Open access • Journal Article • DOI:10.1515/BEJM-2017-0121

Household borrowing constraints and monetary policy in emerging economies

— Source link

Gustavo Arruda, Daniela Cunha de Lima, Vladimir Kuhl Teles

Institutions: Fundação Getúlio Vargas

Published on: 28 Jan 2020 - B E Journal of Macroeconomics (De Gruyter)

Topics: Debt, Emerging markets, Monetary policy, Consumption (economics) and Dynamic stochastic general equilibrium

Working Paper | 375 | Março de 2015

SAO PAULO SCHOOL OF ECONOMICS

Household Borrowing Constraints and Monetary Policy in Emerging Economies

Gustavo Arruda
Daniela Lima
Vladimir K. Teles

SAO PAULO SCHOOL OF ECONOMICS

Household Borrowing Constraints and Monetary Policy in Emerging Economies

Gustavo Arruda [*] Daniela Lima [†] Vladimir K. Teles[‡]

Abstract

Credit markets in emerging economies can be distinguished from those in advanced economies in many respects, including the collateral required for households to borrow. This work proposes a DSGE framework to analyze one peculiarity that characterizes the credit markets of some emerging markets: payroll-deducted personal loans. We add the possibility for households to contract long-term debt and compare two different types of credit constraints with one another, one based on housing and the other based on future income. We estimate the model for Brazil using a Bayesian technique. The model is able to solve a puzzle of the Brazilian economy: responses to monetary shocks at first appear to be strong but dissipate quickly. This occurs because income – and the amount available for loans – responds more rapidly to monetary shocks than housing prices. To smooth consumption, agents (borrowers) compensate for lower income and for borrowing by working more hours to repay loans and erase debt in a shorter time. Therefore, in addition to the income and substitution effects, workers consider the effects on their credit constraints when deciding how much labor to supply, which becomes an additional channel through which financial frictions affect the economy.

Keywords: Credit constrains, emerging markets, monetary policy.

JELs: E20; E44; E51

[*] Sao Paulo School of Economics - FGV
[†] Sao Paulo School of Economics - FGV
[‡] Sao Paulo School of Economics - FGV, email: vladimir.teles@fgv.br

1 Introduction

Although researchers have documented that financial frictions, in particular household borrowing constraints (Iacoviello, 2005; Monacelli, 2008), play a key role in business cycles, very little attention has been paid to the heterogeneity of that friction in different countries, particularly in developing countries. In developed economies, households use their houses as collateral for loans, but in emerging economies this is uncommon due to the difficulty in foreclosing against this type of collateral in the event of default, among other institutional and legal reasons. One consequence of this difficulty in collateralizing credit is that the volume of credit that is available to households in emerging countries is much lower than in developed countries. (In 2005, household credit represented 9.2% of GDP in emerging countries in Latin America, 12.1% in emerging countries in Europe, and 27.5% in emerging countries in Asia; however, household credit represented 58% of GDP in mature markets (IMF, 2006)).

Therefore, when offering credit, banks in developing countries evaluate income as a proxy for household wealth and the capacity of the household to make repayment. A clear example of this difference is Brazil, where the government promoted institutional changes in 2003 to diminish the risk for banks that were introducing payroll loans. With these lines of credit, a worker's debt service is automatically deducted from his/her payroll check each month, reducing the risk of default. The volume of credit extended to households as a percentage of GDP has doubled since the introduction of these institutional changes, and payroll loans now represent 70% of the volume of household credit in Brazil[1].

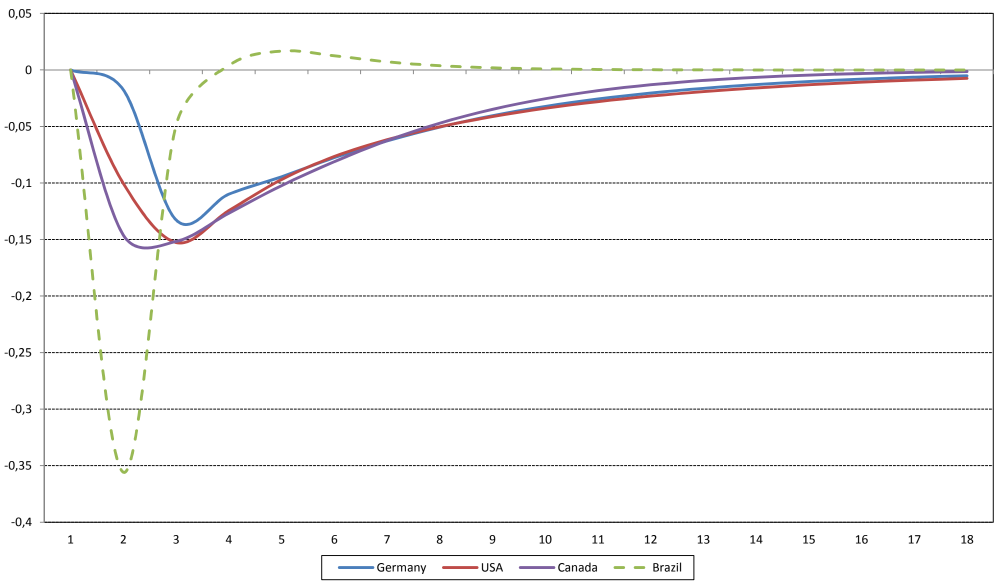
As a result, certain aspects of the credit markets in these economies may not perform as predicted by standard models, such as the difference in the reaction of the product to monetary policy shocks. In Brazil, this response is quite different from that observed in developed countries (Fig. 1[2]), with much less persistence, although stronger.

Differences in parameters in the Brazilian economy – including the stickiness of prices and wages, habit formation and strategic complementarity – may explain the more severe impact of monetary policy on the product, but there should also be greater persistence (da Silva, et al, 2012). In this paper, we solve this puzzle by developing a model that incorporates differences in the conditions of household credit constraints. This occurs because income – and the amount available for lending – responds more quickly to shocks than housing prices. To smooth consumption, agents (borrowers) compensate for lower income and for borrowing by increasing their working hours and repaying loans and debt in a shorter time.

[1]Other articles studying the importance of this alternative line of credit in the behavior of agents (Costa and de Mello, 2008) or in the scheme of Brazilian macroeconomics (Carvalho et al, 2013;. Carvalho et al 2014) have proven to be important, but those models address different aspects of such loans than those covered in this article.

[2]The impulse response of a shock in the interest rate on the product is obtained from a VAR with 4 variables: Interest rate, exchange rate, credit and GDP. We use the Cholesky decomposition in the same order and quarterly data from 1999.I to 2013.IV.

Figure 1: Impulse response of GDP to interest rates



This result provides a new channel through which financial frictions affect the economy – the choice of labor supply by households – because the choice of labor supply now largely determines the credit constraints to which households are subject. Thus, in a period of economic contraction, families suffer an immediate impact on their credit restrictions, but they adjust their labor supply to compensate for the diminished collateral. Therefore, in addition to the income and substitution effects, workers take into account the effects on their credit constraints when deciding how much labor to supply. Somewhat quickly (in due course), the payroll loan channel reinforces the income effect on labor supply.

We compare two kinds of credit constraints – one based on housing and other based on expected future income – with certain adaptations. In Gerald et al (2010), loans are constrained by physical capital (in the case of entrepreneurs) and by the expected value of housing stocks (for impatient households). We will use the expected value of 48 months of future income because it is the average maturity of non-earmarked resource loans to households. We also consider multi-period loans to households, instead of one-period contracts, as in Gerali (2010), such that impatient households are allowed to accumulate debt, which suits better conditions in the credit market, because loans are typically multi-period contract and households are typically able to borrow fresh capital before repaying the previous loan. Existing debt will also limit the amount available for lending. We estimate the model using Bayesian techniques to study the impulse responses to monetary policy and technology shocks.

The rest of the paper is organized as follows: Section 2 describes the model. Section 3 presents the calibration and estimation of parameters. Section 4 analyzes the model properties and emphasizes the study of monetary and technology shocks. Section 5 concludes.

2 Model

We developed a dynamic stochastic general equilibrium (DSGE) model based on the framework presented by Gerali *et al.* (2010) and by incorporating multi-period loans to households – instead of one-period contracts – and a credit constraint based on future income.

The economy consists of a unit mass of households and entrepreneurs (E). There are two groups of households that differ by discount factor: patient and impatient. Patient households' discount factors (β_p^t) are higher than those of impatient households (β_I^t) and those of entrepreneurs (β_E^t). Households work, consume and accumulate capital (deposits). Entrepreneurs hire workers, buy capital from producers of capital goods and produce homogenous intermediate goods. Patient households own firms and banks. Households offer differentiated labor to unions. In addition to entrepreneurs, there is a monopolistically competitive retail sector and there are capital producers (both owned by entrepreneurs).

Heterogeneity in discount factors induces a social need for financial intermediation. The banking sector is characterized by monopolistic competition. Banks supply only two types of financial products: one-period savings contracts and multi-period borrowing contracts – which differs from the one-period borrowing contract represented in Gerali et. al. (2010) – such that impatient households accumulate debt. Interest rates on loans and deposits are set to maximize profits.

Deposits are received from patient households and impatient households, and entrepreneurs borrow a positive amount, which is financed by deposits and bank capital (accumulated from profits). Loans to entrepreneurs are constrained by physical capital. For households, we will study two types of credit constraints: one based on their housing stocks, as in Gerali *et al.*(2010), and the other based on the expected value of 48 months of future income.

2.1 Patient Households

Each patient household (i) maximizes as follows:

$$E_0 \sum_{t=o}^{\infty} \beta_P^t \left[\left(1 - a^P\right) \varepsilon_t^z log \left(c_t^P(i) - a^P c_{t-1}^P\right) + \varepsilon_t^h log h_t^P(i) - \frac{l_t^P(i)^{1+\phi}}{1+\phi} \right] \tag{1}$$

in which $c_t^P(i)$ represents current individual consumption, c_t^P is aggregate consumption, $h_t^P(i)$ is housing services, $l_t^P(i)$ is hours worked, a^P is a habit consumption coefficient, and ϕ represents the inverse of the Frisch elasticity. Households' preferences are subject to two types of shocks: ε_t^z, a disturbance that affects consumption, and ε_t^h, affects housing demand[3]. Budget constraints in real terms set the following:

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

where expenditure, consumption ($c_t^p(i)$), housing investment at price q_t^h and deposits ($d_t(i)$) are financed by labor income ($w_t^p l_t^p(i)$); w_t^p represents hourly real wage for patient households; π_t=P_t/P_{t-1} is gross inflation) by last period deposits increased by interest deposit rates (r_t^d) and lump-sum transfers t_t^{p4}.

2.2 Impatient Households

As with patient households, impatient agent (i)'s objective is to maximize expected utility:

$$E_0 \sum_{t=o}^{\infty} \beta_I^t \left[\left(1 - a^I\right) \epsilon_t^z log\left(c_t^I(i) - ac_{t-1}^I\right) + \varepsilon_t^h log h_t^I(i) - \frac{l_t^I(i)^{1+\phi}}{1+\phi} \right] \tag{3}$$

subject to the following[5]:

$$c_t^I(i) + q_t^h \Delta h_t^I(i) + \frac{(1 + r_{t-1}^{bH}) debt_{t-1}(i)}{\pi_t} \leq w_t^I l_t^I(i) + debt_t(i) + t_t^I(i) \tag{4}$$

where c_t^I represents impatient households consumption: r_t^{bH} is the borrowing interest rate; w_t^I is the impatient hour wage; l_t^I represents the work hours of impatient; and $t_t^I(i)$ is the lump-sum transfers, which includes only net union fees. Because impatient households borrow from banks, a credit borrowing constraint is imposed. In the original model, Gerali *et al.* (2010) credit borrowing constraints are based on households' housing stock, represented as follows:

$$(1 + r_t^{bH}) b_t^I \leq m_t^{IH} E_t\left(q_{t+1}^h h_t^I(i) \pi_{t+1}\right) - debt_t \tag{5}$$

where b_t^I represents households' real borrowing. However, we will also consider a credit borrowing constraint based on the expectation of future income, as below, and compare these two types of con-

[3]Both disturbances follow an AR(1) process type, as in $\varepsilon_t = (1 - \rho_\epsilon)\overline{\varepsilon} + \rho_\epsilon \varepsilon_{t-1} + \eta_t^\epsilon$, where$\overline{\varepsilon}$ is the steady state value and η_t^ϵ~i.i.d $N(0, \sigma^2)$.

[4]Lump-sum transfers are calculated by dividends received from banks and entrepreneurs, in addition to labor union membership net fees.

[5]We can calculate this budget constraint by considering that each period, in addition to consumption, households must pay for installments and interest. Thus, the budget constraint is $c_t^I(i) + \frac{r_{t-1}^{bH} debt(i)}{\pi_t} + \frac{\phi_d debt_{t-1}(i)}{\pi_t} \leq w_t^I l_t^I(i) + b_t(i) + t_t^I(i)$, where b_t represents real borrowing. Considering the law of motion of outstanding debt (eq.21) set here in real terms, $debt_t = b_t + \frac{(1-\phi_d) debt_{t-1}}{\pi_t}$, $b_t = debt_t - \frac{(1-\phi_d) debt_{t-1}}{\pi_t}$, we can rewrite the budget constraint as $c_t^I(i) + q_t^h \Delta h_t^I(i) + \frac{(1+r_{t-1}^{bH}) debt_{t-1}(i)}{\pi_t} \leq w_t^I l_t^I(i) + debt_t(i) + t_t^I(i)$.

strains with one another, calling the model with the credit constraint based on households' house stock Benchmark (**BK**), and the model with the credit constraint based on future income is called the **IN** model.

$$(1 + r_t^{bH})b_t^I \leq m_t^{II} E_t \left(\sum_{j=1}^{12} w_{t+j} l_{t+j}^I(i) \pi_{t+j} \right) - debt_t \tag{6}$$

where $m_t^{IH} \epsilon (0, 1)$ represents loan-to-value ratio (LTV) for credit constraints based on housing stock and $m_t^{II} \epsilon (0, 1)$ represents the future income that is available for borrowing, net of current debt. Thus, excluding households current debt ($debt_t$), m_t^I determines the amount of credit that each household has available, considering its housing stock and/or income. Debt structure will be fully explained below, in section 3.6.

2.3 Entrepreneurs

Symmetric with households, each firm (i) seeks to minimize the difference between current individual and lagged consumption and to maximize the following utility expectation:

$$E_0 \sum_{t=o}^{\infty} \beta_E^t \left[\left(1 - a^E\right) \varepsilon_t^z log\left(c_t^E(i) - ac_{t-1}^E\right) - \frac{l_t^E(i)^{1+\phi}}{1+\phi} \right] \tag{7}$$

subject to:

$$c_t^E(i) + w_t^P l_t^{E,P} + w_t^I l_t^{E,I} + \frac{(1 + r_{t-1}^{bE}) b_{t-1}^E(i)}{\pi_t} + q_t^K k_t^E + \psi(u_t(i)) k_{t-1}^E = \frac{y_t^E(i)}{\chi_t} + b_t^E(i) + q_t^K (1 - \delta) k_{t-1}^E \tag{8}$$

where q_t^K is the price of one unit of physical capital, b_t^E, represents firm's loans at rate r_t^{bE} , $\psi(u_t(i))$ is the real cost associated with using the level u_t of capacity utilization, and $\chi_t \equiv \frac{P_t}{P_t^w}$ is the relative price of a produced good at wholesale, which is given by the following technology:

$$y_t^E(i) = a_t^E [k_{t-1}^E(i) u_t(i)]^\alpha [l_t^E(i)]^{1-\alpha} \tag{9}$$

Total factor productivity is represented by a_t^E and labor l_t^E is a combination of patient and impatient households' labor, as $l_t^E = (l_t^{E,P})^\mu (l_t^{E,I})^{1-\mu}$. Similar to impatient households, entrepreneurs' borrowings are constrained by physical capital, as depicted in the following:

$$(1 + r_t^{bE}) b_t^E \leq m_t^E E_t \left[q_{t+1}^K \pi_{t+1} (1 - \delta) k_t^E(i) \right] \tag{10}$$

where m_t^E represents the LTV ratio for entrepreneurs.

2.4 Capital and final goods producers

Capital producer firms are perfectly competitive and owned by entrepreneurs. Firms use underappreciated $(1-\delta)k_{t-1}$ capital sold by entrepreneurs at price Q_t^k and i_t units of final goods, sold by retailers at price P_t to increase their effective capital stock, $\overline{x}_t$, and sell back to entrepreneurs at price Q_t^k. Capital producers maximize the following expected utility:

$$E_0 \sum_{t=o}^{\infty} \Lambda_{0,t}^{E} \left(q_t^K \Delta \overline{x}_t - i_t \right) \tag{11}$$

subject to the following:

$$\overline{x}_t = \overline{x}_{t-1} + \left[1 - \frac{\kappa_i}{2} \left(\frac{i_t \varepsilon_t^{qK}}{i_{t-1}} \right)^2 \right] i_t \tag{12}$$

where $q_t^k \equiv \frac{Q_t^k}{P_T}$ is the real price of capital, $\Delta \overline{x}_t = k_t - (1-\delta)k_{t-1}$, κ_i is the adjustment cost of capital creation, ε_t^{qK} is an efficiency shock on investment.

On the other hand, the retail sector is assumed to be in a monopolistic competition. Retailers buy intermediation goods at price P_t^w and differentiate it at no cost. The final good is sold at price $P_t(j)$, which incorporates a mark-up. Prices in the retail sector are sticky and are chosen by the following maximization:

$$E_0 \sum_{t=o}^{\infty} \Lambda_{0,t}^{P} \left[P_t(j) y_t(j) - P_t^w y_t(j) - \frac{\kappa_p}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - \pi_{t-1}^{l_p} \pi^{1-l_p} \right)^2 P_t y_t \right] \tag{13}$$

subject to the following consumption demand:

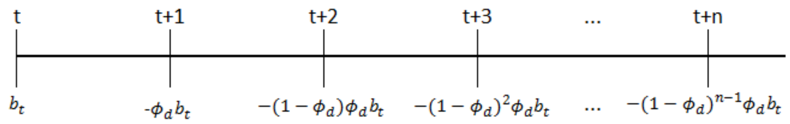
$$y_t(j) \equiv \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon_t^y} y_t \tag{14}$$

where κ_p is the adjustment cost parameter in the event that retailers want to set its price beyond the indexation rule, and ε_t^y represents the stochastic demand price elasticity.

2.5 The labor market

Workers supply a differentiated labor force. Labor unions aggregate and sell to entrepreneurs as two homogeneous labor units: (i) one aggregator for patient households (s) and (ii) one aggregator for impatient households (m). Each union (s,m) sets nominal wages and faces quadratic adjustment costs that are covered by lump-sum fees charged from each member by maximizing the following:

Figure 2: Loans repayments



$$E_0 \sum_{t=o}^{\infty} \beta_s^t \left\{ U_{C_t^S(i,m)} \left[\frac{W_t^s(m)}{P_t} l_t^s(i,m) - \frac{\kappa_w}{2} \left(\frac{W_t^s(m)}{W_{t-1}^s(m)} - \pi_{t-1}^{l_w} \pi^{1-l_w} \right)^2 \frac{W_t^s}{P_t} \right] - \frac{l_t^s(i,m)^{1+\phi}}{1+\phi} \right\} \quad (15)$$

subject to the following:

$$l_t^s(i,m) = l_t^s(m) = \left(\frac{W_t^s(m)}{W_{t-1}^s(m)} \right)^{-\varepsilon_t^l} l_t^s \quad (16)$$

In equilibrium, the labor supply of patient household (s) - and symmetrically for household (m) - is given by the following:

$$\kappa_w \left(\pi_t^{w^s} - \pi_{t-1}^{l_w} \pi^{1-l_w} \right) \pi_t^{w^s} = \beta_s E_t \left[\frac{\lambda_{t+1}^s}{\lambda_t^s} \kappa_w \left(\pi_{t+1}^{w^s} - \pi_{t-1}^{l_w} \pi^{1-l_w} \right) \left(\frac{\pi_{t+1}^{w^S}}{\pi_{t+1}} \right)^2 + (1-\varepsilon_t^l) l_t^S + \frac{\varepsilon_t^l (l_t^s)^{1+\phi}}{\omega_t^s \lambda_t^s} \right] \quad (17)$$

where ω_t^s represents the real wage for type (s) and $\pi_t^{w^s}$ is nominal wage inflation.

2.6 Loan and deposit demand

Loan and deposit contracts bought by households and entrepreneurs represent a basket of slightly different financial products supplied by a branch of j-banks. The elasticity of substitution terms are stochastic, which are represented by $\varepsilon_t^{bH} > 1$ (impatient household loans), $\varepsilon_t^{bE} > 1$ (entrepreneurs loans) and $\varepsilon_t^d < -1$ (patient household deposits), such that bank spreads can move independently of monetary policy. Demand for real loans ($\overline{b_t^I}$) of household i is given by the following:

$$min_{\{b_t^I(i,j)\}} \int_0^1 r_t^{bH} b_t^I(i,j) dj \quad (18)$$

subject to the following:

$$\left[\int_0^1 b^I(i,j)^{\frac{\varepsilon_{t-1}^{bH}}{\varepsilon_t^{bH}}} dj \right]^{\frac{\varepsilon_t^{bH}}{\varepsilon_{t-1}^{bH}}} \geq \overline{b_t^I} \quad (19)$$

where $r_t^{bH} = \left[\int_0^1 r_t^{bH}(j)^{1-\varepsilon_t^{bH}} dj\right]^{\frac{1}{1-\varepsilon_t^{bH}}}$ represents the interest rate on household loans. Impatient households demand for loans at bank j is represented by the Dixit-Stiglitz aggregator:

$$b_t^I(j) = \left(\frac{r_t^{bH}(j)}{r_t^{bH}}\right)^{-\varepsilon_t^{bH}} b_t^I \tag{20}$$

Gerali *et al.* (2010) originally consider deposits and loans as one-period contracts. Because we are analyzing multi-period credit constraints for impatient agents based on expected future income, borrowing contracts for households will be represented as multi-period contracts. In Brazil, non-earmarked loans have an average maturity of 48 months. Deposits and loans to firms remain one-period contracts. Debt structure is modeled following Fortali and Lambertini (2013). In each period t, each household i takes on a new loan, $b_t^I(i)$, constrained by its future income. The amortization rate from the second period onwards is represented by $\phi_d \epsilon (0,1)$. The law of motion of impatient household (i)'s outstanding debt is given by the following:

$$debt_t(i) = (1-\phi_d)debt_{t-1}(i) + b_t^I(i) \tag{21}$$

Thus, current debt, $debt_t$, is represented by outstanding debt in the beginning of the period, $debt_{t-1}$, excluded current amortization[6], and new loans. Loan repayments are illustrated by Fig 2.

Because each impatient household takes on a loan during each period t, current debt can be represented by:

$debt_t = b_t^I + (1-\phi_d)b_{t-1}^I + (1-\phi_d)^2 b_{t-2}^I + (1-\phi_d)^3 b_{t-3}^I + ...$

$debt_t = b_t^I + (1-\phi_d)debt_{t-1}$

Entrepreneurs' demand for loans at bank j is represented by:

$$b_t^E(j) = \left(\frac{r_t^{bE}(j)}{r_t^{bE}}\right)^{-\varepsilon_t^{bE}} b_t^E \tag{22}$$

On the deposit side, the demand for real deposits $(\overline{d_t^P})$ of patient household i is obtained by maximizing the following:

$$max_{\left\{d_t^P(i,j)\right\}} \int_0^1 r_t^d(i,j) d_t^P dj \tag{23}$$

subject to:

[6]Installments are net of interest repayments.

$$\left[\int_0^1 d_t^P(i,j)^{\frac{\varepsilon_{t-1}^d}{\varepsilon_t^d}} dj\right]^{\frac{\varepsilon_t^d}{\varepsilon_{t-1}^d}} \leq \overline{d_t^P} \tag{24}$$

Aggregate demand for deposit at bank j is given by:

$$d_t^P(j) = \left(\frac{r_t^d(j)}{r_t^d}\right)^{-\varepsilon_t^d} d_t \tag{25}$$

where $d_t$represents aggregate deposits of the economy and r_t^d is the average deposit interest rate.

$$r_t^d = \left[\int_0^1 r_t^d(j)^{1-\varepsilon_t^d} dj\right]^{\frac{1}{1-\varepsilon_t^d}} \tag{26}$$

2.7 Banks

The main contribution of Gerali *et al.* (2010) is highlighting that the structure of the banking sector is characterized by imperfect competition at the retail level, which reflects the reality of the Brazilian credit market. In 2013, the four largest banks hold a concentration of 75% of deposits[7].

Banks have market power to set interest rates on deposits and loans in response to shocks. All financial intermediation is performed exclusively by banks. In other words, banks receive all deposits and supply loans to impatient households and entrepreneurs. Every bank must meet the following identity:

$$B_t = D_t + K_t^b \tag{27}$$

Each j bank must use its individual deposits, D_t, and/or its bank capital, K_t^b,to finance overall loans, B_t – these two sources are perfect substitutes for one another. The proportion of deposits and bank capital is defined based on exogenous capital-to-assets levels (leverage). A bank's capital is almost fixed in the short run, and is accumulated over retained earnings. In this framework, bank capital has an important role in setting the conditions to the credit supply and in the economics cycle. A negative macroeconomic environment can lead to a drop in bank profit and capital, which may cause credit conditions to deteriorate as lower loans supplied to private sector credit, which amplifies the original contraction. Each bank j, $j\epsilon[0,1]$, consists of three parts: two "retail" branches and one "wholesale" unit. The wholesale unit is responsible for managing capital group position and retail branches are responsible for (i) supplying differentiated loans to impatient households and to entrepreneurs and (ii) for receiving differentiated deposits from patient households.

[7]Relatório de Estabilidade Financeira, BCB, September 2013. ED: Please note that this is in Portuguese

2.7.1 Wholesale branch

The wholesale branch market is in perfect competition and each wholesale's loans (B_t) must equal wholesale's deposits,D_t, plus bank capital (K_t^b). The cost for moving the capital-to-asset ratio ($\frac{K_t^b}{B_t}$) away from the target level (υ^b) relies on wholesale unit. Gerali *et al.* (2010) set the υ^b parameter at 9%. According to the Brazilian Central Bank financial stability report[8], the Brazilian banking sector's capital-to-asset proportion is approximately 10%.

During each period, the wholesale unit accumulates capital as:

$$\pi_t K_t^b = (1-\delta^b)K_{t-1}^b + j_{t-1}^b \tag{28}$$

where δ^b represents the cost associated with managing bank capital and j_{t-1}^b is the overall real profit made by the three branches. The problem of the wholesale unit is to choose the amount of loans and deposits that maximizes the discounted sum of real cash flows:

$$\begin{aligned} max_{\{B_t,D_t\}} E_0 \sum_{t=o}^{\infty} \Lambda_{0,t}^P \quad = \quad & \Big[(1+R_t^b)B_t - B_{t+1}\pi_{t+1} + D_{t+1}\pi_{t+1} - (1+R_t^d)D_t + \\ & +(K_{t+1}^b \pi_{t+1} - K_t^b) - \frac{\kappa_{k_b}}{2}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)^2 K_t^b \Big] \end{aligned} \tag{29}$$

Subject to the balance sheet, $B_t = D_t + K_t^b$. When R_t^b represents the net wholesale loans rate and R_t^d the net wholesale deposit rates, both are taken as given. Rearranging (27) and including the constraint twice (for t and for t+1), we can rewrite the objective function as the following:

$$max_{\{B_t,D_t\}} R_t^b B_t - R_t^b D_t - \frac{\kappa_{k_b}}{2}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)^2 K_t^b \tag{30}$$

From first-order conditions we have:

$$R_t^b = R_t^d - \kappa_{k_b}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)\left(\frac{K_t^b}{B_t}\right)^2 \tag{31}$$

To guarantee a solution, it is assumed that banks have unlimited access to finance at policy rates r_t. Considering the fact that the wholesale market is perfectly competitive, wholesale deposits rates and interbank market rate are equal: $R_t^d = r_t$. Thus, we have a (29):

[8] Relatório de Estabilidade Financeira, BCB, September 2013.

$$R_t^b = r_t - \kappa_{k_b}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)\left(\frac{K_t^b}{B_t}\right)^2 \tag{32}$$

Rearranging, the spread between wholesale loans and deposits rates is given by:

$$S_t^w \equiv R_t^b - r_t = -\kappa_{k_b}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)\left(\frac{K_t^b}{B_t}\right)^2 \tag{33}$$

The capital-to-asset ratio is inversely related to the spread between wholesale loan and deposit rates. Higher leverage increases the spread and profits per unit of capital. However, if leverage exceeds the υ^b target, a quadratic cost is paid and reduces profits. The first order condition requires that loan rates are chosen such that the marginal cost of increasing leverage is equal to the spread.

2.7.2 Retail branch

Retail banks are monopolistic competitors and consist of loan and deposit branches.

2.7.2.1 Loan branch The retail loan branch from each bank j obtains wholesale loans (B_t) at rate R_t^b from the wholesale unit, differentiates these loans at no cost and then resells them to impatient households and entrepreneurs, charging different mark-ups. In order to introduce sticky rates, it is assumed that each retail bank faces a quadratic cost for changing interest rates on loans. Thus, the retail loan unit maximizes the following:

$$\begin{aligned} max_{\left\{r_t^{bH}(j), r_t^{bE}(j)\right\}} E_0 \sum_{t=o}^{\infty} \Lambda_{0,t}^P \quad = \quad & \Bigg[r_t^{bH}(j) b_t^I(j) + r_t^E(j) b_t^E(j) - R_t^b B_t - \\ & - \frac{\kappa_{bH}}{2}\left(\frac{r_t^{bH}(j)}{r_{t-1}^{bH}(j)} - 1\right)^2 r_t^{bH} b_t^I - \frac{\kappa_{bE}}{2}\left(\frac{r_t^{bE}(j)}{r_{t-1}^{bE}(j)} - 1\right)^2 r_t^{bE} b_t^e \Bigg] \end{aligned} \tag{34}$$

subject to loan demand from impatient households and entrepreneurs:

$$b_t^I(j) = \left(\frac{r_t^{bH}(j)}{r_t^{bH}}\right)^{-\varepsilon_t^{bH}} b_t^I \tag{35}$$

$$b_t^E(j) = \left(\frac{r_t^{bE}(j)}{r_t^{bE}}\right)^{-\varepsilon_t^{bE}} b_t^E \tag{36}$$

where $B_t(j) = b_t(j) = b_t^I + b_t^E$. Assuming a symmetric equilibrium, first order conditions for s={I,E} are given by the following:

$$1-\varepsilon_t^{bs}+\varepsilon_t^{bs}\frac{R_t^b}{r_t^{bs}}-\kappa_{bs}\left(\frac{r_t^{bs}}{r_{t-1}^{bs}}-1\right)\left(\frac{r_t^{bs}}{r_{t-1}^{bs}}\right)+ \tag{37}$$
$$+\beta_P E_t\left\{\frac{\lambda_{t-1}^P}{\lambda_t^P}\kappa_{bs}\left(\frac{r_{t+1}^{bs}}{r_t^{bs}}-1\right)\left(\frac{r_{t+1}^{bs}}{r_t^{bs}}\right)^2\frac{b_{t+1}^s}{b_t^s}\right\}=0$$

where λ_t^P represents the Lagrange multiplier for the budget constraint for patient households. After log-linearizing (35) and assuming $\varepsilon_t^{bs}=\varepsilon^{bs}$ (for a simplified case), we have the following:

$$\begin{aligned}\hat{r}_t^{bs} &= \frac{\kappa_{bs}}{\varepsilon^{bs}-1+(1+\beta_P)\kappa_{bs}}\hat{r}_{t-1}^{bs}+\frac{\beta_P\kappa_{bs}}{\varepsilon^{bs}-1+(1+\beta_P)\kappa_{bs}}E_t\hat{r}_{t+1}^{bs}+\\ &+\frac{\varepsilon^{bs}-1}{\varepsilon^{bs}-1+(1+\beta_P)\kappa_{bs}}\hat{R}_t^b-\frac{\hat{\varepsilon}_t^{bs}}{\varepsilon^{bs}-1+(1+\beta_P)\kappa_{bs}}\end{aligned} \tag{38}$$

2.7.2.2 Deposit branch Retail deposit bank j's unit collects patient household's deposits, d_t^P, and passes them to the wholesale unit, where deposits are remunerated at rate r_t. The problem of the deposit unit is to maximize the following:

$$max_{\{r_t^d(j)\}}E_0\sum_{t=o}^{\infty}\Lambda_{0,t}^P=\left[r_t(j)D_t(j)-r_t^d(j)d_t^P(j)-\frac{\kappa_d}{2}\left(\frac{r_t^d(j)}{r_{t-1}^d(j)}-1\right)^2r_t^d d_t\right] \tag{39}$$

subject to household deposit demand:

$$d_t^p(j)=\left(\frac{r_t^d(j)}{r_t^d}\right)^{-\varepsilon_t^d}d_t^p \tag{40}$$

where $D_t(j)=d_t^P(j)$. After imposing a symmetric equilibrium, the first order condition is given by:

$$-1+\varepsilon_t^d-\varepsilon_t^d\frac{r_t}{r_t^d}-\kappa_d\left(\frac{r_t^d}{r_{t-1}^d}-1\right)\frac{r_t^d}{r_{t-1}^d}+\beta_P E_t\left\{\frac{\lambda_{t-1}^P}{\lambda_t^P}\kappa_d\left(\frac{r_{t+1}^d}{r_t^d}-1\right)\left(\frac{r_{t+1}^d}{r_t^d}\right)^2\frac{d_{t+1}}{d_t}\right\}=0 \tag{41}$$

assuming $\varepsilon_t^d=\varepsilon^d$, in a simplified case), the log-linearization version of eq. (39) consists of the following:

$$\hat{r}_t^d=\frac{\kappa_d}{1+\varepsilon^d+(1+\beta_P)\kappa_d}\hat{r}_{t-1}^d+\frac{\beta_P\kappa_d}{1+\varepsilon^d+(1+\beta_P)\kappa_d}E_t\hat{r}_{t+1}^d+\frac{1+\varepsilon^d}{1+\varepsilon^d+(1+\beta_P)\kappa_d}\hat{r}_t \tag{42}$$

The overall real profits of bank j are the sum of its net profits from its retail branches and its wholesale unit, as represented below:

$$j_t^b = r_t^{bH} b_t^H + r_t^{bE} b^E - r_t d_t - \left(\frac{K_t^b}{B_t} - \upsilon^b \right)^2 K_t^b - Adj_t^B \tag{43}$$

where Adj_t^B represents the adjustment cost of changing interest rates on loans and deposits.

2.8 Monetary policy and market clearing

The Central Bank sets the interest rate r_t according to Taylor's rule as the following:

$$(1 + r_t) = (1 + r)^{(1+\phi_R)} (1 + r_{t-1})^{\phi_R} \left(\frac{\pi_t}{\pi} \right)^{\phi_\pi (1-\phi_R)} \left(\frac{y_t}{y_{t-1}} \right)^{\phi_y (1-\phi_R)} \varepsilon_t^r \tag{44}$$

in which r is the nominal interest rate at stationary level, ϕ_R represents the weight of inflation deviation from the target π, ϕ_y is the weight imputed to output growth and ε_t^r is a white noise shock, with σ_r as its standard deviation.

Market clearing in goods markets is given by the following:

$$y_t = c_t + q_t^k \left[k_t - (1 - \delta) k_{t-1} \right] + k_{t-1} \psi(u_t) + \delta^b \frac{K_{t-1}^b}{\pi_t} + Adj_t \tag{45}$$

where c_t represents aggregate consumption, k_t the aggregate stock of physical capital, K_t^b represents aggregate bank capital and Adj_t are all real adjustment costs of price, wage and interest wage. In the housing market, the aggregate stock is fixed, $\overline{h}$, and equilibrium is set by the following: $\overline{h} = h_t^P(i) + h_t^I(i)$.

3 Estimation

Equations describing the model are used log-linearized around the steady state. We use a Bayesian approach to estimate the parameters regarding the dynamics (AR coefficients and standard deviations) of the model, following Smets and Wouters (2003), and calibrate the others. Most credit data used in this model were discontinued in the fourth quarter of 2012 by the Central Bank of Brazil (from now on, BCB) and replaced by new data that use a different methodology, beginning as of March 2011. Due to this circumstance, the sample period was set from 2001:Q1 to 2012:Q4.

3.1 Data and sources

Twelve series are used, as described below. We de-meaned rates, except for monetary policy rates, which were detrended once the natural rate in Brazil presented a clear downward trend during the sample period.

All other variables were detrended, using the HP filter with smoothing parameters set at 1600.

Real consumption: final consumption of households, constant price, seasonally adjusted. Source: IBGE, Contas Nacionais.

Real investments: gross fixed capital formation, constant price, seasonally adjusted. Source: IBGE, Contas Nacionais.

Real housing prices: proxy using civil construction deflator, real estate deflator and rent deflator. Source: IBGE, Contas Nacionais.

Wages: proxy using real payroll and hours per worker, seasonally adjusted. Source: IBGE, BCB

Inflation: quarter over quarter log difference of IPCA. Source: IBGE

Nominal interest rate: SELIC. Source: BCB

Nominal interest rate on loans to households: proxy using non-earmarked loans to households, firms, interest rate on non-earmarked loans to firms and interest rate on non-earmarked loans. Source: BCB, series 8288, 3959, 3960 and 8287.

Nominal interest rate on loans to firms: rate on non-earmarked loans to firms. Source: BCB, series 8288.

Nominal interest rate on deposits: weighted average interest rate on term deposits, with preset rate, post set rate and floating. Source: BCB, series 32, 33, 40,41,1167,1168,1183 and 1184.

Loans to households: non-earmarked loans to households. Source: BCB, series 3960.

Loans to firms: non-earmarked loans to firms. Source: BCB, series 3959.

Deposits: sum of preset, post set and floating term deposits. Source: BCB, series 33, 41,1168 and 1184.

3.2 Calibrated parameters and Prior distributions

We calibrate 18 parameters, following Castro *et al.* (2011) and Gerali *et al.* (2010) for the Brazilian economy.

For the patient household discount factor, we consider real interest rate ex ante[9] during the analyzed period, such that $\beta^P$is set as 0.98. Impatient discount factor (β^I) and firms' (β^E) are set to 0.96 because Gerali *et al.* (2010) used a 0.2 gap between patient and impatient household discount factor and impatient. For the inverse of the Frisch elasticity, ϕ, the share of unconstrained households, μ, and weight of housing in households' utility function, ε^h, we use the same values as in Gerali *et al.*(2010).

For the capital share of the production function, α, we use 0.448, according to de Castro *et al.* (2011), which matches average ration capital GDP for Brazilian economy. With respect to the depreciation rate

[9]Real interest rate ex ante is built considering the Swap 360 and the inflation expectation 12 months forward.

of physical capital ($\delta = 0.015$), the markup in goods markets ($\frac{\varepsilon^y}{\varepsilon^y - 1} = 10\%$) and the markup in labor markets, ($\frac{\varepsilon^l}{\varepsilon^l - 1} = 50\%$), we also calibrate using de Castro *et al.* (2011).

Regarding the banking sector, parameters associated with LTV for households are calibrated as follows: (i) for credit constraints based on future income, we considered LTV, $m^{II} = 0.35$, to represent non-earmarked loans to annual disposable income in the Brazilian credit market; (ii) for credit constraints based on housing, we assume $m^{IH} = 0.70$, which is the same value as in Gerali *et al.* (2010). Moreover, we set entrepreneurs' LTV, m^E, at 0.20, which is lower than the 0.35 LTV used in Gerali *et al.* (2010). Non-earmarked loans to entrepreneurs in Brazil are characterized by short term maturity, as BNDES offers long-term loans at rates below market average, which justifies the lower LTV that was seen in the original paper. Because the average maturity for non-earmarked credit to households is 48 months in Brazil, we calibrate the amortization rate per period, ϕ_d, at 0.0625. For banking capital-to-loan ratio, v^b, we use 10%, according to Brazilian bank system data. Finally, for banking mark ups $\frac{\varepsilon^{bH}}{\varepsilon^{bH} - 1}$, for households, and $\frac{\varepsilon^{bE}}{\varepsilon^{bE} - 1}$, for entrepreneurs, and mark downs, $\frac{\varepsilon^d}{\varepsilon^d - 1}$, we adjust to reflect the wider spreads seen in Brazilian data. For the cost of managing the bank's capital position, δ^P, the same value from Gerali *et al.* (2010) is used.

All prior distributions, means and standard deviations are used as in Gerali *et al.* (2010).

4 Model Properties

We study how the transmission mechanism of monetary and technology shocks is affected by the following two different credit constraints: (i) credit constraints based on household housing stock, called the Benchmark (**BK**) and (ii) credit constraints based on future income, called **IN**.

4.1 Monetary shock

Financial intermediation has an important role in transmitting shocks: in an adverse macroeconomic environment, banks' profits decrease and might negatively affect capital – which increases leverage and may force banks to respond by reducing the amount of loans and thereby may widen the effect of the original negative shock.

The literature regarding DSGE models with financial friction and financial intermediation shows that, in an environment with perfect competition, the banking sector amplifies the response to GDP due to a monetary policy shock – see Christian *et al.* (2008). Conversely, when considering imperfect competition in the banking sector, an attenuating effect is found, either with flexible rates, see Andrés e RacerACE (2012), or sticky rates, Gerali *et al.* (2010), Goodfriend and McCallum (2007). However, Gerali *et al.*

Table 1: Calibrated Parameters

Parameter	Description	Values
β_P	Patient household's discount factor	0.98
β_I	Impatient household's discount factor	0.96
β_E	Entrepreneurs discount factor	0.96
ϕ	Inverse of the Frisch elasticity	1.00
μ	Share of unconstrained households	0.80
α	Capital share in the production function	0.448
δ	Depreciation rate of physical capital	0.015
ε^y	$\frac{\varepsilon^y}{\varepsilon^y-1}$ is the markup in the good market	11
ε^l	$\frac{\varepsilon^l}{\varepsilon^l-1}$ is the markup in the labour market	3
m^{II}	Households' credit limit ratio - income	0.35
m^{IH}	Households' credit limit ratio - income	0.70
m^E	Entrepreneurs' LTV ratio	0.20
ϕ_d	Amortization rate	0.0625
υ^b	Target to loans ratio	0.10
ε^d	$\frac{\varepsilon^d}{\varepsilon^d-1}$ is the markdown on deposit rate	-10.8
ε^{bH}	$\frac{\varepsilon^{bH}}{\varepsilon^{bH}-1}$ is the markup on rate on loans to householc	2.23
ε^{bE}	$\frac{\varepsilon^{bE}}{\varepsilon^{bE}-1}$ is the markup on rate on loans to firms	2.23
δ^b	Cost for managing the bank's capital position	0.10
ξ_1	Parameter of adjustment cost for capacity utilisatior	0.0469
ξ_2	Parameter of adjustment cost for capacity utilisatior	0.00469

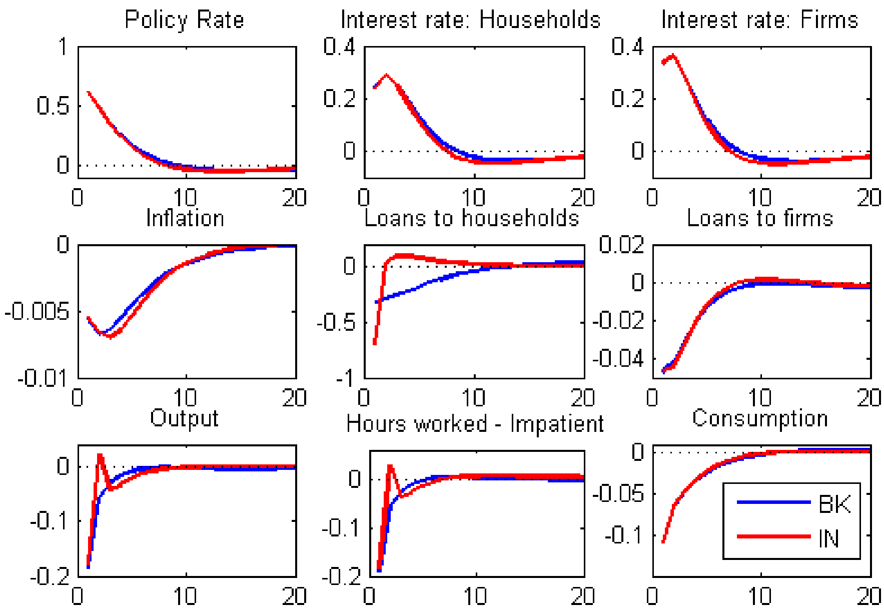
Table 2: Prior and posterior distribution of the structure parameters

	Prior distribution				Posterior distribution		
	Parameter	distribution	Mean	Std. Dev.	mean	2.5 percent	97.5 percent
κ_p	p stickness	Gamma	50.00	20.00	49.84	27.10	70.44
κ_w	w stickness	Gamma	100.00	20.00	117.05	89.34	143.84
κ_i	Invest. adj.cost	Gamma	2.50	1.00	7.36	5.40	9.30
κ_d	Dep. rate adj. cost	Gamma	10.00	2.50	5.08	2.58	7.47
κ_{bE}	Firm rate adj. cost	Gamma	3.00	5.00	0.95	0.36	1.56
κ_{bH}	HHs rate adj. cost	Gamma	6.00	0.50	2.15	0.57	3.75
κ_{Kb}	Leverage dev. cost	Gamma	10.00	0.10	9.10	4.36	13.44
ϕ_π	T.R. coeff. on π	Gamma	2.00	0.15	2.48	1.72	3.21
ϕ_R	T.R. coeff. on **R**	Beta	0.75	0.15	0.89	0.86	0.93
ϕ_y	T.R. coeff. on y	Normal	0.10	0.15	0.09	-0.11	0.28
l_p	p indexation	Beta	0.50	0.15	0.53	0.31	0.74
l_w	w indexation	Beta	0.50	0.15	0.44	0.22	0.66
a^h	Habit coefficient	Beta	0.50	0.10	0.19	0.12	0.27

Table 3: Prior and posterior distribution of the structure parameters

Prior distribution					Posterior distribution		
Parameter		distribution	Mean	Std. Dev.	mean	2.5 percent	97.5 percent
AR coefficients							
ρ_z	Consumpt. prefer.	Beta	0.80	0.10	0.24	0.15	0.33
ρ_h	Housing prefer.	Beta	0.80	0.10	0.80	0.69	0.92
ρ_{mE}	Firms' LTV	Beta	0.80	0.10	0.94	0.89	0.99
ρ_{mI}	HH's LTV	Beta	0.80	0.10	0.81	0.70	0.93
ρ_d	Dep. Markdown	Beta	0.80	0.10	0.55	0.39	0.72
ρ_{bH}	HHs loans markup	Beta	0.80	0.10	0.62	0.46	0.78
ρ_{bE}	Firms loans markup	Beta	0.80	0.10	0.79	0.66	0.93
ρ_a	Technology	Beta	0.80	0.10	0.936	0.90	0.975
ρ_{qk}	Invest. Efficiency	Beta	0.80	0.10	0.75	0.59	0.91
ρ_y	p markup	Beta	0.80	0.10	0.80	0.64	0.96
ρ_l	w markup	Beta	0.80	0.10	0.55	0.41	0.69
ρ_{Kb}	Balance sheet	Beta	0.80	0.10	0.94	0.90	0.98
Standard deviations							
σ_z	Consumpt. prefer.	Inv. Gamma	0.01	0.05	0.37	0.30	0.45
σ_h	Housing prefer.	Inv. Gamma	0.01	0.05	0.03	0.02	0.04
σ_{mE}	Firms' LTV	Inv. Gamma	0.01	0.05	0.01	0.01	0.02
σ_{mI}	HH's LTV	Inv. Gamma	0.01	0.05	0.07	0.05	0.09
σ_d	Dep. Markdown	Inv. Gamma	0.01	0.05	0.10	0.07	0.12
σ_{bH}	HHs loans markup	Inv. Gamma	0.01	0.05	2.84	1.57	4.14
σ_{bE}	Firms loans markup	Inv. Gamma	0.01	0.05	0.19	0.13	0.24
σ_a	Technology	Inv. Gamma	0.01	0.05	0.006	0.004	0.007
σ_{qk}	Invest. Efficiency	Inv. Gamma	0.01	0.05	0.08	0.05	0.10
σ_R	Monetary policy	Inv. Gamma	0.01	0.05	0.003	0.002	0.003
σ_y	p markup	Inv. Gamma	0.010	0.050	0.009	0.002	0.017
σ_l	w markup	Inv. Gamma	0.01	0.05	5.03	3.69	6.35
σ_{Kb}	Balance sheet	Inv. Gamma	0.01	0.05	0.85	0.71	0.99

Figure 3: Impulse response function of a contractionary monetary policy shock



(2010) show that this attenuating effect is mainly due to sticky rates, weakening the transmission from an increase in interest rate to lending rates. In fact, they illustrate that market power in the banking sector has limited influence in output - once markups amplify effects for borrowers – although markdown attenuates changes for lenders.

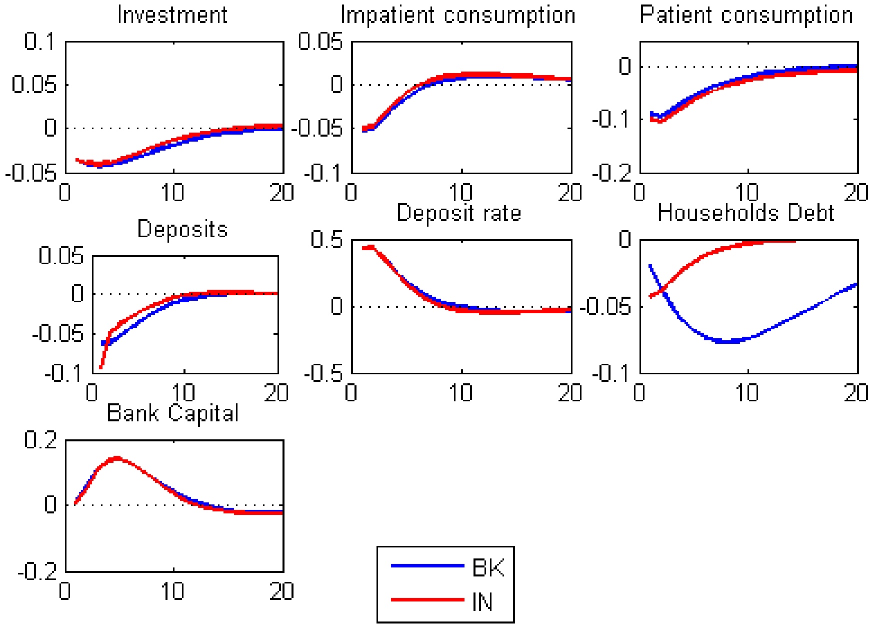
Here, the traditional interest channel of monetary impulse accompanies the others, see Calza *et al.* (2009): (i) nominal debt, i.e., because amortization and interest payments are set in nominal terms, a fall in inflation rates redistributes resources between lenders and borrowers; (ii) credit constraints, i.e. innovation regarding monetary policy rates can change loan-to-value ratios because it modifies system liquidity, impacting borrowers consumption; and (iii) asset-price effects, i.e, monetary policy may affect housing prices and by doing this affect the value available for borrowing.

In the model with payroll loans, a new channel is added. Shocks in interest rates affect the credit constraint households because they affect wages, which directly influences their collateral. Thus, families react by changing their labor supply to reduce this negative effect. Furthermore, the labor supply is governed not only by traditional substitution and income effects, but also by household decisions aimed at adjusting the restriction of credit.

Figures 3 and 4 show impulse responses to an unanticipated 50 basis points exogenous shock in monetary policy rate, r_t. Overall, the direction of responses proceeds as described in the literature.

We can see that transmission to GDP is less persistent in the IN model than in the BK models. As income falls due to lower wages and lower working demand at first, the impatient agent faces another constraint: a decrease in available loans. Since monetary policy has a larger effect on wages than on

Figure 4: Impulse response function of a contractionary monetary policy shock



housing prices, a tightening policy has a larger effect on credit constraints based on income, which leads agents to experiment with a larger drop in borrowing. To smooth consumption, households adjust their working hours[10] and compensate total gain, so we see a quick recovery in loans to households and also in debt. However, in the BK model, impatient agents have limited influence in the amount available for loans because this amount depends on their housing stocks. As housing prices recover slowly, so do loans to households. In this sense, the behavior predicted by the IN model fits better with the picture presented by emerging economies, such as Brazil, than that predicted by the BK model, as demonstrated by Fig 1, which incorporates the stylized facts discussed in the introduction.

4.2 Technology shock

Gerali *et al.* (2010) show that the presence of a banking system accentuates the endogenous effect of a technology shock, as impulses exhibit more persistent responses. Furthermore, the banking system attenuates the response of consumption and output of a technology shock, while the response of investment is widened. Conversely, banking market power and sticky rates contribute somehow to limiting and postponing the shock's transmission, as the responses of borrowing rates are partial and slow.

Figures 5 and 6 show responses to a one standard deviation technology shock, a^E. Due to a fall in the prices of final goods, there is a cut in the monetary policy rate, triggering a decrease in lending rates, making loans more attractive. Investment is boosted by increases in technology and also by an improvement

[10] In the modality of payroll loans, banks lend only to families with low risk of becoming unemployed. Therefore, we disregard a possible effect of unemployment on the collateral of families or on the balance sheets of banks here.

Figure 5: Impulse response function of a positive technology shock

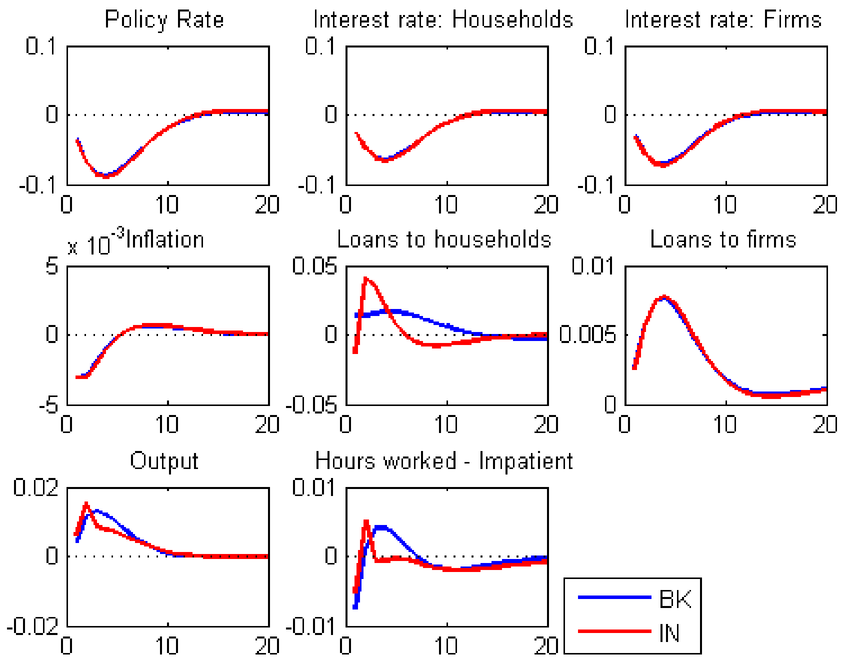
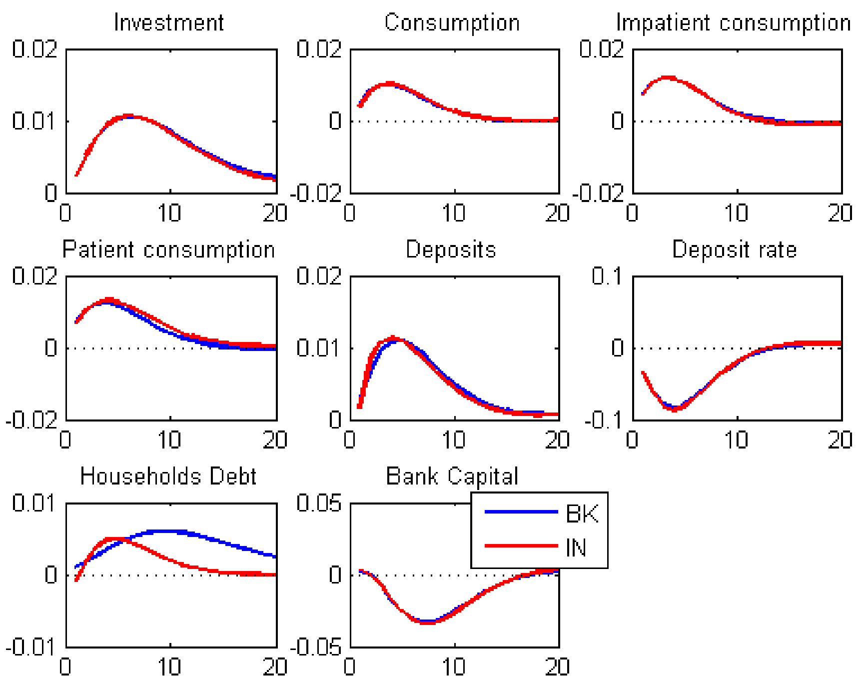


Figure 6: Impulse response function of a positive technology shock



in loan conditions. As investment rises, capital prices increase, which increases entrepreneurs' borrowing capacity even more .

The household credit borrowing constraint is also affected in two different ways: by improved collateral and by decreased borrowing rates. At first, there is a fall in working hours due to this increase in productivity. However, as labor becomes more productive, entrepreneurs increase labor demand, amplifying wages and working hours with a lag. In the IN model, collateral is boosted through this channel, leading to an increase in loans and subsequently in household debt. The BK model also experiences a loosening in credit constraints as housing prices increase.

The debt deflation channel is worth noting, as in Iacoviello (2005). As the economy experiences deflation, the expansionary effects of a technology shock are mitigated by the fact that the debt contracts are set in nominal terms, as a fall in prices induces an increase in debt amount, and this limits the amount available for borrowing. When considering imperfect competition in the banking sector and sticky rates, this effect is amplified because the decline in policy rates will slowly and partially repassed to borrowers.

5 Conclusion

This study presented a DSGE model based on Gerali *et al.* (2010), which is characterized by a monopolistic competitive banking sector and sticky rates, with some adjustments for an emerging market economy. We explore divergences in the collateral of loans to households. In developed economies, households use their houses as collateral for loans, but emerging economies, as Brazilian, suffer from lack of collateral, which leads to unfavorable loan terms and wider spreads. The baseline model was modified by adapting credit constraints to Impatient households accounting for four years of expected future income and multi-period loans such that households are allowed to assume debt, which will also affect the amount available for loans.

We study how this credit constraint behaves when confronting problems based on income changes, monetary policy and transmission of technology shocks compared with an identical model with credit constrains based on housing. To do so, we can calibrate and estimate the parameters for the Brazilian economy using Bayesian techniques. Overall, the direction of impulse responses proceeds as predicted by the literature in both cases. Notwithstanding the foregoing, the model with households' credit constraints based on income responds more quickly to shock than to housing prices, which is the same for the amount available for loans. In order to smooth consumption, agents compensate lower income and borrowing by increasing their working hours, thus repaying loans and debt in a shorter time.

References

[1] Andrés, J., & Arce, O. (2012). Banking Competition, Housing Prices and Macroeconomic Stability. *The Economic Journal*, *122(565)*, 1346-1372.

[2] Arruda, G. (2013). DSGE model with banking sector for emerging economies: estimated using Bayesian methodology for Brazil. *Dissertação, Escola de Economia de São Paulo*, *FGV*.

[3] Banco Central do Brasil. (2013). Relatório de Estabilidade Financeira. *v. 12 n^{o}2*.

[4] Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics, 1,* 1341-1393.

[5] Carvalho, F., Castro, M., Costa, S., (2013), Traditional and Matter-of-fact Financial Frictions in a DSGE Model for Brazil: The Role of Macroprudential Instruments and Monetary Policy, Banco Central do Brasil Working Paper No 336.

[6] Carvalho, C.V., Pasca, N., Souza, L., Zilberman, E. (2014), Macroeconomic Effects of Credit Deepening in Latin America, PUC-Rio Working paper.

[7] Calza, A., Monacelli, T., & Stracca, L. (2013). Housing finance and monetary policy. *Journal of the European Economic Association, 11(s1)*, 101-122.

[8] Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. J*ournal of political Economy, 113(1)*, 1-45.

[9] Christiano, L., Motto, R., & Rostagno, M. (2007). Financial factors in business cycles. *Mimeo*.

[10] Costa, A.C.; De Mello, J.M.P. (2008) Judicial Risk and Credit Market Performance: Micro Evidence from Brazilian Payroll Loans, In *Financial Markets Volatility and Performance in Emerging Markets*, Sebastian Edwards and Marcio Garcia, editors, Chicago: The University of Chicago Press, pp. 155-184.

[11] da Silva, M.; Andrade, J.; Silva, G.; Brandi, V. (2012) Financial frictions in the Brazilian banking system: a DSGE model with Bayesian estimation. *Annals of Brazilian Econometric Society Meeting*.

[12] de Castro, M. R., Gouvea, S. N., Minella, A., dos Santos, R. C., & Souza-Sobrinho, N. F. (2011). Samba: Stochastic analytical model with a bayesian approach. *Working Paper Series, 239, Banco Central do Brasil*.

[13] Cúrdia, V., & Woodford, M. (2010). Credit spreads and monetary policy. *Journal of Money, Credit and Banking, 42(s1)*, 3-35.

[14] Forlati, C., & Lambertini, L. (2013). Mortgage Amortization and Welfare. *Job Market Paper, École Polytechnique Fédérale de Lausanne,* EPFL

[15] Gerali, A., Neri, S., Sessa, L., & Signoretti, F. M. (2010). Credit and Banking in a DSGE Model of the Euro Area. *Journal of Money, Credit and Banking, 42(s1)*, 107-141.

[16] Gertler, M., & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. *Handbook of monetary economics, 3(11)*, 547-599.

[17] Gertler, M., & Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics, 58(1)*, 17-34.

[18] Goodfriend, M., & McCallum, B. T. (2007). Banking and interest rates in monetary policy analysis: A quantitative exploration. *Journal of Monetary Economics, 54(5)*, 1480-1507.

[19] Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American economic review*, 739-764.

[20] IMF (2006) *Global Financial Stability Report: Market Developments and Issues.*

[21] Kornelius, A. (2011). Política monetária e compulsório em um modelo DSGE com fricções financeiras. *Dissertação, Universidade Católica de Brasilia.*

[22] McCulley, P., & Toloui, R. (2008). Chasing the neutral rate down: Financial conditions, monetary policy, and the taylor rule. *Global Central Bank Focus*, 2002-2008.

[23] Monacelli, T. (2008). Optimal Monetary Policy with Collateralized Household Debt and Borrowing Constraints. *Asset Prices and Monetary Policy*, 103.

[24] Silva, G. C. D. (2013). Avaliando o mecanismo de transmissão da política monetária por meio do canal do crédito: estimação bayesiana em modelos DSGE com fricções financeiras. *Tese, Universidade de Brasília*

[25] Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European economic association, 1(5)*, 1123-1175.

[26] Taylor, J. B. (1993, December). Discretion versus policy rules in practice. *In Carnegie-Rochester conference series on public policy (Vol. 39, pp. 195-214)*. North-Holland.

[27] Taylor, J. B. (2008). Monetary Policy and the State of the Economy. *Testimony before the Committee on Financial Services, US House of Representatives.*

Appendix

Prior and posterior marginal distribution. The marginal posterior densities are based on 10 chain, each which 100,000 draws based on the Metropolis algorithm. Black lines denote the posterior distribution and gray lines the prior distribution.

Figure 7: Prior and posterior marginal distributions

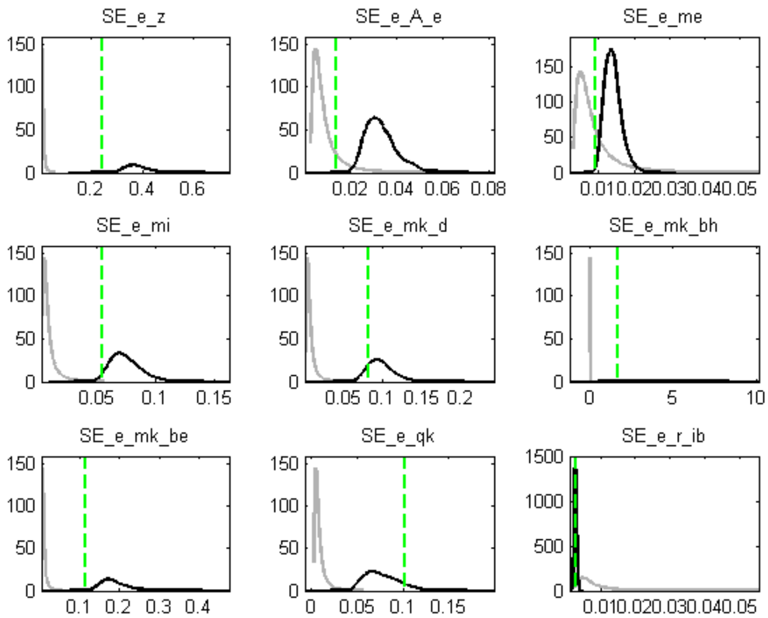


Figure 8: Prior and posterior marginal distributions

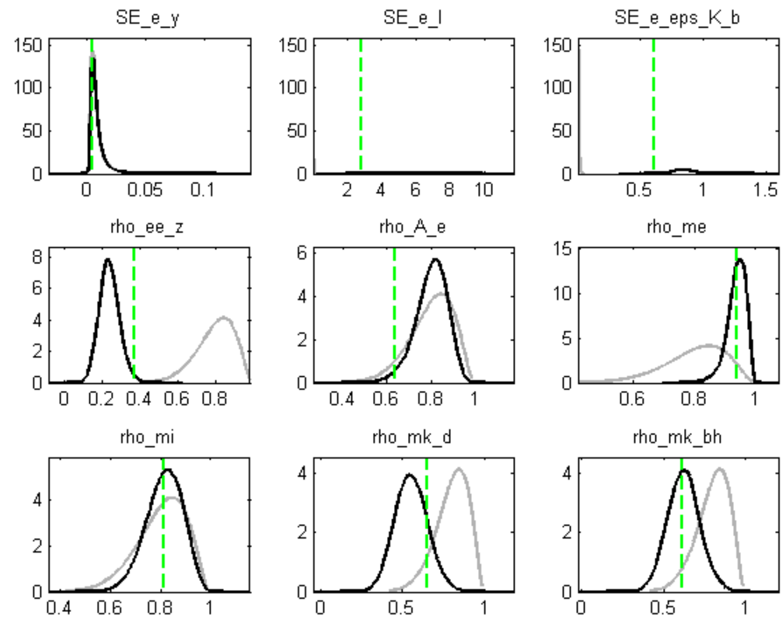


Figure 9: Prior and posterior marginal distributions

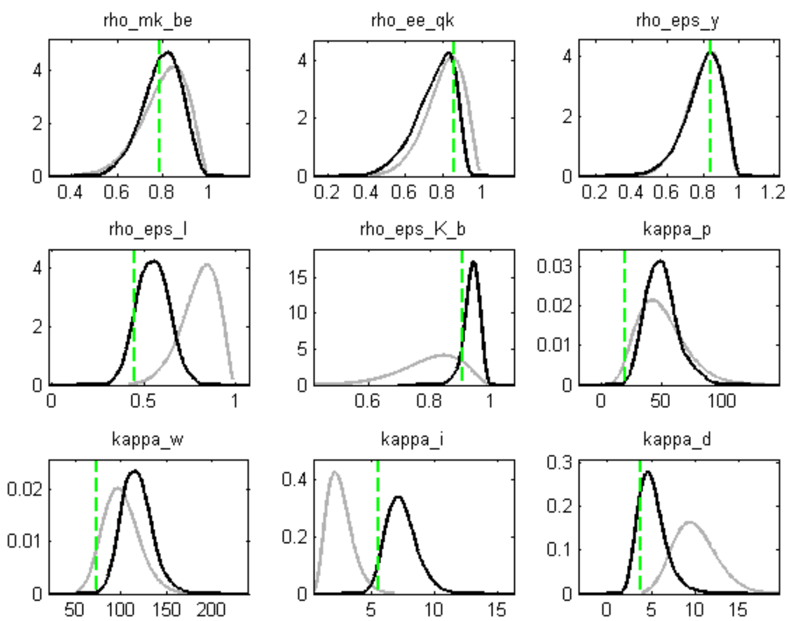


Figure 10: Prior and posterior marginal distributions