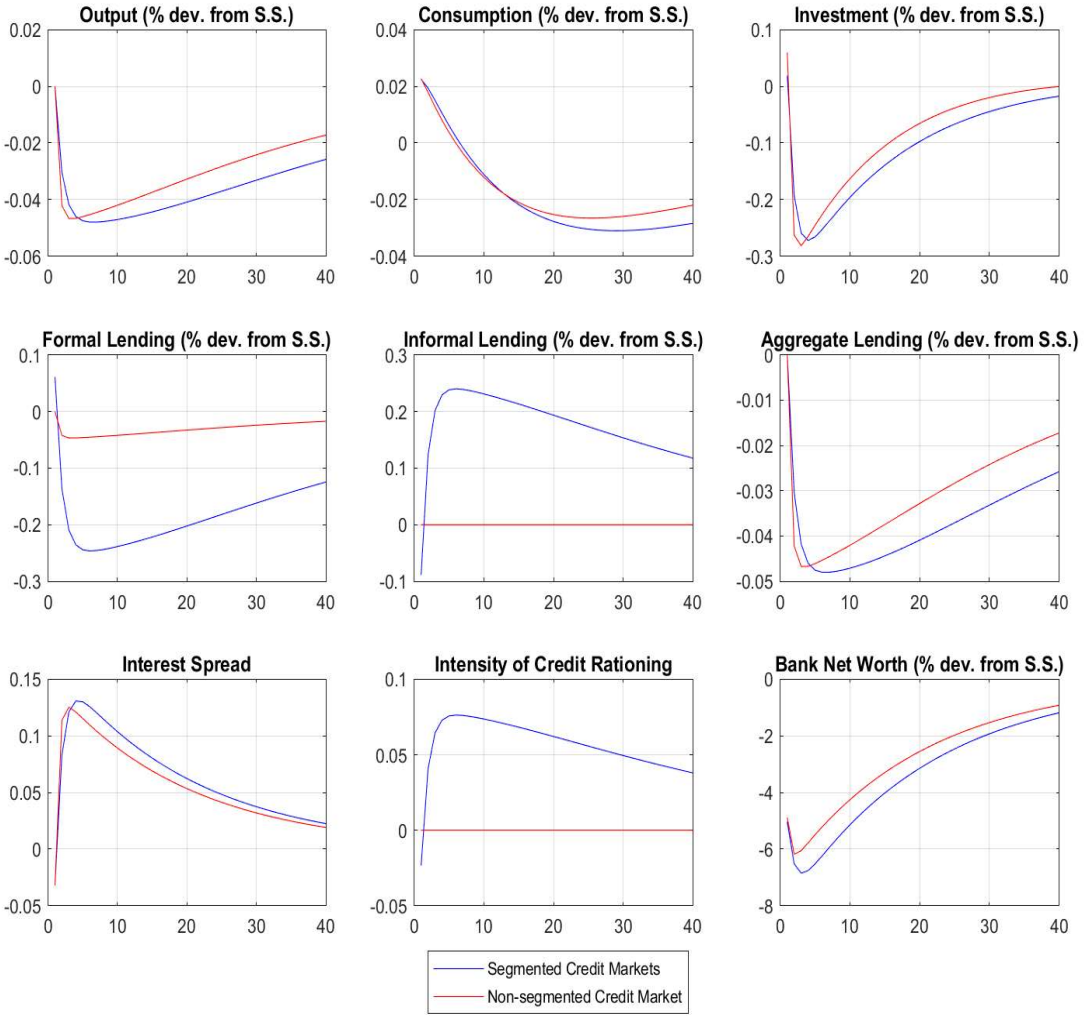
The model is solved in the first order using DYNARE in MATLAB (Julliard, 1996). In the present section I analyse this model to gain some intuition into its dynamics and study how they vary in the absence of credit market segmentation.

I obtain the Impulse Response Functions of relevant variables to a negative financial shock. As discussed before, the financial shock adversely affects the balance sheet position of banks by reducing their available net worth for the next period. This simplistic mean zero shock to the aggregate bank net worth has previously been used in related literature, for example by Gerali et al. (2010)[6] and Anand, Delloro and Peiris (2014)[3] in analysing the banking sector. As in Gerali et al. (2010)[6] , to maintain the equivalence of shocks across the two types of economies, I calibrate the shocks in a way so as to ensure they lead to a 5% contraction in the bank net worth on impact in both cases.

The IRFs for both types of economies are provided in Figure (6.1). One notable observation is the difference in the response of formal lending across the two economies. Given that there is no rationing of credit in the non-segmented economy, the banks satisfy the working capital requirements of all the firms in the economy. The fall in lending in this case is because of the reduced demand for factors of production by the firms after an increase in the lending interest rate. Compared to this, in the economy with segmented credit markets, a negative financial shock and the associated increase in lending rates not only results in reduced demand for factors of production but also an increase in intensity of credit rationing. With this increase in intensity of credit rationing more firms in the economy have to depend on the more expensive informal sector loans, which further depresses the demand for factors of production. Thus, there are two interrelated effects at play in the segmented market

economy which reinforce each other, leading to more persistent effects of a negative shock to the bank balance sheets. Lastly, given a significant fall in the formal sector lending in the segmented economy, the earnings (net worth) of the bankers are also more strongly affected than in the non-segmented economy, after the equivalent initial impact.

Figure 6.1: Impulse Response Functions to a Financial Shock



These Impulse Responses serve to illustrate that financial shocks can have more persistent effects in the presence of credit market segmentation.

Chapter 7

Macroprudential Regulation

The Indian economy has recently been hit by a wave of significant realizations of non-performing assets. This has brought to the fore a debate on whether it will be prudent to increase the Capital Requirement Ratio of the Indian banks up to or even beyond the Basel III levels (10.5%). The argument in favour of the proposed move is that an increase in the ratio would help the banks absorb these adverse financial shocks more efficiently. In the current chapter, I carry out simulations of the model in the presence of negative shocks to the aggregate bank net worth for different values of the Capital Requirement Ratio to get an understanding of the implications of segmentation for this policy. I use four values of the CRR: (10.5, 13.5, 16.5, 19.5) %, to show the effects of uniform increments in the ratio beyond the Basel III levels. However, the choice of these values is not crucial to the analysis. Qualitatively, the results remain the same for any variation in these values of CRR.

I follow Rubio (2017)[18] in using the volatility of aggregate credit as a proxy for the level of financial stability in the economy. I also provide the results for the volatility of output to show how, in the presence of only financial shocks, volatility of aggregate credit drives the volatility of output, showing the importance of financial sector for the real economy. The objective of macroprudential policy in this scenario is to reduce the volatility of aggregate credit, in order to preserve financial stability.

7.1 Non-segmented Credit Markets

Since the model is solved in the first degree, and the objective is to study changes in volatility rather than the absolute volatility itself, the exact magnitude of the shock does not matter as long as it is equivalent across the two economies. I, therefore, consider a large shock which leads to an initial impact of a 100% fall in the bank net worth in each of the two economies, to get a large magnitude of the standard

deviations under consideration. To begin with, I analyse the case of an economy with no credit market segmentation. The results obtained are provided in Table (7.1)

Table 7.1: Macroprudential regulation in the absence of segmentation

Capital Requirement Ratio	Agg. Credit	Output
	Standard Deviation	
10.5%	2.363	5.670
13.5%	2.347	5.632
% dev. from 10.5 to 13.5	**-0.67**	
16.5%	2.335	5.604
% dev. from 13.5 to 16.5	**-0.51**	
19.5%	2.325	5.579
% dev. from 16.5 to 19.5	**-0.43**	

For the non-segmented economy, aggregate credit equals formal sector lending. Note that for a change in the CRR, the percentage deviation in volatility is the same for both aggregate credit and output. This is as expected, since aggregate credit drives volatility in output, in the presence of only financial shocks.

In the case of a non segmented economy, the main consequence of a rise in CRR is an increase in bank net worth, through higher interest rates, rather than a drastic fall in lending. With this change, the banks are in a better position to absorb negative realizations to their balance sheet. From the Table (7.1), we can observe that as expected, an increase in the Capital Requirement Ratio in an economy without segmentation leads to a fall in the standard deviation of aggregate credit and output. In the context of this study, this means that the macroprudential regulation achieves its objective of reducing the financial volatility in the economy.

7.2 Segmented Credit Markets

Following the analysis of the non-segmented economy, I look at the same variation in the Capital Requirement Ratio for the economy with segmented credit markets and obtain the results provided in Table (7.2):

We can make two important observations from the Table (7.2). Firstly, within the range of 10.5-16.5% CRR, increasing the capital requirements in the presence

Table 7.2: Macroprudential regulation in the presence of segmentation

Capital Requirement Ratio	Agg. Credit	Output
	Standard Deviation	
10.5%	2.578	6.186
13.5%	2.571	6.170
% dev. from 10.5 to 13.5	**-0.27**	
16.5%	2.570	6.167
% dev. from 13.5 to 16.5	**-0.04**	
19.5%	2.572	6.171
% dev. from 16.5 to 19.5	**+0.07**	

of credit market segmentation has lower effectiveness than the non-segmented case analysed above. Secondly, if the CRR is increased beyond this range (to 19.5% in this instance) there is an increase in the volatility of aggregate credit and output. This goes to show that for segmented economies, Capital Requirement Ratio is a less effective tool for financial stabilisation than in non-segmented economies, and may even lead to an increase in the volaitlity of aggregate credit if executed beyond a reasonable level.

The exact maximum level of the CRR beyond which the volatility of aggregate credit begins increasing depends on the calibration of the model, especially on the ι parameter signifying the dependence of informal sector loan rates on the overall volume of informal sector lending. In the current analysis, I calibrate the model to set the steady state informal sector rates at the lower end of the estimated range. If this calibration is varied then this maximum level of CRR changes as well. Getting an exact estimate of the dependence of informal loan rates on the total volume is an extremely difficult task, since very little information is available on informal activity. Because of these reasons, I focus primarily on the first observation, that the CRR is less effective in the presence of segmentation; which is robust to a wide range of calibrations. Robustness of the results for different values of this parameter, and for the parameter ϵ denoting the bank discount factor, is provided in the appendix B.

The above results provided in Table 7.2 are of some significance to the Emerging Market Economies characterized by co-existence of segmentation and notable depen-

dence on high capital requirements[1]. In order to explain the reasons for these results we need to look further into the dynamics of the financial sector for different levels of the CRR. Since reduction in the volatility of aggregate credit is the main channel through which financial shocks are transmitted to the real variables in this model, I focus primarily on this variable in the subsequent analysis.

The aggregate credit consists of both formal and informal sector lending. Denoting aggregate credit by $L_t^{Aggregate}$, its variance can thus be dissected as:

$$Var(L_t^{Aggregate}) = Var(L_t^f + L_t^i) \tag{7.1}$$

Hence,

$$Var(L_t^{Aggregate}) = Var(L_t^f) + Var(L_t^i) + 2Cov(L_t^f, L_t^i) \tag{7.2}$$

With an increase in CRR, I observe that there is always a reduction in the individual variance of formal and informal sector lending. The interesting results therefore arise because of the third term in equation (7.2). The covariance represents the degree of co-movement of formal and informal sector lending. As shown in Table (7.3), following an increase in the CRR, this degree of co-movement of the two forms of lending reduces. The extent of the fall in covariance determines whether the increase in CRR is less effective, or as in the extreme case, has the opposite effect as intended.

Table 7.3: Variance Decomposition of Aggregate Credit

Feature	CRR=10.5%	CRR=13.5%	CRR=16.5%	CRR=19.5%
$Var(L_t^f)$	61.48	59.59	58.13	57.02
$Var(L_t^i)$	27.99	26.76	25.78	25.01
$Cov(L_t^f, L_t^i)$	-41.42	-39.87	-38.65	-37.71
$Var(L_t^{Aggregate})$	6.64	6.61	6.60	6.61

Reason for the fall in covariance of Formal and Informal Lending: As the CRR increases, the banks are constrained into maintaining a greater fraction of net worth with respect to their overall lending. This results in an increase in the formal loan rates; which in turn lead to an intensification of credit rationing. With an increase in the volume of informal lending, the informal rates increase as per the households first order condition:

$$1 + r_t = (1 + R_t^i)(q(L_t^i) + q'(L_t^i)L_t^i)$$

[1]Jumreornvong et al. (2018)[11] compare the capital requirements across advanced and emerging economies and find that, on average, the level is much higher for the emerging economies

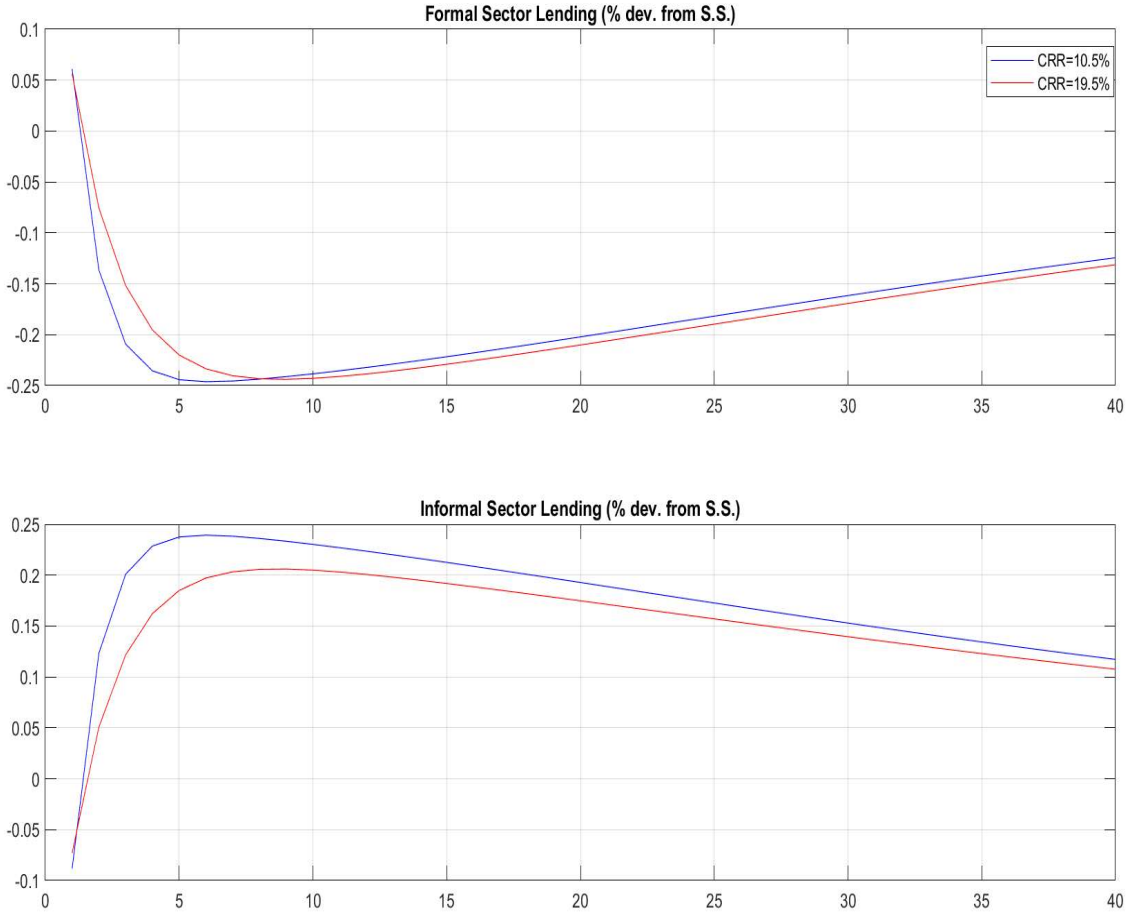
where as before,

$$q(L_t^i) = 1 - \iota(L_t^i)^2$$

In this scenario, for higher values of CRR, a negative shock to the bank net worth qualitatively has the same effect: a fall in formal loans and an associated rise in informal loans. However, the extent to which these variables react is different. At a higher level of CRR, given the higher informal loan rates, the demand for informal loans does not rise by as much as the fall in formal lending. This points towards lower co-movement of the informal and formal sector loans. As explained above, this reduced covariance ultimately leads to reduced effectiveness of the Capital Requirement Ratio. In Table (7.2), when the CRR is increased beyond 16.5%, fall in the (absolute value of) covariance outweighs the fall in the variance of formal and informal lending, leading to a rise in the variance of aggregate lending.

The Impulse Response Functions provided in Figure (7.1) serve to illustrate that at higher levels of CRR, the rise in informal lending arising out of a negative shock, is lower than the fall in formal lending. This depicts a reduction in co-movement of the two variables with an increase in CRR.

Figure 7.1: Impulse Response Functions to a Negative Financial Shock



Chapter 8

Policy Recommendation

Informal sector exists in my model because of a pre-commitment problem between the banks and the firms, wherein there exists a possibility that the firms choose to default on their loans. This pre-commitment problem leads to the necessity of collateral for obtaining loans from the banks. The level of financial development and the efficiency of contract enforcement in an economy determines the fraction of the firm assets that can be used as collateral. I refer to this fraction as the liquidation value of firm assets. For an economy where the legal framework is weak and the level of financial development low, the liquidation value of the same amount of collateral is lower.

An effective legal framework to ensure that the lenders can recover collateral easily in the face of default is essential in increasing this liquidation value of the firm assets. Here I take the example of the Insolvency and Bankruptcy Act (2016) recently introduced in India, which provides relief to the banking sector in expediting the insolvency and bankruptcy process in the face of large scale defaults. In terms of the mechanism in my model, legal provisions such as these lead to an increase in the liquidation value of firm assets. This increase in liquidation value results in the reduction of segmentation in the economy, with a higher proportion of firms now possessing enough collateralizable assets to approach the formal sector.

In order to show the possible effects of the changes, in Table (8.1) I compare the response of volatility of aggregate credit to changes in the CRR for two cases of the segmented economy:-the original segmented economy considered previously with a rationing of around 24%, and a variation of that economy with a higher liquidation value of firm assets leading to rationing of about 20%. The results provided in Table (8.1) show that an increase in the liquidation value can improve the effectiveness of the Capital Requirement Ratio.

Therefore, in economies with segmented credit markets, stronger legal frameworks to ensure a painless process for the banks in case of defaults, can increase the effec-

Table 8.1: Macroprudential regulation with higher liquidation value of assets

Capital Requirement Ratio	Original: $\chi, \psi = 0.12$	$\chi, \psi = 0.13$
	Standard Deviation of Agg. Credit	
10.5%	2.578	2.329
13.5%	2.571	2.319
% dev. from 10.5 to 13.5	**-0.27**	**-0.43**
16.5%	2.57	2.316
% dev. from 13.5 to 16.5	**-0.04**	**-0.13**
19.5%	2.572	2.315
% dev. from 16.5 to 19.5	**+0.07**	**-0.04**

tiveness of macroprudential regulation by reducing the level of rationing by the formal banks.

Chapter 9

Conclusion

In this paper, I develop a model to analyse the implications of credit market segmentation for the effectiveness of bank-specific macroprudential regulation, in the presence of negative financial shocks. I find that for an economy with segmentation, the Capital Requirement Ratio is less effective as a macroprudential measure. This conclusion is based on the observation that an increase in CRR in the segmented economy leads to a lower reduction in the volatility of aggregate credit and output as compared to a non-segmented economy. Finally, the paper proposes an improvement in the legal framework of the respective segmented economies so as to provide better support to the banking sector in the event of defaults. Such improvements could enhance the liquidation value of collateral leading to lower segmentation and greater effectiveness of the CRR.

This framework also provides avenues for further research. Most of the rationed firms in the economy are usually the smaller and less capital intensive firms hiring labour from the poorer sections of the society. In this respect, it will be interesting to analyse the distributional consequences of macroprudential regulation by modelling two sets of households: rich households which provide informal loans, and the poor hand-to-mouth households which work in the smaller, less capital intensive firms of the economy.

To conclude, the basic message of this paper is simple: financial sector in the emerging markets is fundamentally different from that in the developed markets. Therefore, one cannot simply assume that macroprudential policy which works well in the advanced economies would have the desired effects in the emerging economies as well. While in this instance I focus on the difference in terms of segmentation, there are numerous other structural variations which might be crucial in determining effective policy.

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Appendix A

Derivations

A.1 Banker's Optimization Problem

The banker maximises the discounted value of its future net worth,

$$V(n_t) = max\Big[(1-\sigma)\{E_t\Lambda_{t,t+1}\Big((1+R_t^f)L_t^f - (1+r_t)d_t\Big)\} + \sigma\{E_t\Lambda_{t,t+1}[V_{t+1}(n_{t+1})]\}\Big]$$

Using the law of motion of net worth, $n_{t+1} = (1+R_t^f)L_t^f - (1+r_t)d_t$, this can be expressed as,

$$V(n_t) = max\Big[(1-\sigma)\{E_t\Lambda_{t,t+1}n_{t+1}\} + \sigma\{E_t\Lambda_{t,t+1}[V_{t+1}(n_{t+1})]\}\Big]$$

And assuming $V(n_t) = \gamma_t n_t$, we can express this as,

$$V(n_t) = max\Big[(1-\sigma)\{E_t\Lambda_{t,t+1}n_{t+1}\} + \sigma\{E_t\Lambda_{t,t+1}[\gamma_{t+1}n_{t+1})]\}\Big]$$

Using the variable Ω_t to denote $1-\sigma+\sigma\gamma_t$, we get the maximisation problem of the banker as:

$$V_t = max_{L_t^f} E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}n_{t+1}\Big\}$$

Using the law of motion of net worth, and the balance sheet identity: $n_t + d_t = L_t^f$, we get:

$$V_t = max_{L_t^f} E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}\Big((R_t^f - r_t)L_t^f + (1+r_t)n_t\Big)\Big\}$$

subject to the constraint:

$$V_t \geq \theta L_t^f$$

Maximising this with respect to L_t^f, we get the first order condition with μ_t as the lagrange multiplier,

$$E_t\Big[\Lambda_{t,t+1}\Omega_{t+1}(R_t^f - r_t)\Big] = \theta\mu_t$$

A.2 Capital Requirement Ratio

We know from the previous part that,

$$V_t = E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}\Big((R_t^f - r_t)L_t^f + (1+r_t)n_t\Big)\Big\}$$

Also, using our guess for the value function and dividing the equation by n_t we get,:

$$\gamma_t = E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}\Big((R_t^f - r_t)\frac{L_t^f}{n_t} + (1+r_t)\Big)\Big\}$$

or using the relation, $\frac{n_t}{L_t^f} = \frac{\theta}{\gamma_t}$

$$\gamma_t = E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}\Big((R_t^f - r_t)\frac{\gamma_t}{\theta} + (1+r_t)\Big)\Big\}$$

We can finally obtain the relation,

$$CRR = \frac{\theta}{\gamma_t} = \frac{\theta - E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(R_t^f - r_t)\Big\}}{E_t\Big\{\Lambda_{t,t+1}\Omega_{t+1}(1+r_t)\Big\}}$$

A.3 Resource Constraint

The individual household's Budget Constraint is as follows:

$$c_t + d_{t+1} + L_{t+1}^i + i_t \leq (1+r_t)d_t + (1+R_t^i)q(L_t^i)L_t^i + w_t l_t + R_t^k k_t + \Pi_t$$

Since only $(1-\overline{\Theta}_t)$ proportion of the firms need to access the informal sector loans, in the aggregate household budget constraint becomes:

$$c_t + d_{t+1} + (1-\overline{\Theta}_{t+1})L_{t+1}^i + i_t \leq (1+r_t)d_t + (1+R_t^i)q(L_t^i)(1-\overline{\Theta}_t)L_t^i + w_t l_t + R_t^k k_t + \Pi_t \tag{A.1}$$

Similarly, the budget constraint for the individual banker is as follows:

$$L_{t+1}^f + (1+r_t)d_t \leq (1+R_t^f)L_t^f + d_{t+1}$$

In the aggregate only $\overline{\Theta}_t$ proportion of the total firms need to access formal sector loans, hence the aggregate bank constraint becomes:

$$\overline{\Theta}_{t+1}L_{t+1}^f + (1+r_t)d_t = (1+R_t^f)\overline{\Theta}_t L_t^f + d_{t+1} \tag{A.2}$$

Aggregate Profits of the firms with access to formal sector loans:

$$\Pi_t^f = \overline{\Theta}_t \Big(Y_t - (1 + R_t^f) L_t^f - R_t^k k_t - w_t l_t \Big) \tag{A.3}$$

Aggregate Profits of the firms with access to informal sector loans:

$$\Pi_t^i = (1 - \overline{\Theta}_t) \Big(Y_t - (1 + R_t^i) q(L_t^i) L_t^i - R_t^k k_t - w_t l_t \Big) \tag{A.4}$$

Thus, the aggregate profits of the firms are:

$$\Pi_t^f + \Pi_t^i = \Pi_t$$

Assuming that in aggregate only q proportion of the informal lenders pay back their loans, combining the bank budget constraint with the households budget constraint we obtain the following resource constraint:

$$c_t + i_t + \overline{\Theta}_{t+1} L_{t+1}^f + (1 - \overline{\Theta}_{t+1}) L_{t+1}^i = Y_t \tag{A.5}$$

where, $\overline{\Theta}_{t+1} L_{t+1}^f$ constitutes the aggregate formal lending for the next period and $(1 - \overline{\Theta}_{t+1}) L_{t+1}^i$ constitutes the aggregate informal lending for the next period.

Since $L_{t+1}^f = \frac{\overline{\Theta}_t}{2} k_{t+1}^\alpha l_{t+1}^{1-\alpha}$ and $L_{t+1}^i = \frac{1+\overline{\Theta}_t}{2} k_{t+1}^\alpha l_{t+1}^{1-\alpha}$ Finally, using these we get the required resource constraint:

$$c_t + i_t + 0.5 k_{t+1}^\alpha l_{t+1}^{1-\alpha} = Y_t \tag{A.6}$$

A.4 Labour Supply Elasticity

If we differentiate the household budget constraint with respect to l_t, then we obtain the following relation:

$$V'(l_t)/w_t = U'(c_t)$$

or,

$$\eta (1 - l_t)^{-1} = \frac{w_t}{c_t} \tag{A.7}$$

Differentiating this with respect to l_t, we get:

$$\eta \frac{\partial (1 - l_t)^{-1}}{\partial l_t} \frac{\partial l_t}{\partial w_t} = \frac{1}{c_t}$$

$$\eta(1-l_t)^{-2}\frac{\partial l_t}{\partial w_t} = \frac{1}{c_t}$$

Using equation (A.7), we can obtain,

$$\frac{w_t}{1-l_t}\frac{\partial l_t}{\partial w_t} = 1$$

Finally we obtain:

$$\frac{w_t}{l_t}\frac{\partial l_t}{\partial w_t} = \frac{1-l_t}{l_t} \tag{A.8}$$

Under the calibration 0.7 for the value of η that I consider in my model, the steady state value of l_t comes out to be about 0.5. This means that the value of labour supply elasticity for my model is 1. This is the value of labour supply elasticity in most of the related literature.

Appendix B

Sensitivity Analysis

B.1 Analysis for different values of informal sector loan rate parameter ι

I carry out sensitivity analysis for different values of ι, which denotes the dependence of informal loan rates on the total volume of informal loans:

Capital Requirement Ratio	No Segmentation	Original ($\iota = 0.5$)	$\iota = 0.45$	$\iota = 0.55$
	Standard Deviation of Agg. Credit			
10.5%	2.363	2.578	2.904	2.749
13.5%	2.347	2.571	2.894	2.745
% dev. from 10.5 to 13.5	**-0.67**	**-0.27**	**-0.34**	**-0.15**
16.5%	2.335	2.57	2.889	2.746
% dev. from 13.5 to 16.5	**-0.51**	**-0.04**	**-0.17**	**+0.03**
19.5%	2.325	2.572	2.888	2.751
% dev. from 16.5 to 19.5	**-0.43**	**+0.07**	**-0.03**	**+0.18**

Observation: With an increase in the value of ι the differences between the economies with and without segmentation widen. The value 0.45 implies a 10% steady state value of the quarterly informal loan rate; while the value 0.55 implies a value of 14%. Since there is no concrete estimate of the informal loan rate, any rates within and even beyond this range are very plausible. However, even in the presence

of the variation, the basic finding remains the same. Capital requirement ratio is less effective as a stabilization tool in the presence of segmentation.

B.2 Analysis for different value of banker's discount factor ϵ

Finally, I study the effects of an increase the banker's discount factor on the final results for both the segmented economy and the non-segmented economy.

Capital Requirement Ratio	Non-segmented: $\epsilon = 0.85$	Segmented: $\epsilon = 0.85$
	Standard Deviation of Agg. Credit	
10.5%	1.365	2.018
13.5%	1.346	1.997
% dev. from 10.5 to 13.5	**-1.39**	**-1.04**
16.5%	1.328	1.981
% dev. from 13.5 to 16.5	**-1.33**	**-0.8**
19.5%	1.312	1.971
% dev. from 16.5 to 19.5	**-1.20**	**-0.50**

Observation: Compared to the initial 0.8 value of the discount factor, we see an increase in the value of the discount factor results in an increase in the effectiveness of the Capital Requirement Ratio for both the segmented and the non-segmented economy. Irrespective, the basic message remains unchanged. In comparing the effects of changes in the Capital Requirement Ratio across the two types of economies, the CRR as an instrument of stabilisation is more effective in the non segmented economy. Moreover, as obtained previously, the effectiveness of the capital requirement ratio falls as its level keeps rising.