Risk Aversion, Credit and Banking*

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Abstract

The degree of risk aversion between households, firms, and bankers is differentiated to assess its influence in the business cycle. A Constant Relative Risk Aversion (CRRA) utility function is assumed for all agents to compare the transmission channels of three different shock categories: economic, financial and risk aversion shocks. Our non-linear framework allows a reinterpretation of economic and financial dynamics under several risk aversion levels and fluctuations. Agents' risk aversion is found to be an essential indicator for policy-makers. We find that an increased risk aversion level generally attenuates the response of output to economic and financial shocks. A positive risk aversion shock substantially influences the real economy. This shock also impacts central and retail bank interest rates through consumption smoothing and precautionary saving behaviours.

Keywords: Banks, Credit, Collateral constraints, Risk aversion, DSGE.
JEL Codes: E23, E31, E51.

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1 Introduction

Changes in the economic environment are assumed to influence risk and time preferences. In particular, Malmendier and Nagel (2011) and Cohn et al. (2015) emphasize the counter-cyclical nature of risk aversion based on the emotion of fear of agents so that risk aversion changes in bust and boom scenarios. In the aftermath of a crisis, banks are less willing to lend and households and entrepreneurs are less willing to borrow. Time preferences are also impacted since the intertemporal elasticity of substitution is positively correlated with the level of wealth (Atkeson and Ogaki, 1996).

The typical households' preferences in a macroeconomic dynamic stochastic general equilibrium (DSGE) framework are modelled with constant relative risk aversion (CRRA) utility functions. Since these preferences are inter-temporal in this framework, the coefficients for relative risk aversion (RRA) and inter-temporal elasticity of substitution (EIS) are linked to each other- RRA is equal to the inverse of the EIS. The RRA coefficient of consumption represents the attitude of households toward risky outcomes within a given time period (intra-temporal preference), while the EIS represents the attitude of households toward smoothing consumption between periods (intertemporal preference).

With respect to the modeling of risk aversion, the recent DSGE literature suffers from problems. First, RRA is usually assumed to be constant over time (Christiano et al., 2005; Smets and Wouters, 2003, 2007). Some authors offset the income effect and substitution effect on savings by assuming a log-utility function (Iacoviello, 2005; Gerali et al., 2010). This parameter is almost always assumed identical across each type of agents in the models. DSGE models also failed to reproduce the positive empirical correlation between consumption and loan rates, a problem pointed out by Angelini et al. (2014) about Gerali et al. (2010). Finally, those models only consider financial shocks coming from a change in the value of collateral, or from an exogenous increase in interest rates while the slow recovery of credit after the crisis may have stemmed from a change in demand (Kremp and Sevestre, 2013).

In this paper, we study how heterogenous and time-varying preferences can solve some of these shortcomings. To this end, we first assume a specific CRRA utility function for each type of agents (patient and impatient households, entrepreneurs and bankers) to differentiate preferences according to agents' characteristics. This specification allows to analyse several RRA scenarios and to simulate and compare the transmission mechanisms to a benchmark case where all agents have an identical RRA. Second, we estimate our model with Bayesian techniques, using US data from 1975 to 2018, to analyse and estimate the effects of RRA shocks. This shock is characterised by an exogenous change in the preferences of agents whose source may be a change in the economic environment or its behaviour. It is expected to impact output, consumption, and investment in the way that it makes agents more risk-averse with a higher preference for the present.[1]

[1] Our RRA shock differs from a simple preference shock because it considers inter and intra-temporal dimensions. It also differs from risk shocks. Indeed, risk shocks model the typical effect of a recession by considering that when firms borrow, they suffer a risk premium that reflects the opinion of lenders that the firm represents or not a risky bet (Christiano et al., 2014). Thus, the

Our paper is related to two stands of literature. First, to a behavioural economics literature arguing that preferences are heterogenous and time-varying and, second, to DSGE models with financial frictions and a banking sector. Developments in behavioural economics point out that preferences are heterogeneous across agent's characteristics. The heterogeneity of RRA is highlighted in particular by Guiso and Paiella (2008) and Alan and Browning (2010). They show that risk preferences differ considerably from one individual to another and that they are essential to explain differences in behaviour between individuals. Evidences about a heterogenous EIS parameter are also highlighted by Attanasio and Weber (1989) and by Vissing-Jørgensen (2002).

Beyond heterogeneities, the hypothesis of a time-varying parameters was advanced for instance by Guiso et al. (2018). Indeed, in the light of the global financial crisis (GFC) fallout, some authors consider risk aversion as an explanatory factor of the slow recovery and the dynamics of the real economy and credit during and after the GFC. (Benchimol, 2014) explores empirically the idea of a time-varying risk aversion which is shown to be a non-negligible component of output slowdown during the last crises in the Eurozone. In addition, Atkeson and Ogaki (1996) and Crossley and Low (2011) show that the intertemporal preference parameter varies over time, rejecting the idea of a constant parameter. In particular, it is assumed to depend on the variations of wealth. To our knowledge, only few papers integrate the idea of a time-varying coefficient in a DSGE framework. Benchimol and Fourçans (2017) consider a time-varying RRA coefficient in the households' utility function but assess its variations only through rolling window estimations. Bretscher et al. (2019) use Epstein-Zin utility function to show that the response of macro-economic variables to volatility shocks are stronger when households' risk aversion is higher. Torul (2018) uses alternative formulations of risk aversion and show that a stochastic RRA generates a better fit with the observed volatilities of the real variables.

From the perspective of DSGE models, we are closely related to the paper of Gerali et al. (2010) integrating financial frictions and a banking sector. No consensus about how to integrate financial frictions within DSGE models has yet emerged. The first wave of modelling introduces a financial accelerator (Bernanke et al., 1999) involving an inverse relationship between borrowers' net worth and the external finance premium. Choi and Cook (2004) thereby analyse the balance sheet channel in emerging markets. Christiano et al. (2010) also study the business cycle implications of financial frictions in light of this concept. Another approach considers a financial accelerator working through the amplification role of nominal debt and collateral constraints. First introduced by Kiyotaki and Moore (1997) and incorporated into a DSGE model by Iacoviello (2005), this approach introduces frictions that directly affect the quantity of loans. Other recent works based on this framework study the role of credit supply by adding an imperfectly competitive banking sector to analyse a credit crunch scenario. Our study is based on this second approach by extending the model of Gerali et al. (2010). As in Christiano et al. (2005) and Smets and Wouters (2003, 2007), we introduce market imperfections

rate spread fluctuates with the risk: when the risk increases, the spread increases leading to a decline in the credit, and then a decline in investment, consumption, and output.

and price rigidities to reproduce the main characteristics of the business cycle. Following Bernanke et al. (1999), we assume monopolistic competition in the retail market. Retailers purchase an intermediate good, produced by entrepreneurs at the wholesale price, transform it into a consumption good at no cost. We assume that retailers are the source of nominal rigidities. Imperfect competition and rigidities are also assumed in the banking sector in a way similar to Gerali et al. (2010) such that monopolistic competition between banks and sticky rates are assumed.

Our model improves the results of the existing literature. In particular, it solves shortcomings of the Gerali et al. (2010)'s model, pointed out by Angelini et al. (2014) by matching the positive correlation between consumption and loan rates. Second, we obtain two sets of results. The first one is that the transmission mechanism of shocks is generally attenuated for higher levels of RRA, attenuating the response of consumption and output. This result is explained by the reaction of individuals following changes in real interest rates. Indeed, since higher RRA implies increasing the curvature of the inter-temporal utility function, RRA transforms the response of consumption after a change in the real rate. This finding points to a first effect: the *consumption smoothing behaviour*. We note, however, that these results are magnified by a second effect when we are faced with borrowers. The increase in real rate is acting on the borrowing constraint, pushing borrowers to reveal a willingness to deleverage in order to maintain their future consumption. This result puts forward a second effect whose interpretation is close to the *precautionary motive*.

The second set of findings comes from the estimation of aversion shocks. We find that a positive RRA shock substantially influences the real economy through changes in consumption and credit demand. This allows to put forward a new source of variation of quantity of credit in addition to financial frictions based on collateral constraint and to credit crunch scenarios introduced by Gerali et al. (2010) and Brzoza-Brzezina and Makarski (2011). Finally, by estimating our model through Bayesian technique for US data from 1976 to 2018 , we confirm the hypothesis of the heterogeneity of the parameters of risk aversion and of inter-temporal substitution: we find that the heterogeneous value of the RRA parameter depends on the agent's characteristics. Specifically, we find that patients households are more risk averse than entrepreneurs and bankers, themselves more risk-averse than impatient households.

The remainder of the paper is organised as follows. Section 2 presents the theoretical setup. Section 3 discusses the data, the calibration and prior distributions and presents the estimation. Section 4 presents our first set of impulse response functions (IRFs) obtained under simulation. They compare transmission mechanisms of economic shocks under alternative RRA scenario. Section 5 presents our second set of IRFs obtained under estimation. They analyse the impact of a RRA for each agents. Concluding remarks and policy implications are presented in sections 8 and 7. Finally the Appendix presents additional theoretical results.

2 The model

The economy is populated by six types of agents: patient and impatient households, entrepreneurs, bankers, retailers, capital producers, and a central bank. Our model, summarised in Fig. 1, substantially extends Iacoviello (2005) by considering CRRA utility functions and including a banking sector close to Gerali et al. (2010).

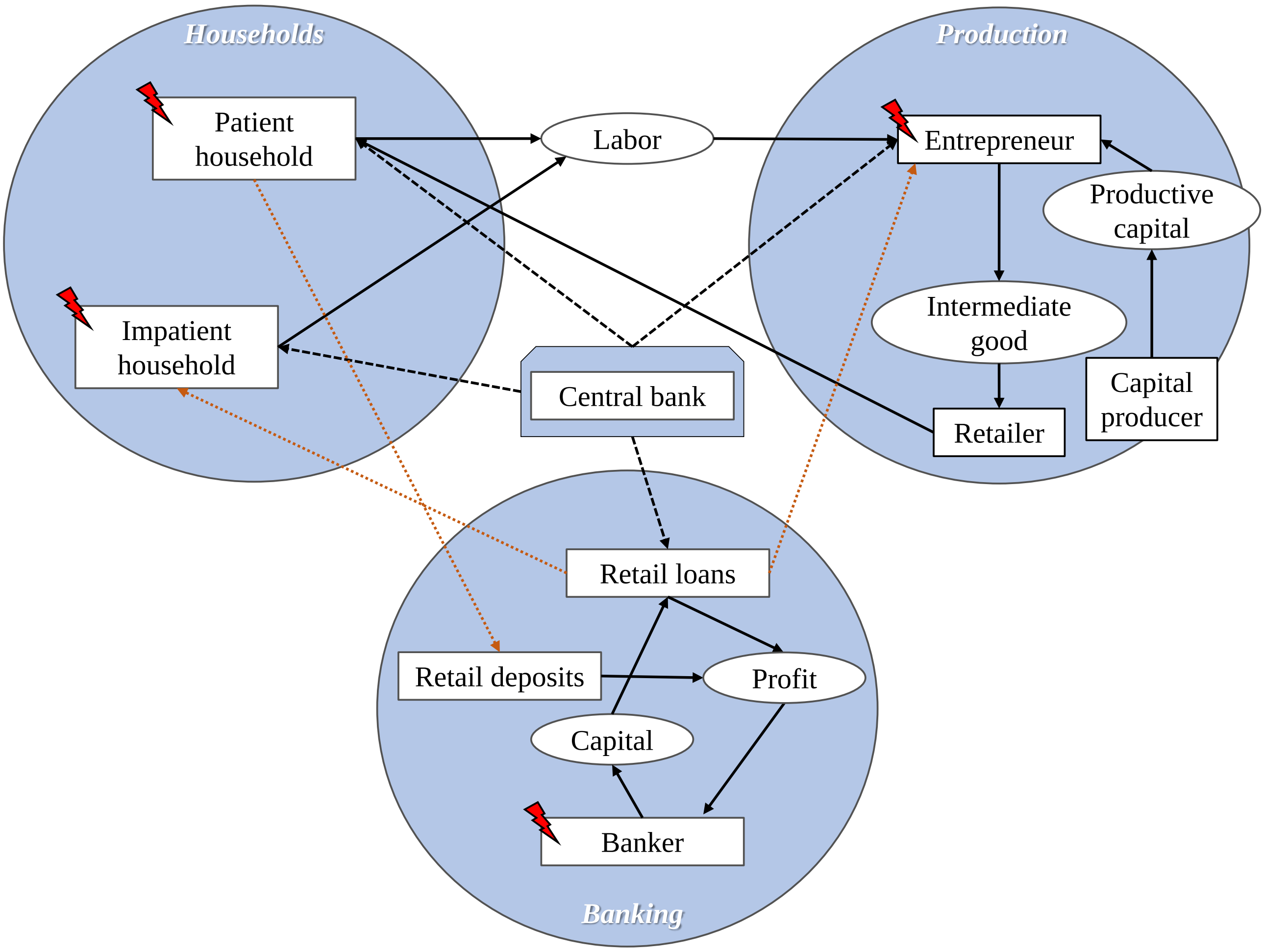


Figure 1: Our model in a nutshell. Note: the red flash denotes the agent-specific relative risk aversion shock.

Households supply labor, purchase goods for consumption, and accumulate housing. Entrepreneurs produce a homogeneous intermediate good using productive capital and labor supplied by households. Beyond the fact we assume agents with heterogeneous levels of risk aversion, we consider that they differ in their degree of impatience: entrepreneurs and impatient households discount the future more heavily than patient ones. This assumption introduced by Iacoviello (2005) determines their profiles in the banking sector thereby entrepreneurs and impatient households are borrowers and patient households are lenders. Retailers are the source of nominal rigidities. Following Bernanke et al. (1999) retailers buy intermediate goods from entrepreneurs in a competitive market, brand them at no cost and sell the final differentiated goods at a price which includes a mark-up over the purchasing cost. This allows considering monopolistic competition on the good market. Also, we assume price rigidities in line with Gerali et al. (2010). Financial frictions are introduced through the use of collateral constraints: borrowers face a borrowing constraint which is tied to their value of tomorrow's collateral holding. We consider the stock of housing as collateral for impatient households and the stock of capital for entrepreneurs. A change in the value of these assets changes the value of loans granted by the bank. The introduction of capital producers is a modelling device introduced to consider varying prices of capital, important as it determines the entrepreneurs' collateral value. Intermediaries are introduced according to Gerali et al. (2010) assuming a segmented retail banking sector with both a loan and a deposit branch. Retail banks operate in a regime of monopolistic competition implying that they set interest rates. In order to introduce bank capital as an internal source of funding for banks, we assume that bankers are the sole owner of the banks, such that the entire profit are used by bankers to consume or accumulate bank capital. Finally, the central bank adjusts money supply and transfers to support its interest rate rule.

In what follows, all agent preferences are assumed to follow a CRRA utility functional form implying the formulation of the coefficient of RRA, σ_k, (where k denotes each type of agents) which is also the inverse of EIS. We assume two cases: first, σ_k is a calibrated parameter which takes alternately different values, allowing to compare alternative scenarios of RRA. Second, $\sigma_{k,t}$ is formulated as a time-varying coefficient detailed in Section 2.10 in order to introduce risk aversion shocks.

2.1 Patient households

There is a continuum of patient households p that follow a CRRA utility function separable in consumption, housing and labor (leisure) such as

$$E_0 \sum_{k=0}^{\infty} \beta_p^k \left(\epsilon_t^z \frac{c_{p,t+k}^{1-\sigma_{p,t+k}}}{1-\sigma_{p,t+k}} + j \ln h_{p,t+k} - \frac{l_{p,t+k}^{1+\varphi}}{1+\varphi} \right) \tag{1}$$

where $c_{p,t}$ is consumption, $h_{p,t}$ is housing and $l_{p,t}$ represents the worked hours. $\beta_p \in]0;1[$ is the static discount factor of the patient households, φ the inverse of the elasticity of work effort with respect to the real wage (Frisch elasticity), j the weight of housing services in the household preferences and ϵ_t^z is a preference shock that affects consumption, it follows an AR(1) , i.e. first-order autoregressive, process detailed in Section 2.10.

Patient households maximise their lifetime utility function (Eq. 1) subject to an inter-temporal budget constraint

$$c_{p,t} + q_{h,t} \left(h_{p,t} - h_{p,t-1} \right) + d_t = \frac{1+R_{t-1}^d}{\pi_t} d_{t-1} + w_{p,t} l_{p,t} + j_{r,t} + j_{cb,t} \tag{2}$$

where $q_{h,t} = Q_{h,t}/\pi_t$ is the real housing price,[2] π_t the gross inflation rate, and

[2] $Q_{h,t}$ is the nominal housing price. Unlike Gerali et al. (2010), our model does not consider the depreciation rate of housing immobilisation for simplification purposes.

$w_{p,t} = W_{p,t}/\pi_t$ the patient households' real wage. d_t is the real amount of deposit, R_t^d is the nominal interest rate on deposits. $j_{r,t}$ denotes dividend received from the retail firms and $j_{cb,t}$ the seigniorage transfer from the central bank.

The maximisation of the objective function of patient households (Eq. 1) subject to the budget constraint (Eq. 2) with respect to consumption yields the following first order condition (FOC)

$$\epsilon_t^z c_{p,t}^{-\sigma_{p,t}} = \beta_p E_t \left[\frac{1 + R_t^d}{\pi_{t+1}} \epsilon_{t+1}^z c_{p,t+1}^{-\sigma_{p,t+1}} \right] \tag{3}$$

representing the Euler equation of patient households. Patient households choose, at each period, between consuming or saving one unit and consume R_t^d/π_{t+1} units tomorrow given $u'_{c,t+1}$ extra units of utility. As this utility comes in the future, it is discounted by β_p.

The FOC related to the housing demand is

$$\frac{j}{h_{p,t}} = q_{h,t} \epsilon_t^z c_{p,t}^{-\sigma_{p,t}} - \beta_p E_t \left[q_{h,t+1} \epsilon_{t+1}^z c_{p,t+1}^{-\sigma_{p+1}} \right] \tag{4}$$

where the housing demand of patient households depends negatively on house prices and positively on consumption, with a RRA equal to $\sigma_{p,t}$.

The FOC related to the supply of labor is

$$l_{p,t}^{\varphi} = w_{p,t} \epsilon_t^z c_{p,t}^{-\sigma_{p,t}} \tag{5}$$

where the labor supply of patient households depends positively on real wages with an elasticity equal to $1/\varphi$ and negatively on consumption with an elasticity equal to $\sigma_{p,t}/\varphi$.

2.2 Impatient households

There is a continuum of impatient households indexed by i following a CRRA utility function separable in consumption, housing and labor (leisure), as in the patient households case (Eq. 1), such as

$$E_0 \sum_{k=0}^{\infty} \beta_i^k \left(\epsilon_t^z \frac{c_{i,t+k}^{1-\sigma_{i,t+k}}}{1 - \sigma_{i,t+k}} + j \ln h_{i,t+k} - \frac{l_{i,t+k}^{\varphi+1}}{\varphi + 1} \right) \tag{6}$$

where $c_{i,t}$ is consumption, $h_{i,t}$ is housing and $l_{i,t}$ represents the worked hours. $\beta_i \in]0;1[$ is the discount factor of impatient households assumed to be lower than the patient one (β_p). As a result impatient households discount the future more heavily than patient ones. This assumption allows to determine the profile of households in the loan market (Iacoviello, 2005). ϵ_t^z is the same preference shock as for patient households.

Impatient households maximise their lifetime utility function (Eq. 6) subject to an inter-temporal budget constraint such as

$$c_{i,t} + q_{h,t} \left(h_{i,t} - h_{i,t-1} \right) + \frac{1 + R_{t-1}^{b_i}}{\pi_t} b_{i,t-1} = b_{i,t} + w_{i,t} l_{i,t} + j_{cb,t} \tag{7}$$

where $w_{i,t} = W_{i,t}/\pi_t$ is the real wage of impatient households, $j_{cb,t}$ the seigniorage transfer from the central bank, $b_{i,t}$ is the real amount of impatient households' loans and $R_t^{b_i}$ is the nominal interest rate on impatient households' loans.[3]

In line with Kiyotaki and Moore (1997), lenders ask that borrowers attach collateral[4] when issuing debt. If a borrower fails to pay interest or principal on a loan or security before due date, the lender reclaims the borrowers' assets by paying a proportional transaction cost of $(1 - m_{i,t}) E_t [q_{h,t+1} h_{i,t} \pi_{t+1}]$. Hence, the maximum borrowable amount, $b_{i,t}$, is bounded according to the following collateral constraint

$$\left(1 + R_t^{b_i}\right) b_{i,t} \leq E_t \left[m_{i,t} q_{h,t+1} h_{i,t} \pi_{t+1}\right] \tag{8}$$

where $m_{i,t}$ is the impatient households' exogenous loan-to-value (LTV) ratio detailed in Section 2.10. This shock allows for studying the effect of credit supply restrictions on the real economy. The amount of credits banks make available to each type of household, for a given value of their housing stock, can be summarised by $m_{i,t}$.

The maximisation of the objective function of impatient households (Eq. 6) subject to the budget constraint (Eq. 7) and the collateral constraint (Eq. 8) with respect to consumption yields the following FOC

$$\epsilon_t^z c_{i,t}^{-\sigma_{i,t}} = \beta_i E_t \left[\frac{1 + R_t^{b_i}}{\pi_{t+1}} \epsilon_{t+1}^z c_{i,t+1}^{-\sigma_{i,t+1}} \right] + \lambda_{i,t} \left(1 + R_t^{b_i}\right) \tag{9}$$

The FOC related to the demand for housing is

$$\frac{j}{h_{i,t}} = q_{h,t} \epsilon_t^z c_{i,t}^{-\sigma_{i,t}} - \beta_i E_t \left[q_{h,t+1} \epsilon_{t+1}^z c_{i,t+1}^{-\sigma_{i+1}} + \lambda_{i,t} m_{i,t} q_{h,t+1} \pi_{t+1} \right] \tag{10}$$

The FOC related to the impatient households labor supply is

$$l_{i,t}^{\varphi} = w_{i,t} \epsilon_t^z c_{i,t}^{-\sigma_{i,t}} \tag{11}$$

The functional form of the Euler (Eq. 9) and the housing demand (Eq. 10) equations of impatient households differs from patient households' corresponding equations (Eq. 3 and Eq. 4) because of the shadow value $\lambda_{i,t}$ of the borrowing constraint. According to the impatient households' Euler equation (Eq. 9), and housing demand equation (Eq. 10), $\lambda_{i,t}$ can be interpreted as the increase in lifetime utility obtained by borrowing $\left(1 + R_t^{b_i}\right)$ units (Iacoviello, 2005).

2.3 Entrepreneurs

Entrepreneurs produce intermediate goods y_t following a Cobb and Douglas (1928) constant return to scale production function given by

$$y_t = A_t k_{e,t-1}^{\alpha} l_{p,t}^{\mu(1-\alpha)} l_{i,t}^{(1-\mu)(1-\alpha)} \tag{12}$$

[3]It reflects that loans are set in nominal terms, a feature from the financial friction literature (Iacoviello, 2005; Gerali et al., 2010; Guerrieri and Iacoviello, 2017).

[4]Collateral assets trade at a market price.

where $k_{e,t}$ is the capital input, $l_{p,t}$ and $l_{i,t}$ are the patient and impatient households' labor inputs, respectively, and A_t is the total factor productivity detailed in Section 2.10. α is the output elasticity of capital and μ the labor income share of patient households.

Following Bernanke et al. (1999) and Iacoviello (2005), output cannot be transformed immediately into consumption which causes sticky prices. Retailers purchase intermediate good from entrepreneurs at a wholesale price $P_{w,t}$ to transform it into a composite final good of price P_t. Then, $x_t = P_t/P_{w,t}$ represents the markup of final over intermediate goods.

Our economy is populated by an infinity of entrepreneurs e maximising their CRRA lifetime utility function which depends only on consumption such as

$$E_0 \sum_{k=0}^{\infty} \beta_e^k \frac{c_{e,t+k}^{1-\sigma_{e,t+k}}}{1-\sigma_{e,t+k}} \tag{13}$$

where $c_{e,t}$ is the entrepreneurs' consumption, β_e the discount factor such that entrepreneurs discount the future more heavily than patient households. Entrepreneurs maximise their lifetime utility function (Eq. 13) subject to the following intertemporal budget constraint

$$c_{e,t} + \frac{1+R_{t-1}^{b_e}}{\pi_t} b_{e,t-1} + w_{p,t} l_{p,t} + w_{i,t} l_{i,t} + q_{ke,t} k_{e,t} = \frac{y_t}{x_t} + b_{e,t} + q_{ke,t}\left(1-\delta_{ke}\right) k_{e,t-1} + j_{cb,t} \tag{14}$$

where $q_{ke,t}$ is the real price of one unit of capital in term of consumption and δ_{ke} the depreciation rate of physical capital. $b_{e,t}$ is the real amount of entrepreneurs' loans and $R_t^{b_e}$ the nominal interest rate on entrepreneurs' loans. y_t/x_t denotes revenues obtained from the sale of wholesale goods where $1/x_t$ represents the price in terms of the consumption good of the wholesale good produced by each entrepreneur. $j_{cb,t}$ is the seigniorage transfer from the central bank to entrepreneurs.

As for impatient households, lenders require that borrowers attach collateral when issuing debt. The collateral constraint of entrepreneurs is tied to their endowment of capital. If an entrepreneur fails to pay interest or principal on a loan or security when due, the lender reclaims the entrepreneur's assets by paying a proportional transaction cost of $(1-m_{e,t}) E_t \left[q_{ke,t+1}\left(1-\delta_{ke}\right) k_{e,t}\pi_{t+1}\right]$. Hence, the maximum amount to borrow, $b_{e,t}$, is bounded according to the following collateral constraint

$$\left(1+R_t^{b_e}\right) b_{e,t} \leq E_t \left[m_{e,t} q_{ke,t+1}\left(1-\delta_{ke}\right) k_{e,t}\pi_{t+1}\right] \tag{15}$$

where $m_{e,t}$ is the exogenous LTV ratio detailed in Section 2.10. The presence of this borrowing constraint implies that the amount of credit entrepreneurs will be able to accumulate is a multiple of their net worth.

The maximisation of the objective function (Eq. 13) subject to the budget constraint (Eq. 14) and to the collateral constraint (Eq. 15) with respect to consumption, yields the following FOC

$$c_{e,t}^{-\sigma_{e,t}} = \beta_e E_t \left[\frac{1+R_t^{b_e}}{\pi_{t+1}} c_{e,t+1}^{-\sigma_{e,t+1}}\right] + \lambda_{e,t}\left(1+R_t^{b_e}\right) \tag{16}$$

where $\lambda_{e,t}$ is the shadow value of entrepreneurs collateral constraint.

The FOC related to the demand of capital is

$$c_{e,t}^{-\sigma_{e,t}} q_{ke,t} = \beta_e E_t \left[c_{e,t+1}^{-\sigma_{e,t+1}} \left(\alpha \frac{y_{t+1}}{x_{t+1} k_{e,t}} + q_{ke,t+1} \left(1 - \delta_{ke}\right) \right) + \lambda_{e,t} m_{e,t} q_{ke,t+1} \pi_{t+1} \left(1 - \delta_{ke}\right) \right] \tag{17}$$

As entrepreneurs use patient and impatient households' labor as input for production, we also get two types of labor demand, one for patients and one for impatient households.[5]

The FOC related to the labor demand of patient households is

$$w_{p,t} = \frac{\mu \left(1 - \alpha\right)}{l_{p,t}} \frac{y_t}{x_t} \tag{18}$$

and the FOC related to the labor demand of impatient households is

$$w_{i,t} = \frac{\left(1 - \mu\right) \left(1 - \alpha\right)}{l_{i,t}} \frac{y_t}{x_t} \tag{19}$$

2.4 Retailers

Retailers purchase the wholesale good y_t to entrepreneurs at a wholesale price P_t^w, differentiate them at no cost, and resell differentiated goods $y_t(z)$ at a market price P_t. The ratio (markup) of market prices over wholesale prices is $x_t = P_t / P_t^w$. Hence price adjustment costs and monopolistic competition at the retail level are assumed (Bernanke et al., 1999; Iacoviello, 2005).

Retailers bundle the intermediate goods, y_t, according to the following constant elasticity of substitution (CES) technology

$$y_t = \left[\int_0^1 y_t(z)^{\frac{\epsilon_{y,t}-1}{\epsilon_{y,t}}} dz \right]^{\frac{\epsilon_{y,t}}{\epsilon_{y,t}-1}} \tag{20}$$

where $\epsilon_{y,t}$ is the time-varying elasticity of substitution between intermediate goods detailed in Section 2.10.

Given the aggregate output index (Eq. 20) the price index is

$$P_t = \left[\int_0^1 P_t(z)^{1-\epsilon_t} dz \right]^{\frac{1}{1-\epsilon_{y,t}}} \tag{21}$$

so that each retailer faces an individual demand curve such as

$$y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon_{y,t}} y_t \tag{22}$$

Each retailer chooses the market price $P_t(z)$ taking the demand curve (Eq. 22) and the wholesale price P_t^w as given. This corresponds to solving the following problem

$$E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,k}^p \left[\left(P_t(z) - P_{t+k}^w\right) y_{t+k}^*(z) - \frac{\kappa_p}{2} \left(\frac{P_t(z)}{P_{t-1}(z)} - \pi_{t-1}^{\iota_p} \overline{\pi}^{1-\iota_p} \right)^2 P_t y_t \right] \tag{23}$$

[5] Our paper does not assume any difference in skills between the two groups

where $\Lambda^p_{t,k} = \beta_p U_{c,t+k}/U_{c,t}$ is the stochastic discount factor, κ_p is the quadratic adjustment cost observed by retailers when they change their price beyond what indexation allows and, ι_p are the relative weights of past and steady state inflation in the equation of price indexation, subject to an individual demand constraint given by Eq. 22.

The first order condition associated with the retailer problem is

$$1-\epsilon_{y,t}+\frac{\epsilon_{y,t}}{x_t}-\kappa_p\left(\pi_t-\pi_{t-1}^{\iota_p}\overline{\pi}^{1-\iota_p}\right)\pi_t+\beta_p\left(\frac{c_{p,t}}{c_{p,t+1}}\right)\kappa_p\left(\pi_{t+1}-\pi_t^{\iota_p}\overline{\pi}^{1-\iota_p}\right)\pi_{t+1}\frac{y_{t+1}}{y_t}=0 \tag{24}$$

Note that in our model, we assume a negative markup shock which implies an exogenous time-variant elasticity of substitution $\epsilon_{y,t}$. A positive shock to $\epsilon_{y,t}$ will decrease the optimal value of markups.

2.5 Capital goods producers

We introduce a capital producer sector to determine the capital price which is an important value in our model as it determines the value of entrepreneurs' collateral. Capital producers are in a competitive market. Their aim is to produce new capital and to sell it to entrepreneurs at the nominal market price Q_k. The profit maximisation of the capital good producers delivers a dynamic equation for the real price of capital similar to Smets and Wouters (2003, 2007).

Following Gerali et al. (2010), capital producers buy an amount i_t of final good at the beginning of each period and the stock of old undepreciated capital $(1-\delta_{ke})\,k_{e,t-1}$ from entrepreneurs. Old capital can be converted one to one into new capital. We assume quadratic adjustment costs. Finally, the amount that capital good producers can produce is given by

$$k_{e,t}=(1-\delta_{ke})k_{e,t-1}+\left[1-\frac{\kappa_i}{2}\left(\frac{\epsilon_t^{qk}i_t}{i_{t-1}}-1\right)^2\right]i_t \tag{25}$$

where κ_i is the adjustment cost of a change in investment and ϵ_t^{qk} is a shock to the efficiency of investment, which follows an AR(1) process, detailed in Section 2.10.

2.6 Retail banks

2.6.1 Loan and deposit demand

Monopolistic competition at the banking level is introduced to capture the existence of market power. In line with Gerali et al. (2010) we use a Dixit and Stiglitz (1977) framework to aggregate deposits and loans demand. A CES utility function for saving and borrowing, with elasticity of substitution equal to $\varsigma_{d,t}$, $\varsigma_{b_i,t}$ and $\varsigma_{b_e,t}$, is assumed. Each agent buys deposit (loan) contracts from every single bank to save (borrow) one unit of resource. This modeling device used by Gerali et al. (2010) captures the existence of market power in the banking industry. $\varsigma_{d,t}$, $\varsigma_{b_i,t}$ and $\varsigma_{b_e,t}$ are stochastic processes (detailed in Section 2.10) allowing to consider markup shocks for the banking sector, taking into account the shock impacting the spread between policy and retail rates.

The optimal behaviour requires that deposit demand is obtained by maximising he level of total savings. In other words, agent i will choose how much to deposit at bank j by maximising the level of total savings

$$\min_{d_{p,t}(i,j)} \int_0^1 R_t^d(j)\, d_{p,t}(i,j)\, dj \tag{26}$$

subject to the aggregation technology

$$d_t(i) = \left[\int_0^1 d_t(i,j)^{\frac{\varsigma_{d,t}-1}{\varsigma_{d,t}}}\, dj\right]^{\frac{\varsigma_{d,t}}{\varsigma_{d,t}-1}} \tag{27}$$

where $\varsigma_{d,t}$ is the time-varying elasticity of substitution between deposits.

Aggregating the FOC over all patient households leads to the following deposit demand

$$d_t(j) = \left(\frac{R_t^d(j)}{R_t^d}\right)^{-\varsigma_{d,t}} d_t \tag{28}$$

where the aggregated deposit rate R_t^d is defined as

$$R_t^d = \left[\int_0^1 R_t^d(j)^{1-\varsigma_{d,t}}\, dj\right]^{\frac{1}{1-\varsigma_{d,t}}} \tag{29}$$

In what follows, we note b_k equal to the sum of loans to impatient households b_i and entrepreneurs b_e.

Entrepreneurs and impatient households seek the amount of loans $b_{k,t}(i,j)$ allocated to each bank so as to minimise their level of expenditure (total due repayment)

$$\min_{b_{k,t}(i,j)} \int_0^1 R_t^{b_k}(j)\, b_{k,t}(i,j)\, dj \tag{30}$$

subject to the aggregation technology

$$b_{k,t}(i) = \left[\int_0^1 b_{k,t}(i,j)^{\frac{\varsigma_{b_k,t}-1}{\varsigma_{b_k,t}}}\, dj\right]^{\frac{\varsigma_{b_k,t}}{\varsigma_{b_k,t}-1}} \tag{31}$$

where $\varsigma_{b_k,t}$ is the time-varying elasticity of substitution whose exogenous changes are interpreted as a change to the banking interest rate spread arising independently from monetary policy.

Aggregating FOC over all borrowers gives their loan demand

$$b_{k,t}(j) = \left(\frac{R_t^{b_k}(j)}{R_t^{b_k}}\right)^{-\varsigma_{bk,t}} b_{k,t} \tag{32}$$

and the aggregated borrowers' loan rate $R_t^{b_k}$ is defined as

$$R_t^{b_k} = \left[\int_0^1 R_t^{b_k}(j)^{1-\varsigma_{bk,t}}\, dj\right]^{\frac{1}{1-\varsigma_{bk,t}}} \tag{33}$$

2.6.2 Loan activity

Each bank j produces loans $b_{e,t}$ and $b_{i,t}$ according to

$$b_{e,t}(j) + b_{i,t}(j) = k_{b,t-1}^{\chi_b}(j)\left(m_t(j) + d_t(j)\right)^{1-\chi_b} \tag{34}$$

which is equivalent to a balance sheet constraint suggesting that each bank finances its loans by obtaining funds from deposits $d_t(j)$, monetary market $m_t(j)$, and bank equity (bank capital) $k_{b,t}(j)$. Eq. 34 captures basic elements of financial intermediation's balance sheet.χ_b represents the bank capital share in the loan production function.

The banks' production function (Eq. 34) allows us to calculate a positive marginal cost $mc_{b,t}(j)$ associated to the production of loans (details are given in appendix C). Given the nominal rate of funds from the central bank or from the banking sector, R_t, and the interest rate on bank capital, $R_{kb,t}$, the constant nominal marginal cost of loans[6] is

$$mc_{b,t}(j) = \frac{R_t^{1-\chi_b} R_{kb,t}^{\chi_b}}{(1-\chi_b)^{1-\chi_b}\chi_b^{-\chi_b}} \tag{35}$$

while the optimal input ratio for the bank is

$$\frac{m_t(j) + d_t(j)}{k_{b,t}(j)} = \frac{R_{kb,t}}{R_t}\frac{1-\chi_b}{\chi_b} \tag{36}$$

This allows to add endogenous interest rate spreads into the financial accelerator model. In fact, due to the monopolistic competition, deposits face an upward sloping demand curve (Eq. 28) and loans a downward sloping curve (Eq. 32). Consequently, the market power of banks leads them to set their optimal interest rates. Each bank j chooses the interest rate maximising its profit $j_{b,t}(j)$ given by

$$j_{b,t}(j) = \left[\begin{array}{c} R_t^{b_e}(j)\,b_{e,t}(j) + R_t^{b_i}(j)\,b_{i,t}(j) - mc_{b,t}(j)\left(b_{e,t}(j) + b_{i,t}(j)\right) \\ +\left(R_t - R_t^d(j)\right)d_t(j) - \sum_{k=d,b_i,b_e}\frac{\kappa_k}{2}\left(\frac{R_t^k(j)}{R_{t-1}^k(j)} - 1\right)^2 R_t^k k_t \end{array}\right] / \pi_{t+1} \tag{37}$$

where κ_d , κ_{b_i} and κ_{b_e} are parameters determining the speed of adjustment to changes in the policy rate.

2.6.3 Optimal interest rate setting

Retail deposit and retail loan branches are differentiated. The only task of the first one is to accumulate deposits d_t. For each unit of deposit, the benefits generated by the bank j are equal to the difference between the interbank rate, R_t, and the deposit rate, R_t^d. R_t represents the rate at which transfers between the two banks are registered.

The problem for the retail deposit branch j is to set the interest rate R_t^d to maximise its profits given by

$$E_t \sum_{t=0}^{\infty} \Lambda_{t,t+k}^b \left[\left(R_t - R_t^d(j)\right)d_t(j) - \frac{\kappa_d}{2}\left(\frac{R_t^d(j)}{R_{t-1}^d(j)} - 1\right)^2 R_t^d d_t\right] \tag{38}$$

[6] Banks rent at the cost R_{kb} the amount of capital that they desire, while bankers accumulate this capital.

under the individual deposit demand condition (Eq. 28) where $\Lambda^b_{t,t+k} = \beta_p U'_{c,t+k}/U'_{c,t}$ is the stochastic discount factor of bankers, sole owners of the banks, $R^d_t(j)$ is the chosen deposit rate, R^d_t is taken as given by the individual bank, $d_t(j)$ is the demand of deposits for bank j and d_t is the economy-wide demand for deposits.

Imposing a symmetric equilibrium where each bank faces the same optimisation problem yields the following FOC

$$-1 + \varsigma_{d,t} - \varsigma_{d,t}\frac{R_t}{R^d_t} - \kappa_d\left(\frac{R^d_t}{R^d_{t-1}} - 1\right)\frac{R^d_t}{R^d_{t-1}} + \beta_b E_t\left[\frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}}\kappa_d\left(\frac{R^d_{t+1}}{R^d_t} - 1\right)\left(\frac{R^d_{t+1}}{R^d_t}\right)^2\frac{d_{t+1}}{d_t}\right] \tag{39}$$

The deposit interest rate is set by taking into account the expected future level of the policy rate. The speed of adjustment to changes in the policy rate depends inversely on the intensity of the adjustment costs (κ_d) and positively on the degree of competition in the banking sector (inverse of $\varsigma_{d,t}$).

The problem for the retail loan bank j is to choose the interest rates $R^{b_i}_t$ and $R^{b_e}_t$ maximising its following profit

$$E_t\sum_{t=0}^{\infty}\Lambda^b_{t,t+k}\left[\begin{array}{c} R^{b_e}_t(j)\,b_{e,t}(j) + R^{b_i}_t(j)\,b_{i,t}(j) - mc_{b,t}(j)\left(b_{e,t}(j) + b_{i,t}(j)\right) - \\ \frac{\kappa_{b_e}}{2}\left(\frac{R^{b_e}_t(j)}{R^{b_e}_{t-1}(j)} - 1\right)^2 R^{b_e}_t b_{e,t} - \frac{\kappa_{b_i}}{2}\left(\frac{R^{b_i}_t(j)}{R^{b_i}_{t-1}(j)} - 1\right)^2 R^{b_i}_t b_{i,t} \end{array}\right] \tag{40}$$

under the loan demand constraints of impatient households and entrepreneurs (Eq. 32). $R^{b_i}_t(j)$ and $R^{b_e}_t(j)$ are the chosen rates, $R^{b_i}_t$ and $R^{b_e}_t$ are taken as given, $b_{i,t}(j)$ and $b_{e,t}(j)$ are loans granted by bank j and $b_{i,t}$ and $b_{e,t}$ are the economy wide demand of loans.

After imposing a symmetric equilibrium, we obtain the following FOC associated with the bank problem for impatient households' loan rate

$$1 - \varsigma_{b_i,t} + \varsigma_{b_i,t}\frac{mc_{b,t}}{R^{b_i}_t} - \kappa_{b_i}\left(\frac{R^{b_i}_t}{R^{b_i}_{t-1}} - 1\right)\frac{R^{b_i}_t}{R^{b_i}_{t-1}} + \beta_b E_t\left[\kappa_{b_i}\frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}}\left(\frac{R^{b_i}_{t+1}}{R^{b_i}_t} - 1\right)\left(\frac{R^{b_i}_{t+1}}{R^{b_i}_t}\right)^2\frac{b_{i,t+1}}{b_{i,t}}\right] \tag{41}$$

The FOC associated with the bank problem for entrepreneurs' loan rate is

$$1 - \varsigma_{b_e,t} + \varsigma_{b_e,t}\frac{mc_{b,t}}{R^{b_e}_t} - \kappa_{b_e}\left(\frac{R^{b_e}_t}{R^{b_e}_{t-1}} - 1\right)\frac{R^{b_e}_t}{R^{b_e}_{t-1}} + \beta_b E_t\left[\kappa_{b_e}\frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}}\left(\frac{R^{b_e}_{t+1}}{R^{b_e}_t} - 1\right)\left(\frac{R^{b_e}_{t+1}}{R^{b_e}_t}\right)^2\frac{b_{e,t+1}}{b_{e,t}}\right] \tag{42}$$

Loan rates are set by banks taking into account the expected future path of marginal costs.

2.7 Bankers

Bankers solve a relatively short horizon problem. As a result, they have a simple objective function, which is different from that of the banking sector. Bankers allow introducing bank capital as an internal source of funding for banks. They also face a CRRA lifetime utility function allowing us to take into account the bankers' RRA. Bankers consume and accumulate bank capital. Bankers' utility only depend on consumption and their lifetime utility function is

$$E_0 \sum_{k=0}^{\infty} \beta_b^k \frac{c_{b,t+k}^{1-\sigma_{b,t+k}}}{1-\sigma_{b,t+k}} \tag{43}$$

where $c_{b,t}$ is bankers' consumption. $\beta_b \in]0;1[$ is the static discount factor such that bankers discount the future in the same way than households. Bankers budget constraint is

$$c_{b,t} + k_{b,t} = (1 + R_{kb,t-1} - \delta_{kb})k_{b,t-1} + j_{b,t}\,(j) \tag{44}$$

where $j_{b,t}$ is the profit payment received by bankers from bank j activity detailed by Eq. 37, $k_{b,t}$ the bank capital, $R_{kb,t-1}$ the bank capital's rental rate and δ_{kb} the bank capital depreciation rate. As bankers are the sole owners of the banks, they get all profit from intermediation activity and can only invest in bank capital. Those features allow to consider bank capital as an internal source of funding for banks. Thus, changes in equity in each period correspond to the reinvested bank earnings, i.e., profits net of the part distributed and consumed by bankers.

The maximisation of the objective function (Eq. 43) subjects to the budget constraint (Eq. 44) with respect to consumption and bank capital yields the FOC

$$c_{b,t}^{-\sigma_{b,t}} = \beta_b E_t \left[c_{b,t+1}^{-\sigma_{b,t}+1} \left(1 + R_{kb,t} - \delta_{kb}\right) \right] \tag{45}$$

2.8 Monetary policy

The model is closed with the following monetary policy reaction function

$$1 + R_t = (1 + R_{t-1})^{\rho_R} \left(\overline{\pi}^{\rho_\pi} \left(\frac{y_t}{y_{t-1}} \right)^{\rho_y} \left(1 + \overline{R}\right) \right)^{1-\rho_R} \exp\left(\varepsilon_{r,t}\right) \tag{46}$$

where ρ_π and ρ_π are policy coefficients reflecting the weight of inflation and the output gap, respectively, and the parameter $\rho_R \in]0;1[$ captures the degree of interest rate smoothing. $\varepsilon_{r,t}$ is an exogenous *ad hoc* shock that accounts for fluctuations in the nominal interest rate, and $\overline{\pi}$ can be interpreted as the steady-state inflation rate.

Some assumptions about the central bank behaviour will be made. First, we assume a standard monetary policy rule for the central bank interest rate decision as in Taylor (1993). Second, we assume that profits made by the central bank on seigniorage are rebated in a lump-sum transfer to households and entrepreneurs.

The transfer from the central bank is equal to

$$j_{cb,t} = (1 + R_t)\, m_t \tag{47}$$

2.9 Aggregation

Equilibrium in the goods market is expressed as

$$y_t = c_{p,t} + c_{i,t} + c_{e,t} + c_{b,t} + i_t + adj_t \tag{48}$$

where adj_t represent the sum of adjustment costs (adjustment cost on prices and interest rates).
Equilibrium in the housing market is given by

$$h_{p,t} + h_{i,t} = 1 \tag{49}$$

The aggregated labor is

$$l_t = l_{p,t} + l_{i,t} \tag{50}$$

The aggregated wage is

$$w_t = w_{p,t} + w_{i,t} \tag{51}$$

2.10 Stochastic structure

The structural shocks are assumed to follow a first-order autoregressive functional form such as

$$X_t = (1 - \rho_X)\,\overline{X} + \rho_X X_{t-1} + \eta_t^X \tag{52}$$

where $X_t \in \left\{\epsilon_t^z, A_{e,t}, m_{i,t}, m_{e,t}, \epsilon_t, \epsilon_t^{qk}, \varsigma_{d,t}, \varsigma_{b_i,t}, \varsigma_{b_e,t}, \sigma_{p,t}, \sigma_{i,t}, \sigma_{e,t}, \sigma_{b,t}\right\}$, $\overline{X}$ is the steady-state value of X_t, $\rho_X \in [0,1[$ is the first-order autoregressive parameter of the shock X_t and the innovation η_t^X is an $i.i.d$ normal error term with zero mean and standard deviation σ_X.

3 Estimation

We estimate our model with Bayesian techniques. In this section, we present the data, the calibration, the prior distribution of parameters, and then, we report the estimated posterior distribution of parameters. We estimate the parameters driving the model and we calibrate those determining the steady state. Our calibration allows to match the main statistics of the data.

3.1 Data

In our estimation, we use quarterly U.S. data covering the period 1975Q2 to 2018Q3. The 12 observable variables we use are the real consumption, real investment, labor, price inflation (GDP deflator), wage inflation, real housing price, Federal fund rate, nominal interest rate on loans to firms, nominal interest rate on loans to households, loan to firms, loan to households and deposits.[7] All these variables, except interest rates, are expressed in log (first) difference real terms (using the GDP deflator) as in Smets and Wouters (2007). These data are also seasonally adjusted through the standard Census X12-ARIMA(0,1,1) methodology. More information about the data transformations are available in Appendix D.4.

[7] See Appendix D for more details about these data.

3.2 Calibration

Calibrated parameters: Several structural parameter values are calibrated in line with the literature. These calibrated parameters are reported in Table 1. In particular, we calibrate $\beta_p = 0.994$ to obtain a deposit rate close to 2 percent. The discount factor of impatient households and entrepreneurs, respectively β_i and β_e are calibrated to 0.95 to ensure the binding of the collateral constraint in the steady-state.[8] The banker's discount factor β_b is assumed to be equal to that of the patient households as in Hollander and Liu (2016). The labor disutility is $\varphi = 1$ in line with the value of Gerali et al. (2010) and the index of price stickiness κ_p and price indexation ι_p are calibrated to respectively 50 and 0.15. The depreciation rate of capital δ_k is 0.025 as in Brzoza-Brzezina et al. (2013). Based on the recent U.S. commercial banks' balance sheet conditions we calibrate the bank capital share in the production function χ_b to 0.09 and the bank capital depreciation rate δ_{kb} to 0.1.

Description	**Symbol**	**Value**
Patient households' static discount factor	β_p	0.994
Impatient households' static discount factor	β_i	0.95
Entrepreneurs' static discount factor	β_e	0.95
Bankers' static discount factor	β_b	0.994
Inverse Frisch elasticity of labor supply	φ	1
Depreciation rate of physical capital	δ_k	0.025
Bank capital share in the loan production function	χ_b	0.09
Bank capital depreciation rate	δ_{kb}	0.1
Price stickiness	κ_p	50
Price indexation	ι_p	0.15
Steady state value of inflation	$\overline{\pi}$	1

Table 1: Calibrated parameters.

Prior distributions: The prior distribution of the estimated parameters are reported in Table 2 and Table 3. Priors are consistent with the previous literature. The steady-state value of RRA for all agents ($\overline{\sigma_p}$, $\overline{\sigma_i}$, $\overline{\sigma_e}$ and $\overline{\sigma_b}$) is assumed to follow a Normal distribution with a mean of 1.5 and a standard deviation of 1. The interest rate adjustment cost parameters (κ_d, κ_{bi} and κ_{be}) are calibrated in line with Hollander and Liu (2016), and are assumed to follow a Gamma distribution with a mean of 4 and a standard deviation of 1. The investment adjustment cost (κ_i) follows a Normal distribution with a mean of 10 and a standard deviation of 0.5. The LTV ratio of impatient households ($\overline{m_i}$) and entrepreneurs ($\overline{m_e}$) are close to what Gerali et al. (2010) and Iacoviello and Neri (2010) set with a prior mean of 0.75 and 0.35, respectively, and a standard deviation of 0.05 for both parameters. The prior on the parameter governing the relative weight of housing in the utility function, j, is 0.2, which is close to the calculated ratio of US residential investment

[8] In the steady-state, the borrowing constraints are binding if and only if the Lagrange multipliers (λ_i and λ_e) are greater than 0. As $\lambda_i = \frac{1}{c_i^{\sigma_{i,t}}}\left(\beta_p - \beta_i\right)$ and $\lambda_e = \frac{1}{c_e^{\sigma_{e,t}}}\left(\beta_p - \beta_e\right)$, they are greater than zero if and only if $\beta_p > \beta_i$ and $\beta_p > \beta_e$. Satisfying these constraints implies that borrowers always prefer to borrow rather than favour precautionary savings.

to GDP. The prior on the share of patient households μ is 0.8 in line with the evidence of Iacoviello and Neri (2010). The capital share in the production function α is 0.25, a value commonly used in the literature. The steady-state price markup $\overline{\epsilon}$ is calibrated to 6, leading to a price markup of 20%, a common value in the literature. For the banking parameters, only few papers estimate the values for the US in the literature. The elasticity of substitution for deposit $\overline{\varsigma_d}$ is -1.47 calculated as the average monthly spread between deposit rate[9] and the effective federal fund rate (monetary policy rate). The elasticity of substitution for impatient households $\overline{\varsigma_{bi}}$ and entrepreneurs $\overline{\varsigma_{be}}$ loans are calibrated to respectively 3.3 and 2.7 reflecting the average monthly spread between loan rate to impatient households and firms respectively and monetary policy rate. Our calibration and prior distributions allow to determine steady state ratios matching key statistics of the data.[10]

Prior name	**Distribution**	**Mean**	**Std.**	**Posterior mean**	**Posterior std.**
$\overline{\sigma_p}$	Inv. Gamma	1.5	1	2.3242	0.0144
$\overline{\sigma_i}$	Inv. Gamma	1.5	1	0.2873	0.0278
$\overline{\sigma_e}$	Inv. Gamma	1.5	1	2.0812	0.1328
$\overline{\sigma_b}$	Inv. Gamma	1.5	1	0.7347	0.0130
j	Beta	0.2	0.05	0.2610	0.0056
α	Beta	0.25	0.05	0.2695	0.0013
μ	Beta	0.8	0.05	0.8276	0.0013
$\overline{\epsilon}$	Normal	6	1	5.1196	0.0881
κ_d	Gamma	4	1	4.3344	0.0619
κ_{bi}	Gamma	4	1	3.5459	0.0723
κ_{be}	Gamma	4	1	3.8903	0.0400
κ_i	Normal	10	0.5	8.5771	0.0099
ρ_y	Beta	0.2	0.1	0.1373	0.0074
ρ_π	Normal	2	0.5	1.8726	0.0380
ρ_R	Beta	0.8	0.1	0.7947	0.0026
$\overline{m_i}$	Beta	0.75	0.05	0.7101	0.0055
$\overline{m_e}$	Beta	0.35	0.05	0.3524	0.0013
ς_{bi}	Normal	3.3	1	3.3859	0.0348
ς_{be}	Normal	2.7	1	2.5477	0.0664
ς_d	Normal	-1.47	1	-1.2266	0.0211

Table 2: Prior and posterior distributions of structural parameters.

3.3 Posterior Estimates

First, we find a heterogenous parameter of risk aversion between agents. This result is in line with behavioural economics literature pointing out that preferences are heterogeneous across agent's characteristics (Guiso and Paiella, 2008; Alan and Browning, 2010; Attanasio and Weber, 1989; Vissing-Jørgensen, 2002). They show that risk preferences differ considerably from one individual to another and are essential to explain differences in behaviour between individuals. For instance, we

[9]The deposit rate is the National Rate on Non-Jumbo Deposits obtained from FRED database
[10]For more details, see Appendix E.

find that the estimated RRA of patient households (2.3242) is higher than the impatient one (0.2873), a result in line with Hollander and Liu (2016), implying that patient households are less impacted by changes in the economic or financial environment and have a lower preference to smooth their consumption. We also find evidence that patient households are more risk-averse than entrepreneurs (2.0812), which are both more risk-averse than bankers (0.7347).

Prior name	**Distribution**	**Mean**	**Std.**	**Posterior mean**	**Posterior std.**
ρ_{A_e}	Beta	0.75	0.1	0.7270	0.0007
ρ_{m_i}	Beta	0.75	0.1	0.8873	0.0109
ρ_{m_e}	Beta	0.75	0.1	0.7110	0.0023
ρ_{ϵ_y}	Beta	0.25	0.1	0.3029	0.0063
ρ_{ς_d}	Beta	0.5	0.1	0.6466	0.0103
$\rho_{\varsigma_{b_i}}$	Beta	0.5	0.1	0.5077	0.0050
$\rho_{\varsigma_{b_e}}$	Beta	0.5	0.1	0.5489	0.0013
ρ_{σ_p}	Beta	0.5	0.1	0.4714	0.0018
$\rho_{\sigma i}$	Beta	0.5	0.1	0.3851	0.0057
ρ_{σ_e}	Beta	0.5	0.1	0.6374	0.0100
ρ_{σ_b}	Beta	0.5	0.1	0.5196	0.0037
ρ_{ϵ_z}	Beta	0.5	0.1	0.5397	0.0084
$\rho_{\epsilon_{qk}}$	Beta	0.5	0.1	0.4871	0.0049
σ_{A_e}	Inv-gamma	0.001	inf	0.0138	0.0008
σ_{R_e}	Inv-gamma	0.001	inf	0.0043	0.0003
σ_{m_i}	Inv-gamma	0.001	inf	0.1015	0.0203
σ_{m_e}	Inv-gamma	0.001	inf	0.1002	0.0160
σ_{ϵ_y}	Inv-gamma	0.001	inf	2.1359	0.5173
σ_{ς_d}	Inv-gamma	0.001	inf	4.2126	0.5138
$\sigma_{\varsigma_{b_i}}$	Inv-gamma	0.001	inf	0.3915	0.0223
$\sigma_{\varsigma_{b_e}}$	Inv-gamma	0.001	inf	0.4436	0.0294
σ_{σ_p}	Inv-gamma	0.001	inf	0.0021	0.0034
$\sigma_{\sigma i}$	Inv-gamma	0.001	inf	0.4873	0.0435
$\sigma_{\sigma e}$	Inv-gamma	0.001	inf	0.2543	0.3481
σ_{σ_b}	Inv-gamma	0.001	inf	0.1866	0.0068
σ_{ϵ_z}	Inv-gamma	0.001	inf	0.6875	0.0365
$\sigma_{\epsilon_{qk}}$	Inv-gamma	0.001	inf	0.0071	0.0017

Table 3: Prior and posterior distributions of exogenous processes.

Moreover, our estimation results highlight two empirical facts of the American banking market. First, the LTV ratio for entrepreneurs (0.3524) is lower than the impatient households' LTV ratio (0.7101) which stipulates that households can more easily collateralised their loans. Second, we find that the loan rate adjustment cost of entrepreneurs (2.5477) is smaller than the loan rate adjustment cost of impatient households (3.3859) as in Hollander and Liu (2016). This reveals that there are more frequent adjustments on the entrepreneurs than impatient households' loan rate.

4 Simulation

In this section, we study how the transmission mechanism of shocks is affected by the use of alternative values of RRA for each agent. Our model retains two categories of shocks, classified as economic (productivity, monetary policy, and price markup shocks) or financial (impatient households and entrepreneurs' LTV and loan spread shock). For the sake of simplicity, we only present the reactions of the main variables to productivity and monetary policy shocks. We perform simulations under 5 scenarii: the first one is the baseline case where each agent has the same degree of risk aversion, equal to 1 (red line). In scenario 2 (green line), 3 (black line), 4 (pink line) and 5 (red dashed line), we increase the calibrated value of RRA coefficient for each agent, patient and impatient households, entrepreneurs and bankers, respectively. The calibrated values of other variables are kept unchanged.

Simulation results are in line with the New Keynesian literature. In particular, as we assume collateral constraints for borrowers and debt contract in nominal terms, the transmission mechanisms of shocks allow a financial accelerator and a nominal debt effect, similar to (Iacoviello, 2005). Moreover, the sluggishness of the retail bank rates is another force affecting the propagation of shocks to the real economy[11] (Gerali et al., 2010).

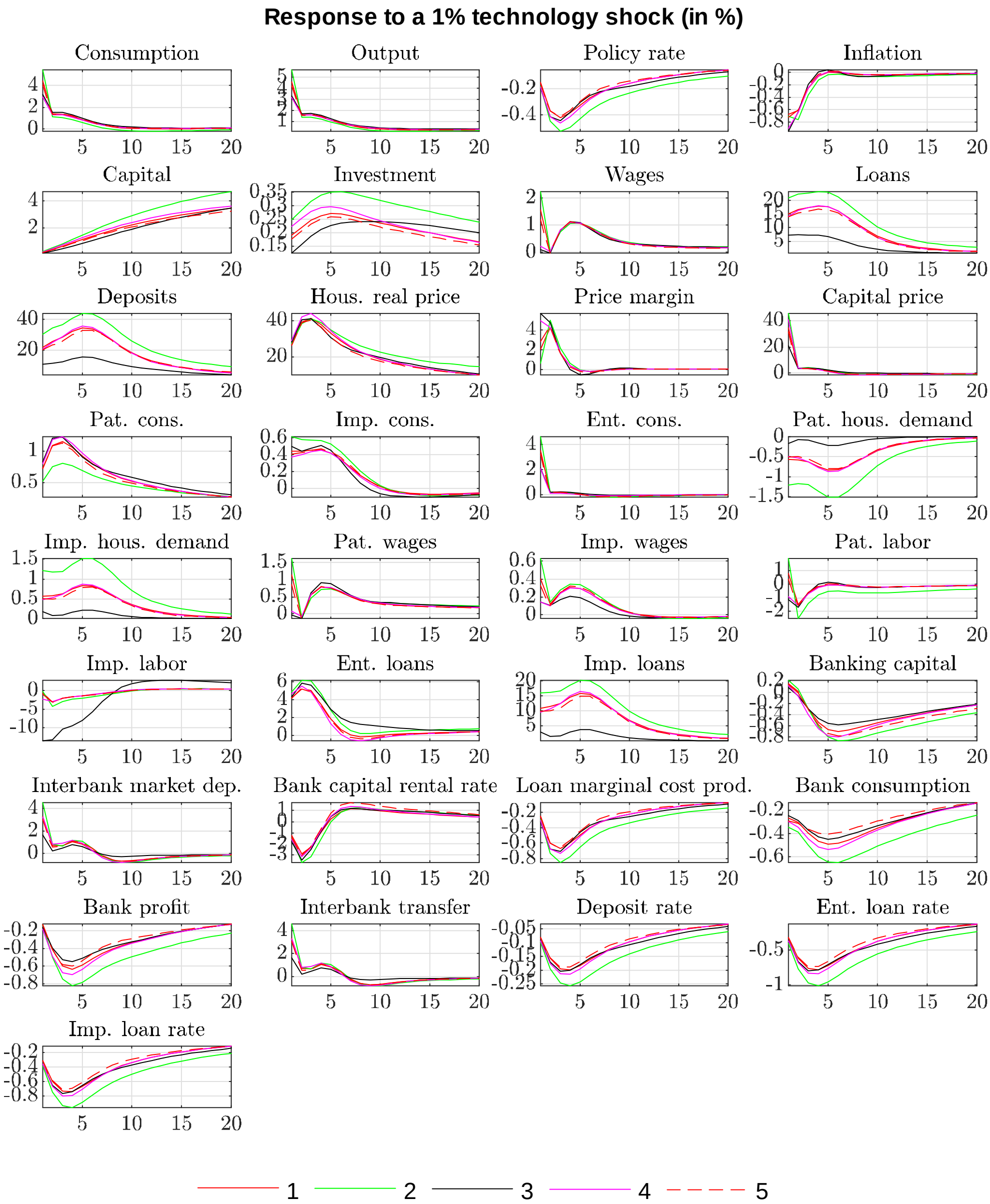
Our IRFs are affected by a change in the level of RRA, and the intensity depends on agent characteristics. In order to consider agent characteristics in our analysis, we divide them into two categories: lenders and borrowers.

4.1 Lender's RRA

We first analyse how a change in the level of RRA for lenders (patient households) affects the transmission mechanism of productivity and monetary policy shocks. We compare the baseline case (first scenario - red line) with the second scenario (green line) corresponding to an increase in patient households' RRA coefficient.

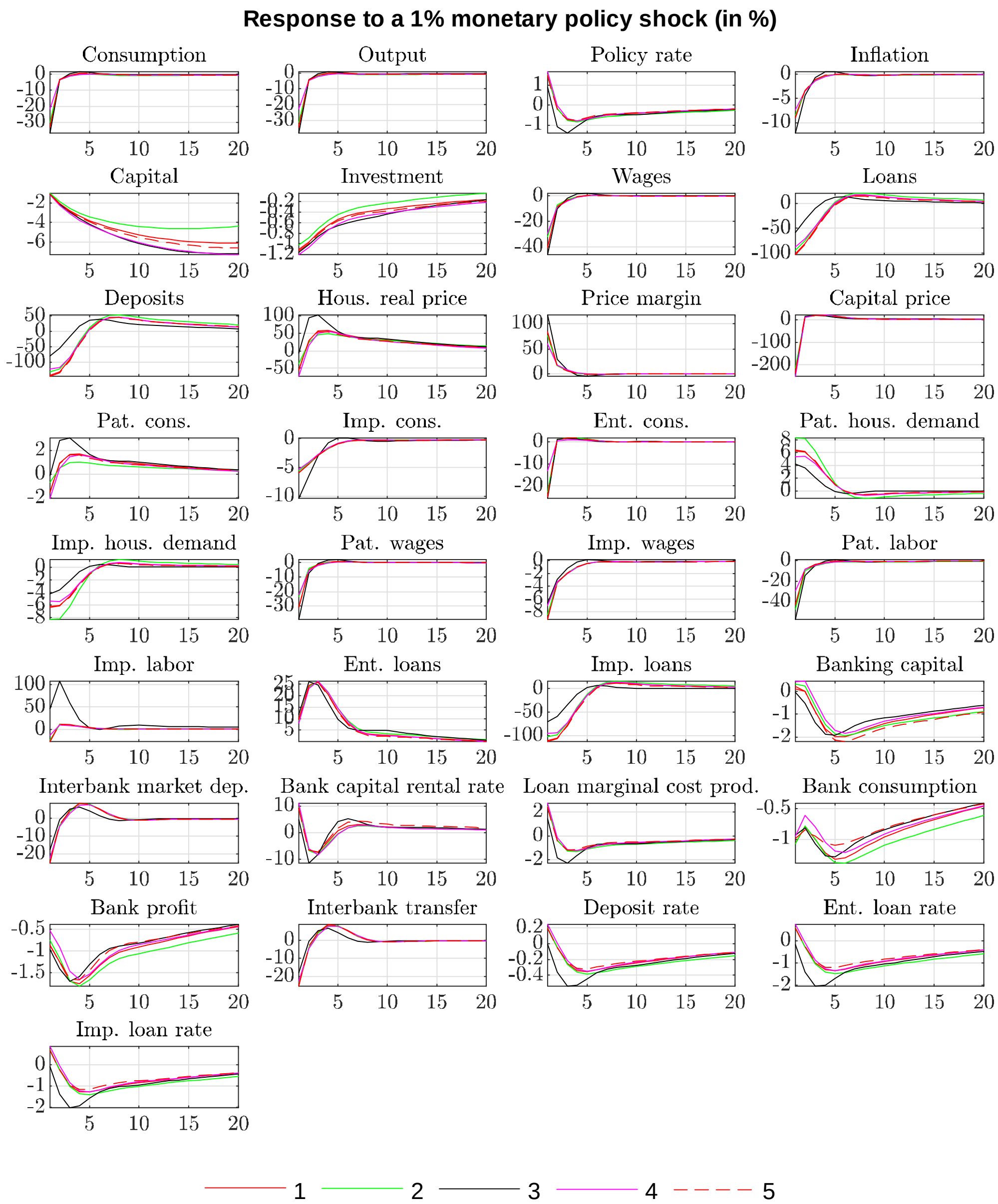
Productivity shock. IRFs of the productivity shock are reported in Fig. 4.1.The baseline case is standard: after a positive productivity shock, the real deposit rate decreases leading to an increase in consumption (Euler equation) and labor supply and a decrease in housing demand for patient households. However, we find that the intensity of the changes depends on the sensitivity of consumption to real deposit rate. In fact, the higher the degree of RRA, the less consumption is sensitive to a change in real deposit rate, meaning that patient households are less interested in smoothing consumption. This implies that the positive response of consumption is attenuated (see Eq. 3), the negative response of housing demand is amplified (see Eq. 4) and the positive response of labor supply is amplified (see Eq. 5).

[11] For more details, see Appendix F.



Impulse response functions to a 1% technology shock with the calibrated model (in %).

Monetary policy shock. IRFs of the monetary policy shock are reported in Fig. 4.1. As for the productivity shock, the baseline case is standard: after a monetary policy shock, real deposit rate increases encouraging households to postpone their consumption. As labor responds positively to the change in consumption and housing demand responds negatively, we observe a decrease in labor supply and an increase in housing demand by patient households. When the sensitivity of consumption to real deposit rate is attenuated (after an increase of the RRA coefficient), the negative response of consumption is mitigated in line with the inter-temporal smoothing effect. The response of housing demand and labor supply is then amplified.



Impulse response functions to a 1% monetary policy shock with the calibrated model (in %).

Finally, our simulation highlights that the level of present and future consumption responds to the real deposit rate. After a negative demand shock, real deposit rates increases leading to lower consumption. The impact on consumption is less important when agents are more risk-averse. Conversely, after a positive supply shock, real deposit rate decreases leading to a positive impact on consumption, and this positive impact is lower for more risk-averse agents.

4.2 Borrower's RRA

In this part, we analyse how a change in the level of risk aversion for borrowers (impatient households and entrepreneurs) affects the transmission mechanism of productivity and monetary policy shocks. We compare the baseline case (red line) with the third and fourth scenarii (black line and pink line respectively) corresponding to an increase in impatient households and entrepreneurs' RRA coefficients.

Borrowers' Euler equations (Eq. 9 and 16) are different from the Euler equation of lenders (Eq. 3) as they reveal an increase in utility of current consumption obtained from borrowing $1 + R^{b_k}$ units. The assumption of a collateral constraint always binding implies that the extra-utility of consumption is positive and increases with the level of RRA. Thus, the higher the RRA coefficient, the more extra-utility obtained from borrowing, giving the intuition that agents need to borrow less to maintain an identical utility of consumption. This assumption ($\lambda_k > 0$) is essential as the effect of borrowing on utility does not compensate the initial effect of a change in real rate of loans- this is the *the consumption smoothing effect* according to which an increase in RRA makes borrowers less sensitive to a change in real rates of loans and thus reduces the intensity of their consumption response.

Productivity shock (IRFs are presented in Fig. 4.1). After a positive productivity shock, the more risk-averse borrowers being less sensitive to changes in real rate of loans, the effect on consumption is mitigated and also the negative effect on borrowing. Thus, the responses of impatient households' housing demand and investment are attenuated.

Monetary policy shock (IRFs are presented in Fig. 4.1). After a monetary policy shock, nominal interest rates on loans rise. The increase in nominal rates leads to a decline in consumption and borrowing for all agents. However, this decline is reduced for the more risk-averse borrowers because they are less sensitive to changes in rates. Thus, the intensity of the consumption and investment response is lower for more risk-averse agents, also leading to an attenuating effect on the impatient households' demand of housing and investment.

Finally, we find that the more risk-averse borrowers are less impacted by changes in the financial market : loan variations are less important as agents are risk-averse. Increasing the impatient household and entrepreneur's RRA coefficient leads to a mitigation of the response of consumption under a *consumption smoothing effect* and, at the same time *a precautionary motive* that pushes borrowers to deleverage when real rates rise in order to maintain their consumption over time.

5 Estimation results

We study the transmission channels of a positive RRA shock for each agent: patient households, impatient households, entrepreneurs and bankers. In other words, we analyse the effect of an exogenous increase in the level of RRA, *ceteris paribus.* We find that a positive RRA shock increases real consumption in line with a *consumption smoothing effect.* In the case of borrowers, the *consumption smoothing effect* is combined with a *deleveraging effect* close to the interpretation of the precautionary motive. The impact on real interest rates is mitigated in line with Wachter (2006) and Bekaert et al. (2010). In fact, the *consumption smoothing effect* is expected to increase real rates but this effect is not straightforward when a *deleveraging effect* occurs, as the decrease in the loan demand pulls the nominal interest rate down.

5.1 Patient households RRA shock

After a patient households' RRA shock (Fig. 2) the behaviour of patient households in terms of consumption, housing demand and labor supply is affected. First, this shock leads to an increase in consumption: if agents are more risk-averse, they prefer present rather than future and uncertain consumption. Also, as RRA coefficient (σ_p) represents the inverse of inter-temporal elasticity of substitution, an increase in σ_p changes the attitude of households toward smoothing consumption between periods: agent are less interested in smoothing consumption.

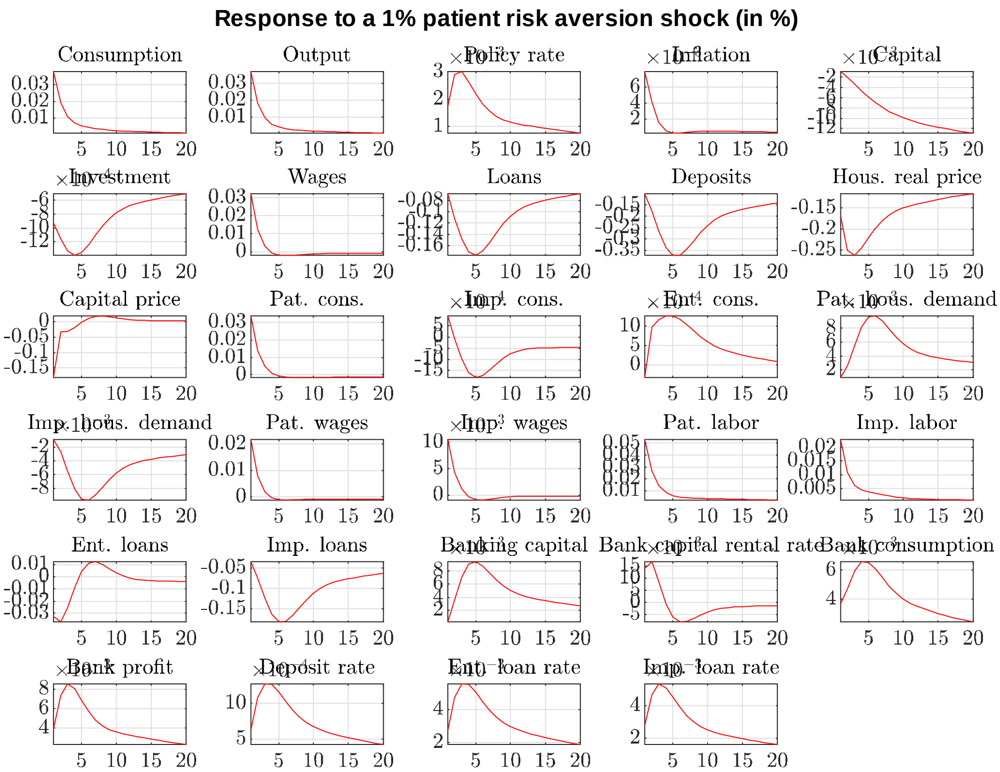
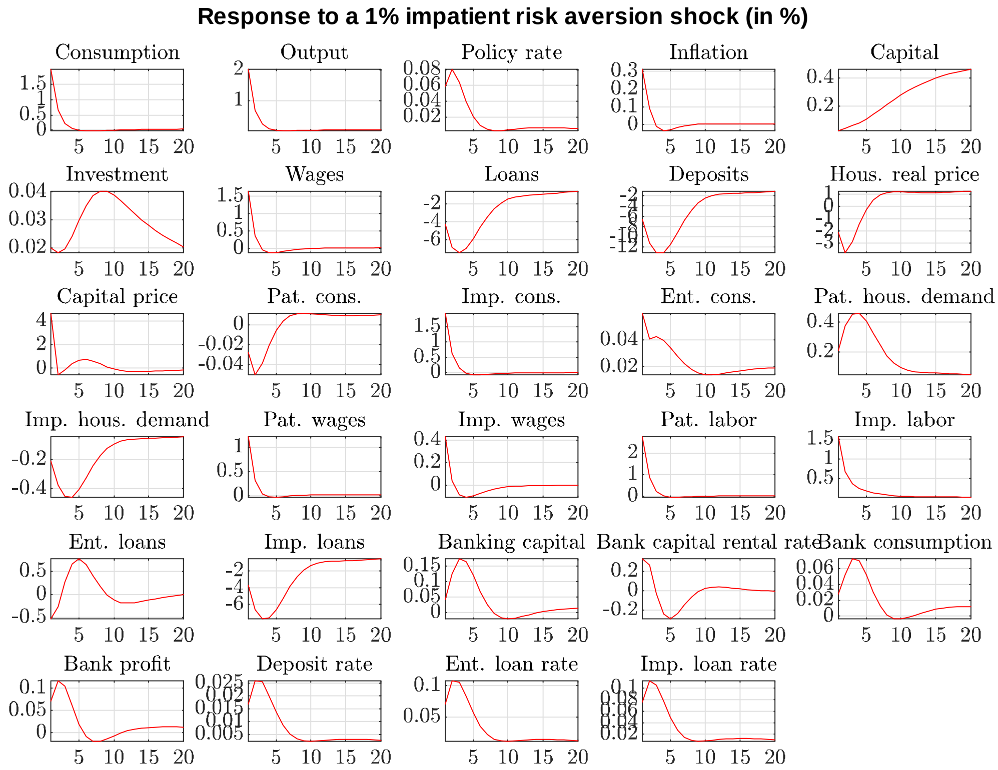


Figure 2: Impulse response functions to a 1% patient household RRA shock with the estimated model (in %).

Second, housing demand increases as we have a positive relationship between current consumption and housing demand (see Eq. 4). Labor supply decreases as we have a negative relationship between consumption and labor supply (see Eq. 5). Those effects are transmitted to the rest of the economy. Under the effect of an increase in patient households' consumption, the aggregate consumption increases, corresponding to a positive demand shock. This type of shock is characterised by an higher level of production, a rise in prices and an increase in interest rates. The rise in interest rates impairs credit conditions and eventually loan demand.

5.2 Impatient households RRA shock

The impatient households' RRA shock (Fig. 5.2) changes the behaviour of impatient households in term of consumption, housing demand and labor supply. The initial impact on consumption and labor is the same as for patient households: current consumption increases through the effect of *consumption smoothing* and labor supply decreases.

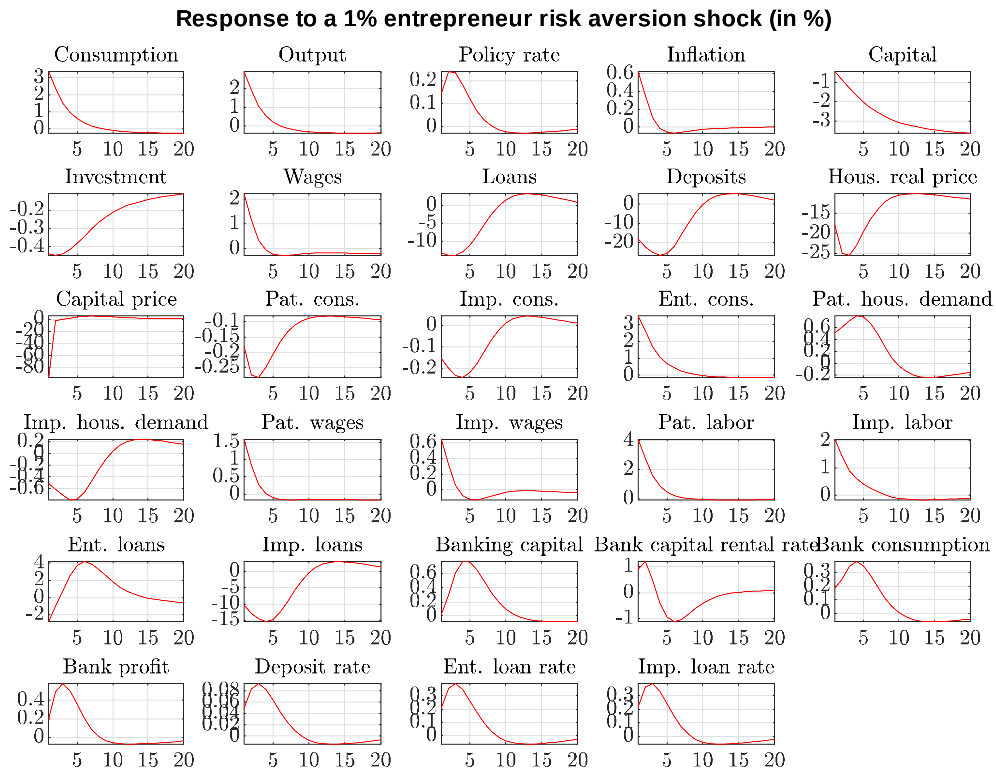


Impulse response functions to a 1% impatient household RRA shock with the estimated model (in %).

The effect on housing demand (see Eq. 10) depends positively on consumption and negatively on $\lambda_{i,t}$, corresponding to the increase of utility obtained from borrowing $\left(1 + R^{b_i}\right)$ units. The value of $\lambda_{i,t}$ is positive and increases with the level of risk aversion. Finally, we observe a decrease in housing demand for impatient households, suggesting that the *consumption smoothing effect* (positive in our case) is outweighed by the *deleveraging effect* (negative in our case). The transmission mechanism to consumption, output, inflation and policy rate are the same than for the shock on patient households.

5.3 Entrepreneurs RRA shock

The entrepreneurs' RRA shock (Fig. 5.3) affects the behaviour of entrepreneurs in term of consumption and capital demand. The effect on consumption is positive as entrepreneurs become less interested by smoothing consumption over time.

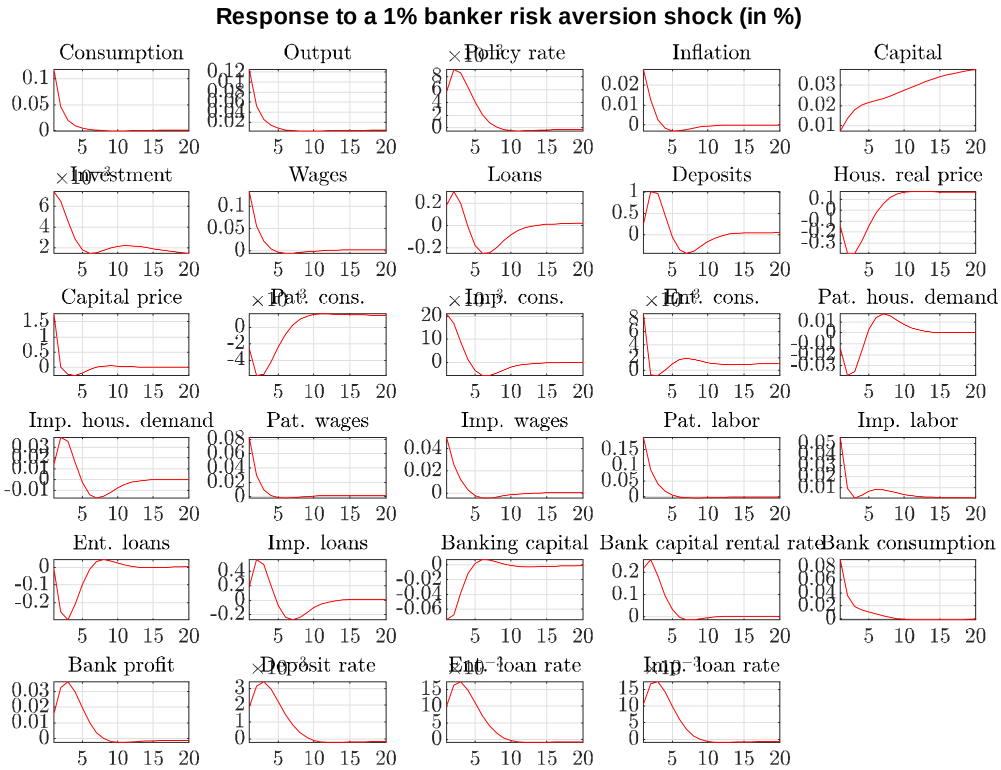


Impulse response functions to a 1% entrepreneur RRA shock with the estimated model (in %).

This positive effect on current consumption has a positive impact on capital demand (see Eq. 17), but this impact is outweighed by the negative relationship between capital demand and λ_e, which is higher when entrepreneurs are more risk-averse . Finally, we observe a negative total impact on capital demand, which reveals that the *deleveraging effect* outweighs the *consumption smoothing effect*. As for impatient households' RRA shock, the impact on entrepreneurs' loans is negative implying a negative demand shock on loan markets.

5.4 Bankers RRA shock

The bankers' RRA shock (Fig. 5.3) changes the behaviour of bankers in term of consumption (see Eq. 45). Bankers' consumption increases such that aggregate consumption, output and inflation are higher.

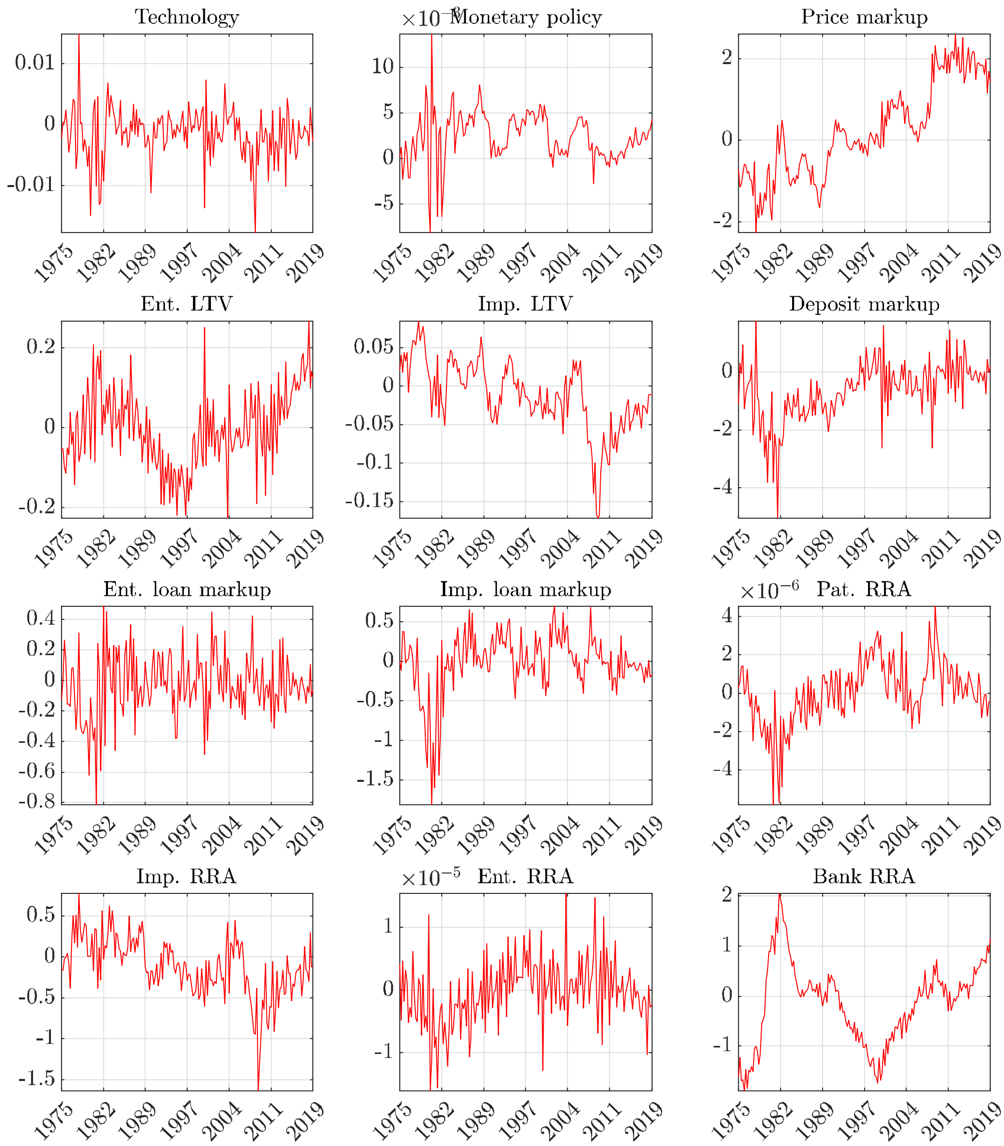


Impulse response functions to a 1% banker RRA shock with the estimated model (in %).

Transmission mechanisms on main economic variables are the same as those observed after a RRA shock on patient households. However, as bankers are more risk-averse, they are less willing to lend, which is reflected into a decrease in loans granted to impatient households and entrepreneurs

6 Estimated shocks

A visual inspection of the estimated shocks indicates if shocks are correctly distributed and allows to detect the presence of trends. Fig. 6 shows several interesting features captured by the estimated shocks such as the Lehman Brothers collapse and the corresponding RRA increase and impatient LTV decrease.



Distribution of estimated shocks

Fig. 6 reveals three main results. First, RRA is time-varying for all agents. Second, the timing of the sharp variations are different among the risk-averse agents. Especially, if we analyse the timing of the variations, Fig. 6 highlights a long period before the crisis of 2008 where bankers are governed by no risk-averse behaviours. They become risk-averse after the crisis and the amplitude of their RRA shock is higher than that of rest of the economy. Second, patient households and entrepreneurs RRA are impacted by the GFC when it occurred while the banking sector was impacted with a lag, which indicates the consequences of the GFC on the banking system was stronger than the GFC itself. Finally, we find that impatient households and bankers are the most subject to RRA shocks.

7 Policy implications

Our paper disentangles two very different key concepts, risk and risk aversion (RRA). Although it is often used in different contexts, the risk is the possibility that an outcome will not be as expected. RRA is the aversion about this possibility. Both of them may be influenced through preemptive actions, but not of the same nature. For instance, banking supervision decisions should decrease risk in the banking system. However, communication is more apt to reduce RRA. The risk can be current, past, or future. The RRA is the adjustment of the people to that very risk but one can adjust both ex-post and ex-ante, meaning anticipating the risk or reacting to the risk. It seems that consumption is indeed affected by ex-post risk aversion (EP RRA), which is directly affected by a risk shock. But it is not sure that consumption is affected by ex-ante risk aversion (EX RRA).

Moreover, RRA could explain the slow recovery of credit which has been observed following the GFC. Despite the expansionary monetary policy aimed at boosting credit, inter and intra-temporal preferences have changed the sensitivity of the response. The impact on the economy was difficult to perceive as banks struggled to grant new credit to increasingly risk-averse agents. This idea is consistent with the literature showing that access to credit over the recovery period was more demand-driven than supply-driven in line with an increase in credit rationing (Kremp and Sevestre, 2013).

8 Concluding remarks

In line with developments in behavioural economics, we introduce heterogenous and time-varying RRA in our model. First, our results confirm the existence of a heterogeneous RRA depending on agents' characteristics. We provide evidences about a level of RRA higher for patient households than for other agents giving the intuition that they are less impacted by changes in the economic and financial environment and have a lower preference to smooth their consumption over time. These realistic results disentangle the widely accepted assumption of uniform RRA assumed in the literature. Second, the analysis of estimated shocks confirms the time-varying nature of RRA, showing that after the occurrence of a crisis, agents modify their risk aversion behaviour. It also highlights the different timing of a change in RRA in response to a crisis among agents. Bankers, entrepreneurs, and households do not display the same dynamics in their RRA over time.

Taking account of those assumptions (heterogeneous and time-varying RRA), we make two sets of analysis.

We find that the presence of a higher level of RRA among agents could hinder the transmission mechanism of economic decisions. The decomposition of this transmission channel is as follows. After an economic shock, the real interest rate impacts the preferences of the agents and then their behaviour. For instance, as a result of an interest rate increase, savings are more attractive while consumption is less as it costs more to consume today than to consume in the future. As shown in this paper, RRA modifies the magnitude of this effect by influencing the agents' sensitivity to rate changes. Consequently, a risk-averse agent will lower his consumption and increase his savings, but to a lesser extent. The expected effect of economic policy will, therefore, be mitigated.

Second, we analyse the transmission mechanism that appears when the RRA undergoes an exogenous shock. As we have shown, this may be the case following serious financial crisis event such as a bank collapse. In this context, given the inverse relationship between the aversion and the inter-temporal substitution effect, two dimensions related to the rise of the RRA should be taken into account: an inter-temporal dimension and an intra-temporal dimension. Regarding the inter-temporal dimension, the drop in the inter-temporal substitution effect leads to an increase in the current consumption. This effect, known as the *consumption smoothing effect*, smooths agent's consumption over time. Thus, all agents show the same response to a positive RRA shock by increasing their current consumption. Concerning the intra-temporal dimension, RRA changes lead agents to adopt less risky behaviours. Borrowers are, therefore, seeking to deleverage in order to maintain their future consumption. Thus, following a positive shock of aversion, borrowers lower the amount of new loans which contributed to lower the investment and the purchase of housings.

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Appendix

A Model Summary

This section presents the theoretical equations of our model

$$c_{p,t} + q_{h,t}\left(h_{p,t} - h_{p,t-1}\right) + d_t = \frac{1 + R^d_{t-1}}{\pi_t} d_{t-1} + w_{p,t} l_{p,t} + \tau_{p,t} \tag{53}$$

$$c_{p,t}^{-\sigma_{p,t}} = \beta_p E_t \left[\frac{1 + R^d_t}{\pi_{t+1}} c_{p,t+1}^{-\sigma_{p,t+1}}\right] \tag{54}$$

$$\frac{j}{h_{p,t}} = q_{h,t} c_{p,t}^{-\sigma_{p,t}} - \beta_p E_t \left[q_{h,t+1} c_{p,t+1}^{-\sigma_{p+1}}\right] \tag{55}$$

$$l_{p,t}^{\varphi} = w_{p,t} c_{p,t}^{-\sigma_{p,t}} \tag{56}$$

$$c_{i,t} + q_{h,t}\left(h_{p,t} - h_{p,t-1}\right) + \frac{1 + R^{b_i}_{t-1}}{\pi_t} b_{i,t-1} = b_{i,t} + w_{i,t} l_{i,t} + \tau_{i,t} \tag{57}$$

$$\left(1 + R^{b_i}_t\right) b_{i,t} \leq E_t \left[m_{i,t} q_{h,t+1} h_{i,t} \pi_{t+1}\right] \tag{58}$$

$$c_{i,t}^{-\sigma_{i,t}} = \beta_i E_t \left[\frac{1 + R^{b_i}_t}{\pi_{t+1}} c_{i,t+1}^{-\sigma_{i,t+1}}\right] + \lambda_{i,t}\left(1 + R^{b_i}_t\right) \tag{59}$$

$$\frac{j}{h_{i,t}} = q_{h,t} c_{i,t}^{-\sigma_{i,t}} - \beta_i E_t \left[q_{h,t+1} c_{i,t+1}^{-\sigma_{i+1}} + \lambda_{i,t} m_{i,t} q_{h,t+1} \pi_{t+1}\right] \tag{60}$$

$$l_{i,t}^{\varphi} = w_{i,t} c_{i,t}^{-\sigma_{i,t}} \tag{61}$$

$$y_t = A_t k_{e,t-1}^{\alpha} l_{p,t}^{\mu(1-\alpha)} l_{i,t}^{(1-\mu)(1-\alpha)} \tag{62}$$

$$c_{e,t} + \frac{1 + R^{b_e}_{t-1}}{\pi_t} b_{e,t-1} + w_{p,t} l_{p,t} + w_{i,t} l_{i,t} + q_{ke,t} k_{e,t} = \frac{y_t}{x_t} + b_{e,t} + q_{ke,t}\left(1 - \delta_{ke}\right) k_{e,t-1} + \tau_{e,t} \tag{63}$$

$$\left(1 + R^{b_e}_t\right) b_{e,t} \leq E_t \left[m_{e,t} q_{ke,t+1}\left(1 - \delta_{ke}\right) k_{e,t} \pi_{t+1}\right] \tag{64}$$

$$c_{e,t}^{-\sigma_{e,t}} = \beta_e E_t \left[\frac{R^{b_e}_t}{\pi_{t+1}} c_{e,t+1}^{-\sigma_{e,t+1}}\right] + \lambda_{e,t}\left(1 + R^{b_e}_t\right) \tag{65}$$

$$c_{e,t}^{-\sigma_{e,t}} q_{ke,t} = \beta_e E_t \left[c_{e,t+1}^{-\sigma_{e,t+1}} \left(\alpha \frac{y_{t+1}}{x_{t+1} k_{e,t}} + q_{ke,t+1}\left(1 - \delta_{ke}\right)\right) + \lambda_{e,t} m_{e,t} q_{ke,t+1} \pi_{t+1}\left(1 - \delta_{ke}\right)\right] \tag{66}$$

$$w_{p,t} = \frac{\mu\left(1 - \alpha\right)}{l_{p,t}} \frac{y_t}{x_t} \tag{67}$$

$$w_{i,t} = \frac{\left(1 - \mu\right)\left(1 - \alpha\right)}{l_{p,t}} \frac{y_t}{x_t} \tag{68}$$

$$\pi^*_t x_{2,t} = \frac{\epsilon_y}{\epsilon_y - 1} x_{1,t} \tag{69}$$

$$1 = \theta \pi_t^{\epsilon - 1} + \left(1 - \theta\right)\left(\pi^*_t\right)^{1-\epsilon} \tag{70}$$

$$x_{2,t} = c_{p,t}^{-\sigma_p} Y_t + \beta^p \theta E_t \pi_{t+1}^{\epsilon-1} x_{2,t+1} \tag{71}$$

$$x_1 = c_{p,t}^{-\sigma_p} Y_t \frac{1}{X_t} + \beta^p \theta E_t \pi_{t+1}^{\epsilon} x_{1,t+1} \tag{72}$$

$$k_{e,t} = (1-\delta_{ke}) k_{e,t-1} + \left[1 - \frac{\kappa_i}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t \tag{73}$$

$$1 = q_k \left(1 - \frac{\kappa_i}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right) - \kappa_i \left(\frac{i_t}{i_{t-1}} - 1\right)\left(\frac{i_t}{i_{t-1}}\right) + \beta_e \left(\frac{c_{e,t+1}}{c_{e,t}}\right)^{-\sigma_{e,t}} q_k \kappa_i \left(\frac{i_{t+1}}{i_t} - 1\right)\left(\frac{i_{t+1}}{i_t}\right)^2 \tag{74}$$

$$b_{e,t}(j) + b_{i,t}(j) = A_{b,t} k_{b,t-1}^{\chi_b}(j) \left(m_t(j) + d_t(j)\right)^{1-\chi_b} \tag{75}$$

$$mc_{b,t}(j) = \frac{1}{A_{b,t}} \frac{R_t^{1-\chi_b} R_{kb,t}^{\chi_b}}{(1-\chi_b)^{1-\chi_b} \chi_b^{-\chi_b}} \tag{76}$$

$$\frac{m_t(j) + d_t(j)}{k_{b,t-1}(j)} = \frac{R_{kb,t}}{R_t} \frac{1-\chi_b}{\chi_b} \tag{77}$$

$$j_{b,t}(j)\,\pi_{t+1} = \begin{array}{c} R_t^{b_e}(j)\, b_{e,t}(j) + R_t^{b_i}(j)\, b_{i,t}(j) - mc_{b,t}(j)\left(b_{e,t}(j) + b_{i,t}(j)\right) \\ + \left(R_t - R_t^d(j)\right) d_t(j) - \sum_{k=d,b_i,b_e} \frac{\kappa_k}{2}\left(\frac{R_t^k(j)}{R_{t-1}^k(j)} - 1\right)^2 R_t^k k_t \end{array} \tag{78}$$

$$\begin{gathered} -1 + \varsigma_{d,t} - \varsigma_{d,t} \frac{R_t}{R_t^d} - \kappa_d \left(\frac{R_t^d}{R_{t-1}^d} - 1\right) \frac{R_t^d}{R_{t-1}^d} + \\ \beta_b E_t \left[\frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}} \kappa_d \left(\frac{R_{t+1}^d}{R_t^d} - 1\right)\left(\frac{R_{t+1}^d}{R_t^d}\right)^2 \frac{d_{t+1}}{d_t}\right] \end{gathered} \tag{79}$$

$$\begin{gathered} 1 - \varsigma_{b_i,t} + \varsigma_{b_i,t} \frac{mc_{b,t}}{R_t^{b_i}} - \kappa_{b_i} \left(\frac{R_t^{b_i}}{R_{t-1}^{b_i}} - 1\right) \frac{R_t^{b_i}}{R_{t-1}^{b_i}} + \\ \beta_b E_t \left[\kappa_{b_i} \frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}} \left(\frac{R_{t+1}^{b_i}}{R_t^{b_i}} - 1\right)\left(\frac{R_{t+1}^{b_i}}{R_t^{b_i}}\right)^2 \frac{b_{i,t+1}}{b_{i,t}}\right] \end{gathered} \tag{80}$$

$$\begin{gathered} 1 - \varsigma_{b_e,t} + \varsigma_{b_e,t} \frac{mc_{b,t}}{R_t^{b_e}} - \kappa_{b_e} \left(\frac{R_t^{b_e}}{R_{t-1}^{b_e}} - 1\right) \frac{R_t^{b_e}}{R_{t-1}^{b_e}} + \\ \beta_b E_t \left[\kappa_{b_e} \frac{c_{b,t+1}^{-\sigma_{b,t+1}}}{c_{b,t}^{-\sigma_t}} \left(\frac{R_{t+1}^{b_e}}{R_t^{b_e}} - 1\right)\left(\frac{R_{t+1}^{b_e}}{R_t^{b_e}}\right)^2 \frac{b_{e,t+1}}{b_{e,t}}\right] \end{gathered} \tag{81}$$

$$c_{b,t} + k_{b,t} = (1 + R_{kb,t-1} - \delta_{kb}) k_{b,t-1} + j_{b,t}(j) \tag{82}$$

$$c_{b,t}^{-\sigma_{b,t}} = \beta_b E_t \left[c_{b,t+1}^{-\sigma_{b,t}+1} \left(1 + R_{kb,t} - \delta_{kb}\right)\right] \tag{83}$$

$$1 + R_t = (1 + R_{t-1})^{\rho_R} \left(\overline{\pi}^{\rho_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\rho_y} \left(1 + \overline{R}\right)\right)^{1-\rho_R} \exp\left(\varepsilon_{r,t}\right) \tag{84}$$

$$j_{cb,t} = (1 + R_t)\, m_t \tag{85}$$

$$y_t = c_{p,t} + c_{i,t} + c_{e,t} + c_{b,t} + i_t + adj_t \tag{86}$$

$$h_{p,t} + h_{i,t} = 1 \tag{87}$$

$$l_t = l_{p,t} + l_{i,t} \tag{88}$$

$$w_t = w_{p,t} + w_{i,t} \tag{89}$$

B Steady-state

The equilibrium is an allocation $\{y, c_p, c_i, c_e, c_b, d, b_i, b_e, l_p, l_i, h_p, h_i, i, k, k_b, j_b, j_{cb}\}$ together with the sequence of value $\left\{P, P^*, x, R, \lambda_i, \lambda_e, q_h, q_k, w_p, w_i, R^d, R^{b_i}, R^{b_e}, R_{kb}\right\}$. One can always normalize the technology parameter A so that $y = 1$ in steady-state, so the trick is to express all the variables as a ratio to y.

$$y = 1 \tag{90}$$

$$\pi = 1 \tag{91}$$

$$\pi^* = 1 \tag{92}$$

$$q_k = 1 \tag{93}$$

$$x = \frac{\epsilon}{\epsilon - 1} \tag{94}$$

$$R^d = \frac{\pi}{\beta^p} - 1 \tag{95}$$

$$R = \frac{\varsigma_d - 1}{\varsigma_d} R^d \tag{96}$$

$$R_{kb} = \frac{1}{\beta_b} - 1 + \delta_b \tag{97}$$

$$mc_b = \frac{R_{kb}^{\chi_b} R^{1-\chi_b}}{\chi_b^{\chi_b} (1 - \chi_b)^{(1-\chi_b)}} \tag{98}$$

$$R^{b_i} = \frac{\varsigma_{b_i}}{\varsigma_{b_i} - 1} mc_b \tag{99}$$

$$R^{b_e} = \frac{\varsigma_{b_e}}{\varsigma_{b_e} - 1} mc_b \tag{100}$$

$$b_e = \frac{\beta^e \mu Y m_e \pi (1 - \delta_k)}{x (1 + R^{b_e})} \frac{1}{1 - \beta_e (1 - \delta_k) - \left(\frac{1}{1+R^{e_e}} - \frac{\beta_e}{\pi}\right) m_e \pi (1 - \delta_k)} \tag{101}$$

$$k_e = \frac{\left(1 + R^{b_e}\right) b_e}{m_e \pi q_k (1 - \delta_k)} \tag{102}$$

$$i = \delta_k k_e \tag{103}$$

$$k_b = \frac{(b_e + b_i)}{\left(\frac{R_{kb}}{R}\left(\frac{1-\chi_b}{\chi_b}\right)\right)^{(1-\chi_b)}} \tag{104}$$

$$m = \frac{k_b \frac{R_{kb}}{R}\left(\frac{1-\chi_b}{\chi_b}\right) R + mc_b\,(b_e + b_i) + \delta_k k_e\,(1 - q_k) + (R_{kb} - \delta_{kb})\, k_b}{-3 - 2R} \tag{105}$$

$$d = k_b \frac{R_{kb}}{R}\left(\frac{1-\chi_b}{\chi_b}\right) - m \tag{106}$$

$$j_{cb} = (1 + R)\, m \tag{107}$$

$$j_b = R^{b_e} b_e + R^{b_i} b_i - mc_b\,(b_e + b_i) + \left(R - R^d\right) d \tag{108}$$

$$c_p = d\left(\frac{1+R^d}{\pi} - 1\right) + \alpha\,(1-\mu)\,\frac{y}{x} + \left(1 - \frac{1}{x}\right) Y + j_{cb} \tag{109}$$

$$c_i = b_i\left(1 - \frac{1+R^{b_i}}{\pi}\right) + (1-\alpha)\,(1-\mu)\,\frac{y}{x} + j_{cb} \tag{110}$$

$$c_e = \frac{y}{x} + b_e\left(1 - \frac{1+R^{b_e}}{\pi}\right) - \alpha\,(1-\mu)\,\frac{y}{x} - (1-\alpha)\,(1-\mu)\,\frac{y}{x} - q_k k_e \delta_k + j_{cb} \tag{111}$$

$$\lambda_i = c_i^{-\sigma_i}\left(\frac{1}{(1+R^{b_i})} - \frac{\beta_i}{\pi}\right) \tag{112}$$

$$\lambda_e = c_e^{-\sigma_e}\left(\frac{1}{(1+R^{b_e})} - \frac{\beta_e}{\pi}\right) \tag{113}$$

$$h_p = \frac{j}{c_p^{-\sigma_p}\left(1 - \beta_p\right)}\left(\frac{1}{q_h}\right) \tag{114}$$

$$h_i = \frac{b_i\left(1 + R^{b_i}\right)}{m_i \pi}\left(\frac{1}{q_h}\right) \tag{115}$$

$$q_h = \frac{j}{c_p^{-\sigma_p}\left(1 - \beta_p\right)} + \frac{b_i\left(1 + R^{b_i}\right)}{m_i \pi} \tag{116}$$

$$w_p = \alpha\,(1-\mu)\,\frac{y}{x l_p} \tag{117}$$

$$l_p = \left(\alpha\,(1-\mu)\,\frac{y}{x} c_p^{-\sigma_p}\right)^{1/(\varphi+1)} \tag{118}$$

$$w_i = (1-\alpha)\,(1-\mu)\,\frac{y}{x l_i} \tag{119}$$

$$l_i = \left((1-\alpha)\,(1-\mu)\,\frac{y}{x} c_i^{-\sigma_i}\right)^{1/(\varphi+1)} \tag{120}$$

$$A = \frac{Y}{k_e^{\mu} l_p^{\alpha(1-\mu)} l_i^{(1-\alpha)(1-\mu)}} \tag{121}$$

$$l = l_p + l_i \tag{122}$$

$$w = w_p + w_i \tag{123}$$

$$x_1 = \frac{c_p^{-\sigma_p} \frac{1}{X} Y}{1 - \beta^p \theta \pi^{\epsilon}} \tag{124}$$

$$x_2 = \frac{c_p^{-\sigma_p} Y}{1 - \beta^p \theta \pi^{\epsilon - 1}} \tag{125}$$

C Marginal cost of producing loans

Banker wants to minimise costs from bank equity $k_{b,t}$ and from getting funds on monetary market and deposits $(m_t + d_t)$, which come at factor prices $R_{kb,t}$ and R_t, respectively, subject to a Cobb and Douglas (1928) production function of loans $b_{e,t} + b_{i,t} = k_{b,t}^{\chi_b} (m_t + d_t)^{1-\chi_b}$. The minimal cost is given by the following problem

$$C = \min_{k_{b,t}, m_t + d_t} R_{kb,t} k_{b,t} + R_t (m_t + d_t) \tag{126}$$

such that

$$b_{e,t} + b_{i,t} = k_{b,t}^{\chi_b} (m_t + d_t)^{1-\chi_b} \tag{127}$$

We solve the constraint for $k_{b,t}$ and we get

$$k_{b,t} = \left(\frac{b_{e,t} + b_{i,t}}{(m_t + d_t)^{1-\chi_b}} \right)^{\frac{1}{\chi_b}} \tag{128}$$

We can rewrite the minimal cost

$$C = \min_{k_{b,t}, m_t + d_t} R_{kb,t} \left(\frac{b_{e,t} + b_{i,t}}{(m_t + d_t)^{1-\chi_b}} \right)^{\frac{1}{\chi_b}} + R_t (m_t + d_t) \tag{129}$$

The first order condition of that problem is

$$R_t = \frac{1 - \chi_b}{\chi_b} R_{kb,t} \left(\frac{b_{e,t} + b_{i,t}}{(m_t + d_t)} \right)^{\frac{1}{\chi_b}} \tag{130}$$

$$= \frac{1 - \chi_b}{\chi_b} R_{kb,t} \left(\frac{k_{b,t}}{(m_t + d_t)} \right)^{\frac{1}{\chi_b}} \tag{131}$$

The optimal use of monetary and deposit funds $((m_t + d_t)^*)$ in the production function of loans is

$$(m_t + d_t)^* = \left(\frac{1 - \chi_b}{\chi_b} \frac{R_{kb,t}}{R_t} \right)^{\chi_b} (b_{e,t} + b_{i,t}) \tag{132}$$

Putting it into the constraint we gat the optimal use of capital $k_{b,t}^*$

$$k_{b,t}^* = \left(\frac{\chi_b}{1 - \chi_b} \frac{R_t}{R_{kb,t}} \right)^{1-\chi_b} (b_{e,t} + b_{i,t}) \tag{133}$$

Now plugging $(m_t + d_t)^*$ and $k_{b,t}^*$ into the initial minimisation problem, we get

$$
\begin{aligned}
C^* &= \left[R_{kb,t}\left(\frac{\chi_b}{1-\chi_b}\frac{R_t}{R_{kb,t}}\right)^{1-\chi_b} + R_t\left(\frac{1-\chi_b}{\chi_b}\frac{R_{kb,t}}{R_t}\right)^{\chi_b}\right](b_{e,t}+b_{i,t}) && (134)\\
&= \left[\left(\frac{\chi_b}{1-\chi_b}\right)^{1-\chi_b} + \left(\frac{1-\chi_b}{\chi_b}\right)^{\chi_b}\right] R_{kb,t}^{\chi_b} R_t^{1-\chi_b}(b_{e,t}+b_{i,t}) && (135)\\
&= \left[\frac{1-\chi_b+\chi_b}{(1-\chi_b)^{1-\chi_b}\,\chi_b^{\chi_b}}\right] R_{kb,t}^{\chi_b} R_t^{1-\chi_b}(b_{e,t}+b_{i,t}) && (136)\\
&= \left(\frac{R_{kb,t}}{\chi_b}\right)^{\chi_b}\left(\frac{R_t}{(1-\chi_b)}\right)^{1-\chi_b}(b_{e,t}+b_{i,t}) && (137)
\end{aligned}
$$

The marginal cost of producing loans is equal to the derivative of cost in relation to loans $(b_{e,t}+b_{i,t})$

$$
mc_{b,t} = \left(\frac{R_{kb,t}}{\chi_b}\right)^{\chi_b}\left(\frac{R_t}{(1-\chi_b)}\right)^{1-\chi_b} \qquad (138)
$$

D Data

This section presents the data used in our Bayesian estimation, the measurement equation and the data transformations performed in order to match the data to the variables of the model.

All the following data are collected from FRED, Federal Reserve Bank of St. Louis. The code in parenthesis correspond to the identifier of the series.

D.1 Economic data

Real gross domestic product: billions of chained 2012 dollars, quarterly, seasonally adjusted annual rate (GDPC1).
Real investment: fixed private investment, billions of dollars,quarterly, seasonally adjusted annual rate (FPI).
Labor: nonfarm business sector, average weekly hours, Index 2012=100, quarterly, seasonally adjusted (PRS85006023).
Price inflation: gross domestic product, implicit price deflator, Index 2012=100,quarterly, seasonally adjusted (GDPDEF).
Real wage: nonfarm business sector: compensation per hour, Index 2012=100,quarterly, seasonally adjusted (COMPNFB).
Real housing price: all transaction house price index for the united states, Index 1980:Q1=100,quarterly, not seasonally adjusted (USSTHPI).
Federal fund rate: effective Federal Funds Rate, percent,quarterly, not seasonally adjusted (FEDFUNDS).
Population: civilian noninstitutional population (CNP16OV).

Description	**Symbol**
RRA of patient households	σ_p
RRA of impatient households	σ_i
RRA of entrepreneurs	σ_e
RRA of bankers	σ_b
Deposit rate's adjustment cost	κ_d
Impatient household loan rate's adjustment cost	κ_{bi}
Entrepreneur loan rate's adjustment cost	κ_{be}
Investment adjustment cost	κ_i
Real output gap growth weight in the monetary policy rule	ρ_y
Inflation weight in the monetary policy rule	ρ_π
Interest rate smoothing in the monetary policy rule	ρ_R
Steady-state loan-to-value ratio of impatient households	$\overline{m_i}$
Steady-state loan-to-value ratio of entrepreneurs	$\overline{m_e}$
Capital's share in production function	α
Share of patient households	μ
Share of housing in utility function	j
Deposit rate adjustment cost	ς_d
Entrepreneurs' loan rate adjustment cost	ς_{be}
Impatient households' loan rate adjustment cost	ς_{bh}
Autoregressive parameter of the technology shock	ρ_{A_e}
Autoregressive parameter of the impatient households LTV shock	ρ_{m_i}
Autoregressive parameter of the entrepreneurs LTV shock	ρ_{m_e}
Autoregressive parameter of the patient households aversion shock	ρ_{σ_o}
Autoregressive parameter of the impatient households aversion shock	ρ_{σ_i}
Autoregressive parameter of the entrepreneurs aversion shock	ρ_{σ_e}
Autoregressive parameter of the bankers aversion shock	ρ_{σ_b}
Autoregressive parameter of the price mark-up shock	ρ_{ϵ_y}
Autoregressive parameter of the deposit mark-up shock	ρ_{ς_d}
Autoregressive parameter of the impatient households' loan mark-up shock	$\rho_{\varsigma_{b_i}}$
Autoregressive parameter of the entrepreneurs' loan mark-up shock	$\rho_{\varsigma_{b_e}}$
Autoregressive parameter of the preference shock	ρ_{ϵ_z}
Autoregressive parameter of the investment shock	$\rho_{\epsilon_{qk}}$
Standard error of the technology shock	σ_{A_e}
Standard error of monetary policy shock	σ_{R_e}
Standard error of the impatient households LTV shock	σ_{m_i}
Standard error of the entrepreneurs LTV shock	σ_{m_e}
Standard error of the patient households aversion shock	σ_{σ_o}
Standard error of the impatient households aversion shock	σ_{σ_i}
Standard error of the entrepreneurs aversion shock	σ_{σ_e}
Standard error of the bankers aversion shock	σ_{σ_b}
Standard error of the price mark-up shock	σ_{ϵ_y}
Standard error of the deposit mark-up shock	σ_{ς_d}
Standard error of the impatient households' loan mark-up shock	$\sigma_{\varsigma_{b_i}}$
Standard error of the entrepreneurs' loan mark-up shock	$\sigma_{\varsigma_{b_e}}$
Standard error of the preference shock	σ_{ϵ_z}
Standard error of the investment shock	$\sigma_{\epsilon_{qk}}$

Table 4: Definition of the estimated parameters.

D.2 Financial data

Deposit (DEP): deposits, all commercial banks, billions of U.S. dollars, seasonally adjusted (DPSACBM027SBOG).
Loan to firms (LTF) = (NCBDBIQ027S) + (BLNECLBSNNCB) + (OLALBSNNCB)+ (NNBDILNECL) + (OLALBSNNB) + (MLBSNNCB) + (NNBTML).
Loan to households (LTHH) = (HNOTMLQ027S) + (CCLBSHNO).
Nominal interest rate on loans to firms (NIROLTF) = (AAA) * (NCBDBIQ027S)/Loan to firms + (MPRIME) * ((BLNECLBSNNCB) + (OLALBSNNCB) + (NNBDILNECL) + (OLALBSNNB))/Loan to firms + (MORTGAGE30US) * ((MLBSNNCB)+(NNBTML))/Loan to firms.
Nominal interest rate on loans to households (NIROLTHH) = (MORTGAGE30US) * (HNOTMLQ027S)/Loan to households + (TERMCBAUTO48NS) * (CCLBSHNO)/Loan to households.

D.3 Data used to calculate financial data

(NCBDBIQ027S) : Nonfinancial corporate business, debt securities; liability, level, millions of dollars, not seasonally adjusted.
(BLNECLBSNNCB): Nonfinancial corporate business, depository institution loans not elsewhere classified; liability, level, billions of dollars, not seasonally adjusted.
(OLALBSNNCB): Nonfinancial corporate business; other loans and advances; liability, billions of dollars, not seasonally adjusted.
(NNBDILNECL): Nonfinancial noncorporate business; depository institution loans not elsewhere classified; liability, billions of dollars, not seasonally adjusted.
(OLALBSNNB): Nonfinancial noncorporate business; other loans and advances; liability, level, billions of dollars, not seasonally adjusted.
(MLBSNNCB): Nonfinancial corporate business; total mortgages; liability, billions of dollars, not seasonally adjusted.
(NNBTML): Nonfinancial noncorporate business; total mortgages; liability, level, billions of dollars, not seasonally adjusted.
(HNOTMLQ027S): Households mortgage: households and nonprofit organizations; total mortgages; liability, level, millions of dollars, not seasonally adjusted.
(CCLBSHNO): Households consumer loans: households and nonprofit organizations; consumer credit; liability, level, billions of dollars, not seasonally adjusted.
(AAA): Moody's Seasoned AAA Corporate Bond Yield: percent, not seasonally adjusted.
(MPRIME): Bank Prime Loan Rate: percent, not seasonally adjusted.
(MORTGAGE30US): 30-Year Fixed Rate Mortgage Average in the United States: percent, not seasonally adjusted.
(TERMCBAUTO48NS): Finance rate on consumer installment loans at commercial banks: new autos 48 month loan, percent, not seasonally adjusted.

D.4 Data transformation

As in Smets and Wouters (2003, 2007), the following data transformations are requested to estimate the model with relevant data:

$$GDP_t = 100 \ln \left(\frac{GDPC1_t}{CNP16OV_t} \right) \tag{139}$$

$$INV_t = 100 \ln \left(\left(\frac{FPI_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{140}$$

$$WAGE_t = 100 \ln \left(\left(\frac{COMPNFB_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{141}$$

$$LABOR_t = 100 \ln \left(PRS85006023_t \left(\frac{CE16OV_t}{100} \right) CNP16OV_t^{-1} \right) \tag{142}$$

$$INF_t = 100 \ln \left(\frac{GDPDEF_t}{GDPDEF_{t-1}} \right) \tag{143}$$

$$QINF_t = 100 \ln \left(\left(\frac{USSTHPI_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{144}$$

$$RATE_t = \frac{FEDFUNDS_t}{4} \tag{145}$$

$$HHRATE_t = \frac{NIROLTF_t}{4} \tag{146}$$

$$ENTRATE_t = \frac{NIROLTHH_t}{4} \tag{147}$$

$$ENTLOAN_t = 100 \ln \left(\left(\frac{LTF_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{148}$$

$$HHLOAN_t = 100 \ln \left(\left(\frac{LTHH_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{149}$$

$$DEPOSIT_t = 100 \ln \left(\left(\frac{DEP_t}{GDPDEF_t} \right) CNP16OV_t^{-1} \right) \tag{150}$$

where $CE16OV_t$ and $CNP16OV_t$ are transformed in indexes of the same base.

D.5 Measurement equation

The following observable equations are in line with Darracq Pariès et al. (2011) and Pfeifer (2019).

$$GDP_{obs,t} = 100 * \ln \left(\frac{y_t}{y} \right) \tag{151}$$

$$INV_{obs,t} = 100 \ln \left(\frac{i_t}{i} \right) \tag{152}$$

$$WAGE_{obs,t} = 100 \ln \left(\frac{w_t}{w} \right) \tag{153}$$

$$LABOR_{obs,t} = 100 \ln \left(\frac{l_t}{l} \right) \tag{154}$$

$$INF_{obs,t} = 100 \ln (\pi_t) \tag{155}$$

$$QINF_{obs,t} = 100 \ln \left(\frac{q_{h,t}}{q_h} \right) \tag{156}$$

$$RATE_{obs,t} = 100 \left(\frac{1 + R_t}{1 + R} - 1 \right) \tag{157}$$

$$HHRATE_{obs,t} = 100 \left(\frac{1 + R_t^{b_i}}{1 + R^{b_i}} - 1 \right) \tag{158}$$

$$ENTRATE_{obs,t} = 100 \left(\frac{1 + R_t^{b_e}}{1 + R^{b_e}} - 1 \right) \tag{159}$$

$$ENTLOAN_{obs,t} = 100 \ln \left(\frac{b_{e,t}}{b_e} \right) \tag{160}$$

$$HHLOAN_{obs,t} = 100 \ln \left(\frac{b_{i,t}}{b_i} \right) \tag{161}$$

$$DEPOSIT_{obs,t} = 100 \ln \left(\frac{d_t}{d} \right) \tag{162}$$

E Steady State ratios

Calibration and prior distribution of parameters allow to find steady-state ratio closed to those of Gerali et al. (2010) and to match key statistics of the data.

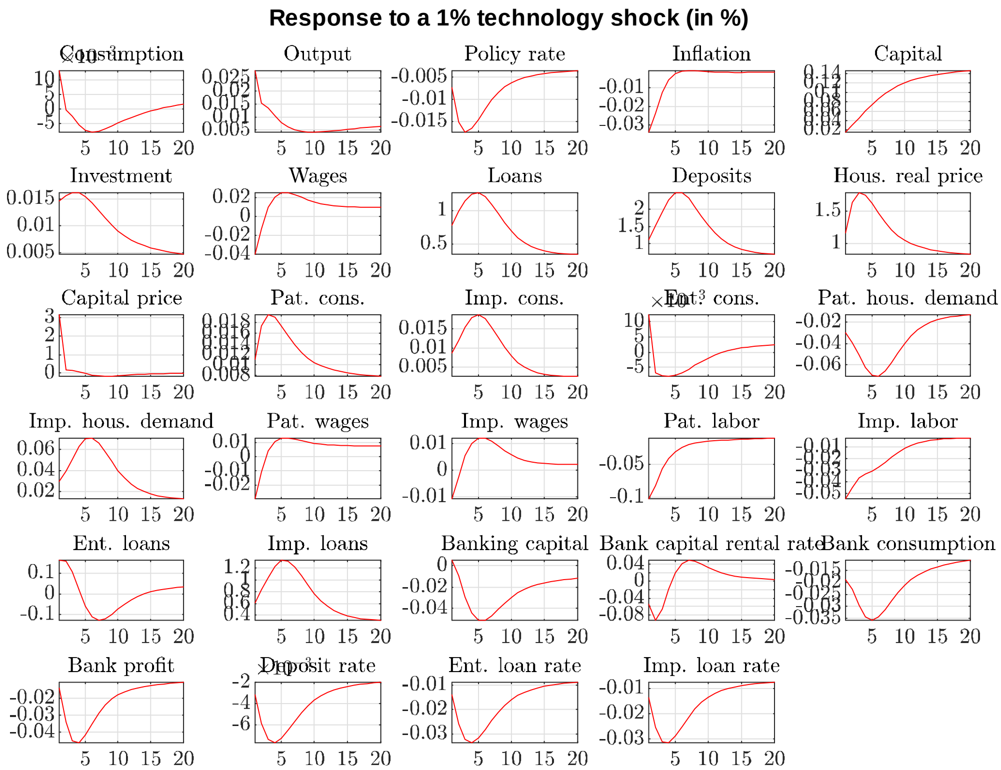
Variable	**Representation**	**Value**
Ratio of consumption to GDP	C/Y	0.92
Ratio of investment to GDP	I/Y	0.07
Ratio of loans to GDP	B/Y	1.54
Ratio of bank capital to GDP	K_b/Y	0.02
Ratio of productive capital to GDP	K/Y	3.01
Ratio of impatient households loans to total loans	b_i/Y	0.54
Ratio of entrepreneurs loans to total loans	b_e/Y	1
Annual policy rate	$4 \times R$	4.05
Annual deposit rate	$4 \times R^d$	2.4
Annual impatient households loan rate	$4 \times R^{b_i}$	9.7
Annual entrepreneurs loan rate	$4 \times R^{be}$	10.7

Table 5: Steady state ratio.

F Shocks analysis

F.1 Productivity shock

Fig. F.1 represents a positive productivity shock.

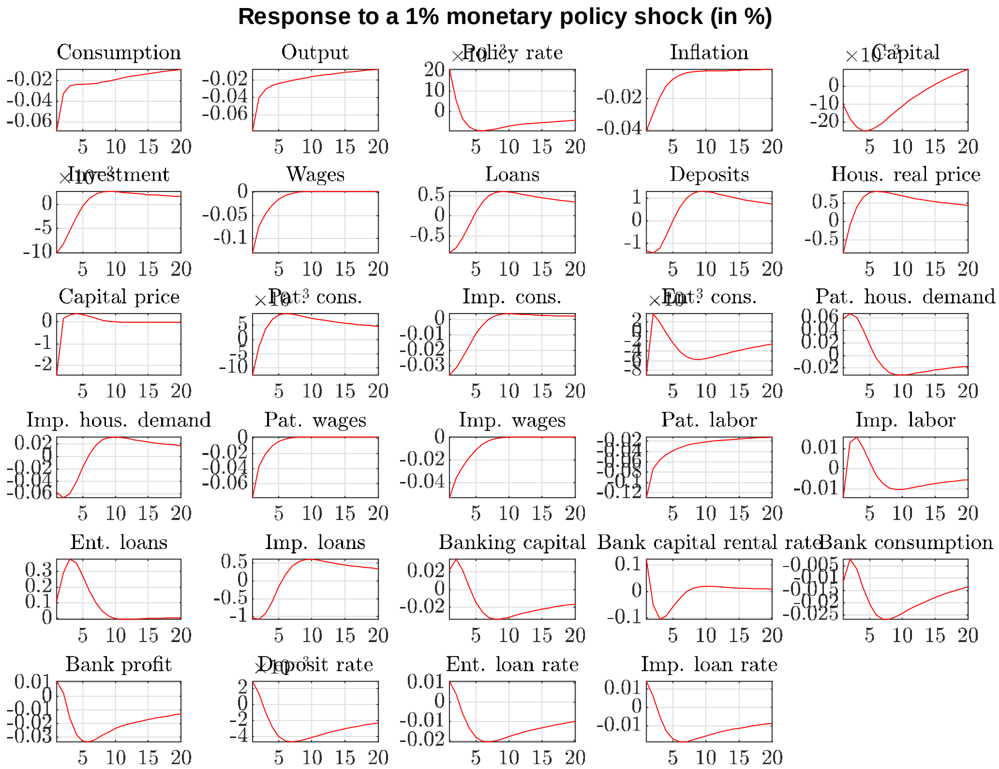


Impulse response functions to a 1% technology shock with the estimated model (in %).

Following a positive productivity shock, production is more efficient which bring inflation down (Galí, 2008). This lead to a wealth effect. Firms are more productive and increase their production. Extra-profits earned under monopolistic competition are related to patient households which enjoy more consumption, and leisure. Impatient households enjoy higher labor wages and increase their consumption and housing demand. Second, our framework makes appear a collateral effect also called in the literature financial accelerator effect. When the economy observes a productivity shock, demand increase for all assets, including housing and capital. House and capital prices are increased, and so, the value of collateral, which allows impatient households and entrepreneurs to borrow more.

F.2 Monetary Policy

Figure.F.2 represent a restrictive monetary policy shock.

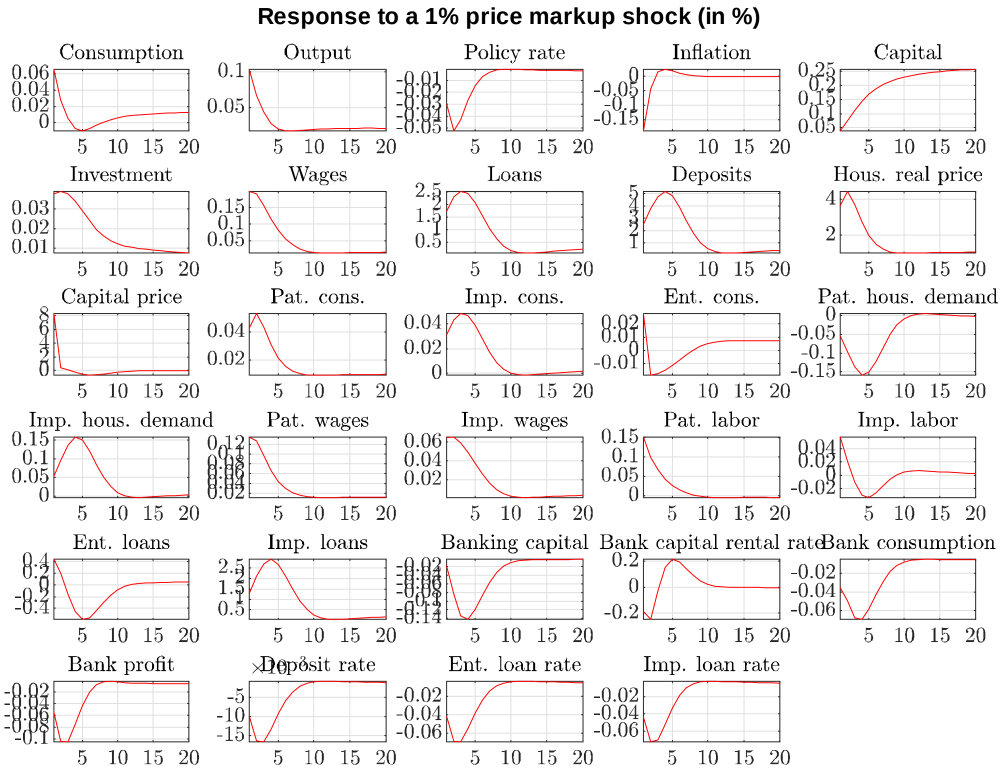


Impulse response functions to a 1% monetary policy shock with the estimated model (in %).

After a restrictive monetary policy (corresponding to an increase of the policy rate), the transmission mechanism in our framework is affected by three main channels which contribute to amplify and propagate the impulse response functions. First, a debt deflation effect: the rise in real interest rates leads to a decline in prices, which implies an increase of the real value of debt borrowing, impacting negatively the net worth of borrowers, and so, their spending. Second, a collateral effect: the rise in real interest rate leads to a decline of all price including house and capital. A decline in their values leads bank to reduce the number of loans, which lower the available resources of borrowers and therefore reduces aggregate demand. Third, a real rate effect: the rise in real interest rate encourages households to postpone present consumption which acts to lower demand again. Facing declining consumption, entrepreneurs are adapting to lower production which in turn reduces labor income.

F.3 Price markup

Fig. F.3 represents a negative price markup shock.



Impulse response functions to a 1% price markup shock with the estimated model (in %).

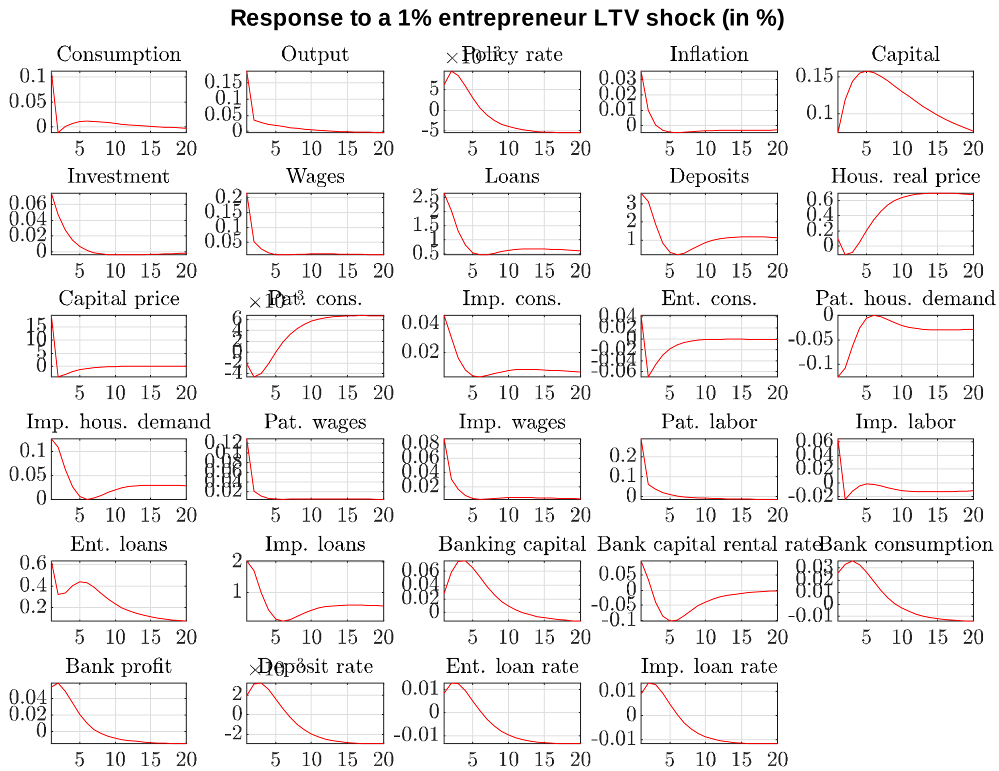
This shock is detailed by Smets and Wouters (2003, 2007). We analyse the impact of a negative price markup shock. As markups are determined by the ability of retailers to set prices over the marginal cost, a negative shock on markup correspond to a fall in prices. As for a productivity shock, we are in the case of a positive supply shock where inflation and output show an opposite response. As for productivity shock, the transmission mechanism works through three main channels such as a wealth effect, an interest rate effect and a collateral effect. As a result, output, consumption, investment, and loans are increased while inflation and interest rate decrease. (See in Appendix).

F.4 LTV

Fig. F.5 represents the impatient household LTV shock. A positive LTV shock is interpreted as an exogenous increase of the borrowers' collateral value giving them the opportunity to demand more loans. Each shock corresponds to an increase of its corresponding loan. As in Brzoza-Brzezina and Makarski (2011), a positive LTV shock leads to more consumption and investment leading to an increase in output and inflation. Thus, in turn, correspond to a monetary policy tightening which brings investment and consumption back to baseline.

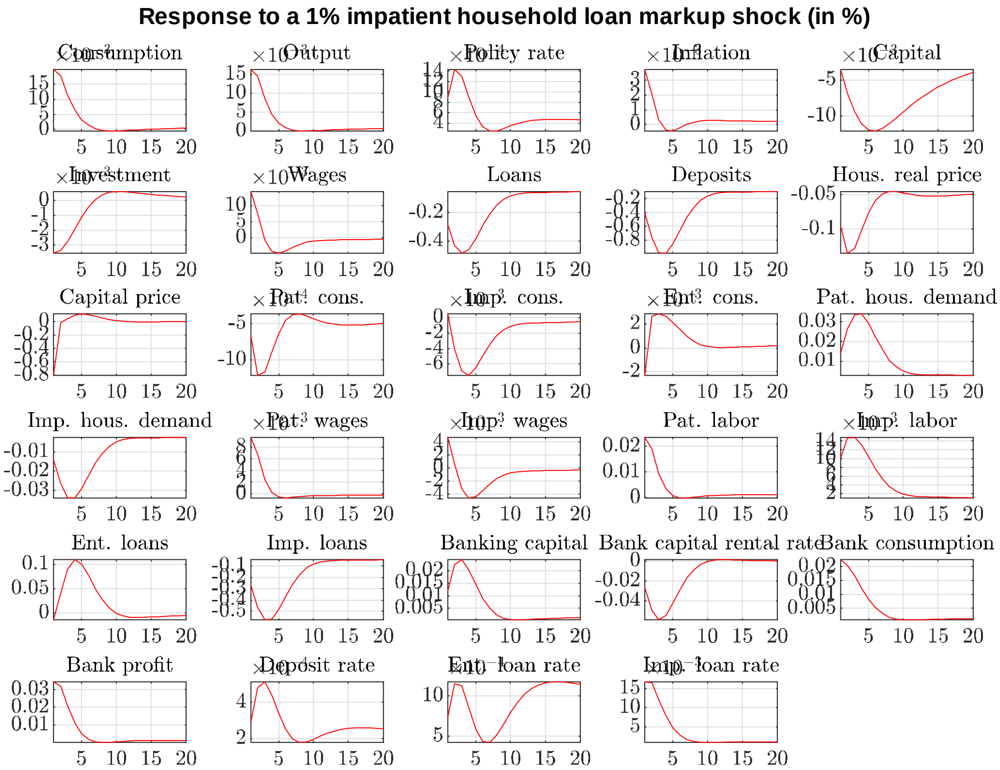
F.5 Spread on loans to household and entrepreneur

Figures F.5 and F.5 represent respectively impatient household and entrepreneur loan spread.

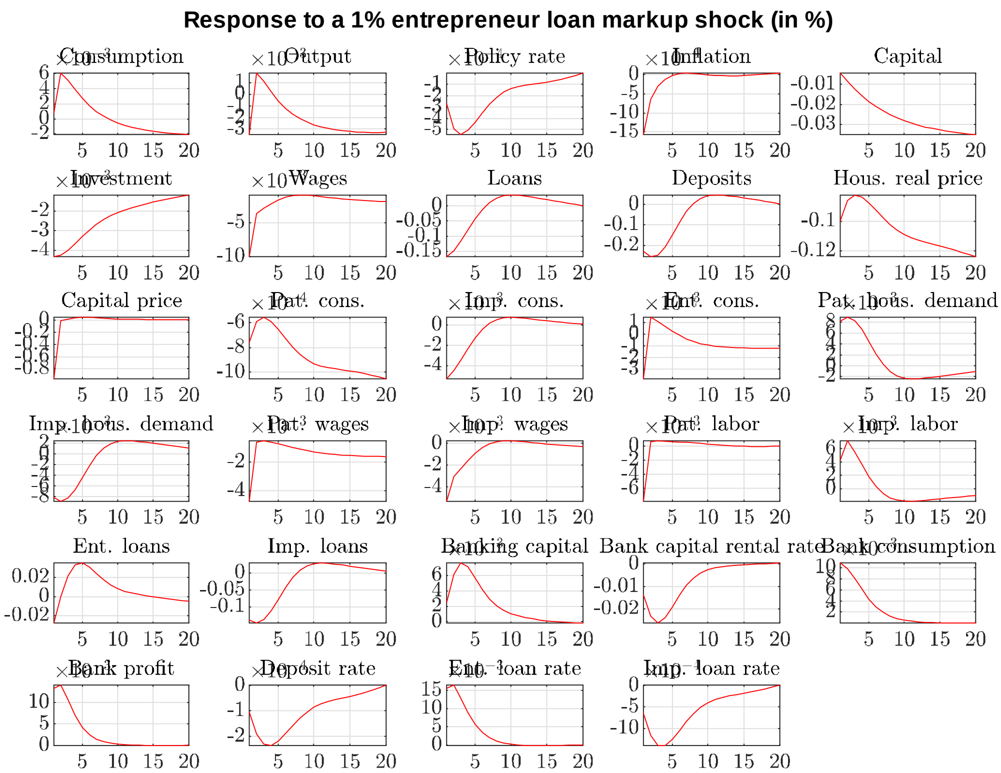


Impulse response functions to a 1% entrepreneur LTV shock with the estimated model (in %).

As in Brzoza-Brzezina and Makarski (2011), these two shocks increase the corresponding cost of borrowing leading to a decline in the number of loans. In our framework, a decline in impatient households' loans reduces the ability of impatient households to accumulate housing and so, reduces house prices. Moreover, a reduction in the amount of borrowing reduces entrepreneurs consumption and investment which in turn reduces output. The spread on entrepreneurs loans leads to a decline in aggregate demand which decreases inflation and interest rate.



Impulse response functions to a 1% impatient household loan markup shock with the estimated model (in %).



Impulse response functions to a 1% entrepreneur loan markup shock with the estimated model (in %).