Capturing macroprudential regulation effectiveness: a DSGE approach with shadow intermediaries*

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Abstract

We develop a New Keynesian DSGE model with heterogeneous agents to investigate how the shadow financial system affects macroeconomic activity and financial stability. In the adopted framework, regulated commercial banks finance small firms through traditional business loans and exert costly effort to screen the projects they finance. Shadow financial intermediaries finance large firms, provide short-term lending to commercial banks, and are engaged in the secondary market for loans. In this market, commercial banks originate asset-backed securities under moral hazard to exploit regulatory arbitrage. Shadow intermediaries purchase these loans from commercial banks under adverse selection. In general equilibrium, this set of externalities is not internalized by the financial system. We show that a macroprudential authority may successfully mitigate the externalities by activating caps to both the leverage ratio and the securitization ratio in the traditional banking sector. Such policy actions are effective in dampening aggregate volatility and safeguarding financial stability.

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1 Introduction

The financial turmoil triggered by the recent sub-prime crisis has unambiguously revealed the flaws of the pre-crisis regulation framework designed for traditional financial intermediaries. Moreover, it has seriously put under the spotlight the functioning of the deep universe of non-bank financial institutions operating within an unregulated or only lightly regulated environment –thereby known as "shadow banking or shadow financial intermediation system". [1]

Shadow financial intermediation can be defined as the set of activities consisting of the origination and acquisition of loans by non-bank financial intermediaries, the assembly of these loans into diversified pools, and the financing of these pools with external debt, much of which is short term and supposedly riskless (Gennaioli et al., 2013).[2]

The growing concerns pertaining to the vulnerability of the financial system in the aftermath of the 2007-2008 crisis have led authorities worldwide to devise a regulatory response aimed at mitigating undesirable consequences of under-capitalization and liquidity shortages in the banking system. Such response, known as Basel III, introduced more stringent (counter-cyclical) capital requirements and liquidity requirements for credit institutions, and the other provisions to be applied to insurers.[3]

Despite the unquestionable necessity of such new measures, the additional costs induced by the burden of the financial compliance has raised new concerns for regulatory authorities, as it may create additional incentives for banks to shift part of their activities outside the regulated environment, thereby increasing the size of the shadow sector even further.[4]

This paper contributes to the theoretical understanding of the implications of the shadow financial intermediation system interacting with both the financial system as a whole and with the real economy.

To visually inspect the connection between regulatory arbitrage and securitization

[1]In this paper, we intend the concepts of "shadow banking system" and "shadow financial intermediation system" interchangeably.

[2]For an excellent description of the securitization process see Stein (2010).

[3]Basel III represents the third wave of the new international regulation framework already initiated with Basel I, which introduced capital adequacy ratios for credit institution, and Basel II, which reinforced Basel I and allowed banks to use internal risk-based measure to weight the different types of of assets held in their portfolio.

[4]This type of behavior follows the so-called "regulatory arbitrage hypothesis". As described by Farhi and Tirole (2017), the regulatory arbitrage view includes two possible sub-views. In the first sub-view, retail banks evade capital requirements by providing liquidity support off-balance sheet to shadow intermediaries. The second sub-view involves capital requirement "evasion" by shadow intermediaries, which face no capital adequacy requirement and yet receive public assistance.

activity, the left panel of Fig (1.1) shows the developments of securitization during the implementation of the regulatory framework "Basel III". The dark line represents the stock of loans that have been securitized or otherwise transferred and derecognized from the balance sheet of the euro area Monetary and Financial Institutions (MFIs), while the light line represents the stock of securitized loans reported in the asset side of Financial Vehicle Corporations (FVC) engaged in traditional securitization. Both series show a marked jump upwards in correspondence with the period of activation of Basel III.[5]

The risks related with a rapidly growing shadow financial sector as a consequence of regulatory arbitrage have been emphasized, notably, by the President of the European Central Bank, Mario Draghi, in the following statement:

> *"The crisis demonstrated that the shadow banking system can itself be a source of systemic risk, both directly and through its interconnectedness with the regular banking system, leading to a build-up of additional leverage and risks. Therefore, enhancing supervision and regulation of the shadow banking system in areas where systemic risk and regulatory arbitrage concerns are inadequately addressed is important*." [6]

Such concerns are not new.

The role of the shadow financial system and its connected securitization activity has long been recognized as controversial. While securitization certainly adds economic value by allowing risk-tranching, it may also undermine the correct mechanism of incentive compatibilities and can create other information problems (Ashcraft, Schuermann, et al. (2008)).

In this paper, we further contribute to the debate on the role of securitization through the lens of a New Keynesian dynamic, stochastic, general equilibrium (NK-DSGE) model with shadow financial intermediaries, which includes macroprudential regulation as a tool for macroeconomic stabilization in the presence of such intermediaries.

In the model, financial intermediaries operating in the traditional banking sector –which we refer to as commercial banks– can originate risky loans, and can finance such loans both with own resources and with interbank credit obtained from the shadow

[5] Data are displayed in logs. Time series are obtained from the ECB SAFE 2017 (Survey on Access to Finance of Enterprises). "ABS MFI" Series key: BSI.M.U2.N.A.A20D.A.1.U2.2240.Z01.E) and "ABS FVC" Series key: FVC.Q.U2.N.T.A40.A.1.A1.0000.00.Z01.E).

[6] Statement by Mario Draghi, Chairman of the Financial Stability Board to the International Monetary and Financial Committee, Washington, DC, 24 September 2011.

financial system. These loans are granted solely to small firms. This assumption is made to replicate structural granular characteristics of the euro area economy. As shown in the right-hand panel of Fig. (1.1), in fact, small firms find it more difficult relative to large firms to access the capital market, thus relying on traditional business loans as the prevalent source of external finance.[7]

Within our framework, loans are subject both to idiosyncratic risk and to aggregate risk. This entails that loan default may occur in equilibrium. Crucially, commercial banks may exert costly screening effort to reduce, although without eliminating, the failure probability of the projects they finance.

Commercial banks are the originators of asset-backed securities which are purchased by the shadow intermediaries. This is an empirically important feature in the euro area as securitized loans represent about two-thirds of total FVCs' assets.[8,9] The decision to securitize a pool of loans made by the commercial bank is the result of the interplay of two key factors present in the model, both exerting upwards pressures on the incentives to securitization, i.e. moral hazard and regulatory arbitrage. Moral hazard arises as a consequence of the possibility for commercial banks to sell off their loans to shadow intermediaries and invest the proceeds towards an alternative investment opportunity. Regulatory arbitrage provides an additional motive to securitize loans due to both the direct and indirect costs associated with holding capital idling unproductively. These two factors lie at the root of the commercial bank's incentives to resort to securitization.

The impact of securitization is twofold. On the one hand, it allows banking capital to accumulate faster and provides an efficient market-based channel to unchain the traditional banking sector from risky and potentially non-performing loans. On the other hand, securitization generates an externality that is not internalized by shadow intermediaries: the acquisition of securitized loans occurs under adverse selection, due to the asymmetric information problem stemming from the uncertainty of the payoff incorporated in the securitized loans when the transaction on the secondary market is cleared. Were shadow intermediaries isolated entities from the rest of the economy, the pass-through of risk entailed by securitization would indeed result in an effective conduit of risk immunization of the traditional banking sector. Instead, in our model and close to reality, shadow intermediaries are interconnected both with the banking sector and

[7] The data are elaborated from the ECB SAFE 2017 (Survey on the Access to Finance of Enterprises in the euro area).

[8] See the report "EU Shadow Banking Monitor", No 2, May 2017, by the European Systemic Risk Board (ESRB).

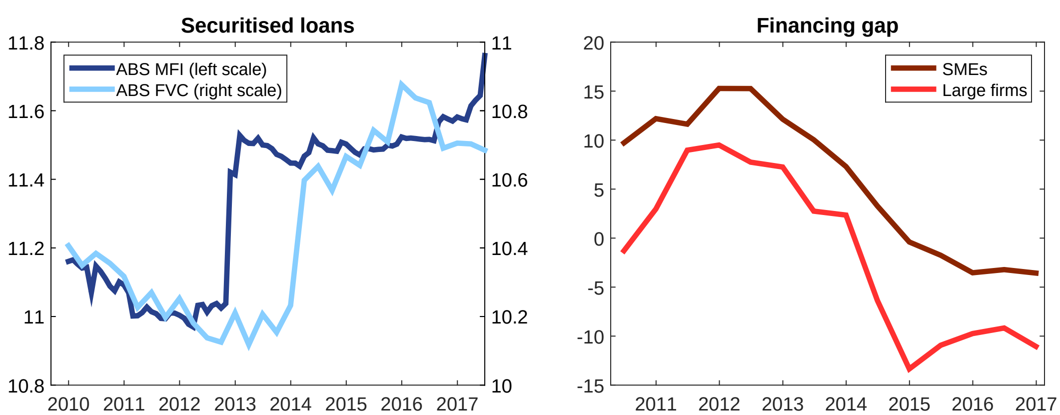
[9] A more detailed analysis about the size of the shadow banking system in the euro area, with comparisons to the United States, can be found in Malatesta et al. (2016).

with the productive sector, as they sell credit contracts both to commercial banks and to large firms. As a consequence, any transfer of risk from the traditional banking to shadow intermediaries may feed back into the former sector through the interbank market and into the productive sector through corporate lending. The interconnectedness plays a role in creating a tension between the two productive sectors, making the relative availability of credit in each of these sectors dependent on shadow intermediaries and on the propagating effects of securitization.

We consider a possible macroprudential policy regulation that aims at safeguarding financial stability and mitigating the undesirable effects of securitization while preserving its potential benefits. Therefore, commercial banks are compelled to conform to a double layer of regulation: the leverage ratio, which imposes the maximum level of exposure towards small firms for a given level of internal capital, and the securitization ratio, which limits the maximum fraction of loans that can be securitized and passed on the secondary market. We find that the activation of these macroprudential policy instruments is effective in smoothing business cycle volatility following the realization of a variety of shocks.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 lays down the structure of the model and describes the optimizing behavior of the economic agents. Section 4 studies the quantitative implications and reports the impulse response functions to different type of shocks. Section 5 studies the role of heterogeneous firms in the transmission mechanism of shocks. Section 6 presents macroprudential policy as macroeconomic stabilization tool. Section 7 concludes.

Figure 1.1: In the left panel, the evolution of securitization measured as the outstanding amount of securitized assets reported in the asset side of euro area FVCs (logs) . In the right panel, the perceived external financial gap for SMEs and large firms as measured by the SAFE composite indicator.



Data source and information: See footnote 5

2 Relations to existing literature

The present paper is broadly related to the class of models introducing financial intermediation into well established securitized DSGE frameworks, such as Goodfriend and McCallum (2007), Christiano et al. (2007), Curdia and Woodford (2010), *inter alia*, and with the subsequent first wave of studies that started to incorporate macroprudential policy to address its welfare implications. Some examples are Acharya et al. (2011) and Benes and Kumhof (2015), which both focus on the welfare effects and argue in favor of bank capital requirements. The first study argues that regulators should impose restrictions on dividends and equity pay-offs, while the second study shows theoretically that a countercyclical buffer requirement has the ability to increase overall welfare by reducing the volatility of output. Further studies, in contrast, emphasize the detrimental effects of bank capital requirements. For example, Diamond and Rajan (2000) show that capital requirements may have an important social cost because they reduce the ability of banks to create liquidity. Van den Heuvel (2008) embeds the role of liquidity creating banks into an otherwise standard general equilibrium growth model for the US, to find that while a capital requirement limits moral hazard, the welfare cost of capital adequacy regulation is surprisingly high.[10]

Later contributions find mixed results for bank capital regulation due to several emerging trade-offs. To mention a few, De Walque et al. (2010) find that Basel I and Basel II regulation reduces steady state but improves the resilience of the economy to shocks; Meh and Moran (2010) show that bank capital increases an economy's ability to absorb shocks; Angeloni and Faia (2013) find that pro-cyclical capital requirements (akin to those in the Basel II capital accord) amplify the response of output and inflation to shocks and reduce welfare, while anti-cyclical ratios have the opposite effect. Martinez-Miera and Suarez (2014) focus on systemic risk and show that capital requirements reduce systemic risk-taking but at the cost of reducing credit and output in calm times, generating non-trivial welfare trade-offs. Clerc et al. (2015) find that capital requirements reduce bank leverage, bank failure risk, but too-high levels of capital requirements may unduly restrict credit availability, so that there exist an optimal level of bank capital requirements.

The literature presented above, however, focuses on direct lending by banks and therefore excludes securitization and non-bank financial activities. Unlike this literature, the present paper accounts for non-bank financial entities, which cater commercial banks'

[10] In relation with the mortgage market, similar conclusions are reached by Keys et al. (2009), whose "findings caution against policies that impose stricter lender regulations which fail to align lenders' incentives with the investors of mortgage-backed securities".

risk-taking thereby fostering regulatory arbitrage. In this respect, this paper is strictly connected with two recent research strands. The first attempts to embed shadow intermediaries into otherwise standard general equilibrium models. Some examples are Goodhart et al. (2012), who construct a two-period model to study the efficacy of several regulatory tools in the presence of shadow intermediaries; Verona et al. (2013), who build a DSGE model and find that central banks ignoring the shadow sector may wrongly anticipate the effects of monetary policy; Meeks et al. (2017), who find that following a liquidity shock, stabilization policy aimed solely at the market in securitized assets is relatively ineffective; Gorton and Metrick (2010), who propose principles for regulating the shadow intermediaries system and Meh and Moran (2015), who study how leverage regulation effects may depend on the existence of shadow intermediaries. The second strand of research further attempts to embed regulatory arbitrage into general equilibrium models with shadow intermediaries. The regulatory arbitrage hypothesis has been investigated empirically by Houston et al. (2012) in a cross-country setting, although without a specific reference to the shadow financial system, finding strong evidence that banks have transferred funds to markets with fewer regulations. In addition, Acharya et al. (2013) analyze asset-backed commercial paper conduits, which experienced a shadow-banking run and played a central role in the early phase of the financial crisis of 2007–2009, and show that regulatory arbitrage was an important motive behind setting up conduits. Quantitative theoretical contributions, although still limited in number, include Plantin (2014), who shows that tightening capital requirements may spur a surge in shadow banking activity that leads to overall larger risk of the formal and shadow banking institutions; Huang (2014), who models shadow intermediaries as an off-balance-sheet financing option for regular banks within the Brunnermeier and Sannikov (2014) framework and suggests that financial stability is a U-shaped function of financial regulation; Ordoñez (2017), who formally shows that a combination of traditional regulation and cross reputation subsidization may enhance shadow intermediation and make it more sustainable. In his study, shadow banking arising to avoid regulation may potentially be welfare improving. Begenau and Landvoigt (2017) built a calibrated general equilibrium model for the US with commercial and shadow intermediaries and find that higher capital requirements shift activity away from traditional banks. In their model, instead of becoming more fragile, the aggregate banking system becomes safer. More recently, Farhi and Tirole (2017) show how prudential regulation must adjust to the possibility of migration toward less regulated spheres.

Finally, the assumed distinction between small and large firms (i.e., a rigidity in the access to the capital market for small firms compared with large firms) finds support in related research showing that small firms are severely credit constrained. Seminal evidence tracks back to Fazzari et al. (1988), who document differences in financing patterns by size of firms in the US and consider a variety of explanations for why internal and external finance are not perfect substitutes. Other contributions are those of Beck and Demirguc-Kunt (2006), Ferrando and Griesshaber (2011), and Artola and Genre (2011) and those studies pointing to the importance of the contribution of small and medium enterprises to aggregate fluctuations, such as Moscarini and Postel-Vinay (2012), Gabaix (2011), and Acemoglu et al. (2012), *inter alia*.

3 The model

The economy consists of households, large firms (LF), small and medium enterprises (SME), commercial banks and shadow intermediaries, capital producers, retailers and an authority conducting monetary and macroprudential policy.

Households provide labor in a competitive labor market and use their labor income to finance consumption and to save. As they cannot directly invest in capital, households deposit their savings either with traditional banks at the gross nominal interest rate R_t^D or with shadow intermediaries at the gross nominal interest rate R_t^{SB}. Small firms produce an intermediate good, which is entirely used in the production process of large firms as input for producing a wholesale good. To introduce price inertia in a tractable manner, we introduce retailers that transform the wholesale good at no cost into a final consumption good.

Firms obtain funding through a financial sector made of commercial banks and shadow intermediaries. Both types of banks are connected through the interbank market in which shadow intermediaries lend to commercial banks. Commercial banks use interbank credit, IB_t, together with own bank capital, K_t^B, to finance risky projects originated by small-medium enterprises (SMEs). On the contrary, shadow intermediaries solely finance large corporate firms (LF). There are two sources of information frictions in the financial sector. On the one hand, moral hazard of commercial banks may arise when an exogenous alternative investment opportunity materializes; in this case, the commercial bank may find it optimal to pool its loans into asset-backed securities (ABS) and sell them on the secondary market to shadow intermediaries, regardless of whether or not such loans are ultimately going to be successful. On the other hand, shadow intermediaries, which are involved in credit transformation, buy pooled loans on the secondary market under adverse selection as the payoff of the loans incorporated into the ABSs is unknown in advance. Beyond ABS, shadow intermediaries lend funds to large firms by purchasing their issued debt, B_t. Therefore, we distinguish the financing channels of both large and small firms, while connecting them indirectly through the interbank market. Finally, shadow intermediaries finance their activity by issuing liabilities. Figure (3.1) summarizes the financial relationships of our agents through their balance sheet positions.

Figure 3.1: Aggregate balance sheet positions of firms, banks and households

Small Firms

K^S	L^S

Large Firms

K^L	$Bonds\ (B)$

Commercial Banks

$(1-\varkappa)L^S$	$Equity\ (K^B)$
$\tau^\lambda(=\varkappa L^S)$	$Deposits\ (D)$
	IB

Shadow Intermediaries

B	$Deposits\ D^{SB}$
IB	
$\varkappa L^S(=ABS)$	

Households

$Deposits\ (D)$	$Savings\ (S^H)$

3.1 Households

Households are risk-averse and infinitely lived. They derive utility from a consumption good and disutility from labor. The consumption good acts as a numeraire. Their income is derived from renting labor to producers at the competitive real wage W_t^H. The available income is used to finance consumption, hold deposits with financial intermediaries and pay the tax bill. Their preferences are described using an external habit formulation common in recent DSGE literature as in Smets and Wouters (2002), Christiano et al. (1997). In particular, households maximize the expected present discounted value of their utility:

$$\mathbb{U}_t\left(C_t, N_t\right) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_H^t \left[log\left(C_t^H - hC_{t-1}^H\right) - \bar{\psi}\frac{\left(N_t\right)^{1+\eta}}{1+\eta} \right], \tag{3.1}$$

where C_t^H is non-durable consumption at time t, N_t is labor supply, $h > 0$ is the coefficient governing the intensity of habit in consumption, $\bar{\psi} > 0$ is a scaling parameter for hours worked and $\eta > 0$ is the inverse of the Frisch elasticity of labor. When choosing the allocation of their savings, households can decide to direct their savings either towards a commercial bank in a deposit account or a shadow intermediary in a custody account. The former can be seen as a traditional current account that offers an interest rate on deposits redeemable at any time. We abstract from deposit insurance. We later characterize the financial contract ensuring that households have an incentive to engage with commercial banks. In contrast, the funds deposited at the shadow intermediary can be seen as a financial investment, for example in money-market funds or assimilated financial products offered by non-bank financial institutions.[11] To model the household investment decisions, we follow Dotsey and Ireland (1996) and Meh and Moran (2015), and assume that households are distributed along a unit interval, with position $i \in [0, 1]$ identifying a typical household. Commercial banks are located at point 0 and shadow intermediaries at point 1. If savings are deposited with a commercial bank, the return is taxed by the government, so that the after-tax return is $R_t^D(1-t^b)$, with t^b the tax rate and R_t^D being the gross nominal interest rate on deposits. If savings are allocated to a shadow intermediary, households incur an ex-ante quadratic cost equal to $\phi(i) = \chi_1 \left[(1-i)/(i)\right]^2$,with $\phi(0) = +\infty$ and $\phi(1) = 0$, and earn a gross nominal interest rate R_t^{SB}.

When maximizing their utility function, households are subject to a sequence of budget constraints:

$$C_t^H + D_t(i)\left[1+\phi(i)\right] = \left[\left(1-t^b\right) R_t^D \Phi_t(i) + R_t^{SB}(1-\Phi_t(i))\right] D_{t-1}(i) + W_t^H N_t + T_t, \tag{3.2}$$

where D_t is the amount of deposits, Φ is a binary function that equals 1 when savings are allocated to commercial banks and 0 when savings are allocated to shadow intermediaries; $W_t^H N_t$ is labor income and T_t is lump-sum transfers, which includes profits from the retail sector, capital good producers and the banking sector.

The first order-condition with respect to consumption reads as:

$$\lambda_t^H = \frac{1}{C_t^H - hC_{t-1}^H} - h\beta_H \mathbb{E}_t\left[\frac{1}{C_{t+1}^H - hC_t^H}\right]. \tag{3.3}$$

The first-order condition with respect to labor yields the labor supply:

$$\lambda_t^H W_t = \bar{\psi}\left(N_t\right)^\eta. \tag{3.4}$$

The first-order condition with respect to deposits, if allocated to a commercial bank is:

$$\lambda_t^H = \beta_H \mathbb{E}_t \lambda_{t+1}^H \left(1-t^b\right) R_t^D, \tag{3.5}$$

while if allocated to a shadow intermediary is:

$$\lambda_t^H\left(1+\phi(i)\right) = \beta_H \mathbb{E}_t \lambda_{t+1}^H R_t^{SB}, \tag{3.6}$$

[11] As argued by Ferrante (2018), we can think of the shadow intermediaries deposits as the set of instruments that over the past years allowed investors to channel funds into this parallel (shadow) sector, such as money market mutual funds (MMMFS), which in normal times were perceived basically as risk-free assets.

where $\mathbb{E}_t\{\cdot\}$ is the rational expectation operator conditional on information available in t, $0 < \beta_t^H < 1$ is the household's subjective discount factor and λ_t^H is the Lagrange multiplier associated with the household's budget constraint. By equating both first-order conditions with respect to deposits we obtain the indifference condition of the household located at position i^*:

$$\lambda_t^H \phi(i^*) = \beta_H \mathbb{E}_t \lambda_{t+1}^H \left[R_t^{SB} - \left(1 - t^b\right) R_t^D\right] \tag{3.7}$$

Aggregating across households, the supply of funding for banks and shadow intermediaries is respectively

$$D_t^B = \int_0^{i^*} D_t \tag{3.8}$$

$$D_t^{SB} = \int_{i^*}^1 D_t \tag{3.9}$$

3.2 The financial sector

The financial sector is made of a continuum of risk neutral commercial banks and shadow intermediaries.

Commercial banks carry out a traditional financial intermediation activity, which consists of pooling together resources collected from depositors and the interbank market (from shadow intermediaries) to finance risky projects of SMEs.

Commercial banks can increase the likelihood of a project to be successful by exerting costly effort in monitoring SMEs' projects. However, when an exogenous investment opportunity materializes, they may decide to sell a portion of their loans to shadow intermediaries in the form of ABS. The activity of commercial bank is subject to a twofold macroprudential regulation: on one hand, the maximum leverage ratio governing the bank's financial exposure towards SMEs; on the other hand, a cap to the securitization ratio. Shadow intermediaries, on the contrary, are non-bank financial institutions whose main activity consists in attracting resources from households and use such resources to operate on the secondary market for loans, provide short term finance to commercial banks and finance large firms. The next subsection provides further details on the financial sector and lays down its modeling approach.

3.2.1 Commercial banks

Commercial banks are financial intermediaries whose role is to attract deposits from households and to finance SMEs' projects.

The balance sheet of the commercial bank is given by:

$$L_t^S = K_t^B + D_t^B + IB_t \tag{3.10}$$

where L_t^S is the amount of loans extended to the SME, K_t^B is commercial bank capital, D_t^B are deposits received from households and IB_t is interbank credit.

The project carried out by the entrepreneur of the small firm is subject to an idiosyncratic shock $\omega^S \in \{0, R\}$, which determines the amount of raw capital of time t that turns into effective capital in time $t+1$. We assume that a project is successful with probability p_t, otherwise it reveals to be a non-performing loan.

The financial contract between the commercial bank, depositors and the shadow intermediary

We now lay out the financial contract between lenders (households and shadow intermediaries) and the borrowers (commercial banks). Following the set up of Meh and Moran (2015), we assume that commercial banks have the ability to screen the projects they finance. Screening at intensity Υ_t allows the bank to identify and eliminate projects with low probability of success.[12] Moreover, exerting effort Υ_t allows the bank to acquire private information about the idiosyncratic shock ω^S. However, screening entails a cost, which is proportional to the value of the loan: $\mu_t = c\Upsilon_t L_t^S$, with $c > 0$.

The project carried out by the small-medium firm is assumed to be successful with probability p_t and subject to an aggregate return, V_{t+1}. In this case, the loan in which the commercial bank invested in generates revenues

$$L_{t+1}^S = V_{t+1} R_t^L L_t^S, \tag{3.11}$$

where

$$V_{t+1} = R_{t+1}^k + (1-\delta) Q_{t+1} \tag{3.12}$$

is the aggregate return of capital.[13] In contrast, with probability $(1-p_t)$ the project is unsuccessful and the loan turns out to be a non-performing loan, $L_{t+1}^S = 0$.

The commercial bank might occasionally receive an outside investment opportunity that brings an excess positive return. In this case moral hazard may arise. We denote

[12] Note that p_t is to be intended as the average probability across small firms projects. However, in this representative firm setup this distinction can be disregarded.

[13] The term R_t^K is the return on capital, δ is the rate of capital depreciation and Q_{t+1} is the price of capital, which is pinned down in the capital producers' problem in subsection 3.3.5.

the probability of the outside investment opportunity occurring by l and the excess return attached to it by $\lambda > 1$. A bank affected by this positive shock will want to sell its loan commitment before it comes to fruition and divert the freed capital resources towards the more profitable alternative investment, τ^{λ}. If the expected return of the outside opportunity is higher than the return on loans, the bank decides to liquidate a fraction of loan commitments to shadow intermediaries through securitization on a secondary market for loans. The timing of the events is such that, first, loan arrangements with SMEs take place, then the commercial bank decides on the screening intensity and learns about the quality of the project. Conditional on both that quality and on the outside opportunity received, it decides whether to keep the loan commitment until it comes to fruition or sell it on the secondary market to shadow intermediaries. In doing so, however, commercial banks must comply with a regulation constraint of the type:

$$\frac{ABS_t}{L_t^S} \leq \varkappa, \tag{3.13}$$

As described in Meh and Moran (2015), due to the private nature of the bank's screening effort, an agency problem between the bank and other stakeholders arise. The bank might choose to screen less intensively than agreed; this action would result in a lower probability of success of the projects and reduces the likelihood that depositors obtain the return pledged by banks. In addition, the private nature of the two types of shocks introduces adverse selection in the secondary market for loans. As a consequence of these information rigidities, the profit maximizing behavior of the bank is subject to the financial contract ensuring that all the agents have appropriate incentives to engage in the borrowing-lending relationship. The contract is such that by the end of period the commercial bank pays a steak R_t^H to households and a steak R_t^{IB} to the shadow intermediary. Therefore, the net return on the risky loan that turned out to be successful for the commercial bank equals $R_t^L = R - R_t^H - R_t^{HB}$.

We assume that commercial banks are owned by households and managed by risk-neutral bankers, whose objective is to maximize the expected return on lending:

$$\max_{L_t, R_t^H, R_t^L, D_t^B, p_t, E_t} \quad p_t V_{t+1}^e R_t^L L_t^S \tag{3.14}$$

subject to the incentive compatible, technology and resource constraints detailed below:

$$
\begin{aligned}
R_t^L V_{t+1}^e p_t(1-l)\left(L_t^S \mathcal{P}_t^{ABS} - ABS_t\right) &\geq c\Upsilon_t Q_t L_t^S && (3.15)\\
p_t V_{t+1}^e L_t^S R_t^H &\geq D_t^B R_t^D && (3.16)\\
p_t V_{t+1}^e L_t^S R_t^{HB} &\geq IB_t R_t^{IB} && (3.17)\\
K_t^B + D_t^B + IB_t - c\Upsilon_t L_t^S &\geq L_t^S && (3.18)\\
R_t &= R^L + R_t^H + R_t^{HB} && (3.19)\\
R_t^L, R_t^D, R_t^{IB} &\geq 0 && (3.20)\\
p_t &= f(\Upsilon_t) && (3.21)\\
\frac{ABS_t}{L_t^S} &\leq \varkappa && (3.22)
\end{aligned}
$$

Condition (3.15) ensures that the bank has an incentive to screen at the agreed intensity.[14] Condition (3.16) is the depositor's incentive to engage in the financial contract with the commercial bank, which states that the share of expected return accruing to the depositor for a project that is successful with probability p_t must be at least equal to the bank's cost for households deposits. Similarly, condition (3.17) is the participation constraint of the shadow intermediary on the interbank market with the commercial bank, so that the shadow intermediary is willing to participate in the financial contract as long as the expected return of the project covers the commercial bank's cost of interbank funding. Condition (3.18) is the bank's resource constraint indicating its ability to bear the project's total cost. Equation (3.19) states that the returns on the projects accruing to the household, the shadow intermediary and the commercial bank must sum up to total return.

To solve the financial contract (3.14)–(3.21), we first start by assuming that the regulation constraint binds and plug it into (3.15) holding with equality. This returns the incentive compatibility constraints of the commercial banks that depends on the securitization ratio parameter.

Solving for the lending rate delivers:

$$
R_t^L = \frac{c\Upsilon_t Q_t}{p_t(1-l)\left(\mathcal{P}_t^{ABS} - \varkappa\right) V_{t+1}^e}.
$$

By using (3.19), the household's share of total return is given by:

$$
R_t^H = R - R_t^{HB} - \frac{c\Upsilon_t Q_t}{p_t(1-l)\left(\mathcal{P}_t^{ABS} - \varkappa\right) V_{t+1}^e}. \qquad (3.23)
$$

[14](see derivation in Appendix A)

Further, plugging (3.23) into the participation constraint of depositors (3.16) holding with equality delivers:

$$\frac{p_t V^e_{t+1}}{R^D_t}\left(R - R^{HB}_t - \frac{c\Upsilon_t Q_t}{p_t(1-l)\left(R^{ABS}_t - \varkappa\right)V^e_{t+1}}\right)L^S_t = D^B_t, \tag{3.24}$$

which reveals the willingness of households to deposit their savings with the commercial banks.

Finally, introducing (3.24) into the resource constraint (3.18) and rearranging, the following bank capital to-asset ratio can be obtained:

$$\frac{K^B_t}{Q_t L^S_t} = 1 + c\Upsilon_t - \frac{p_t V^e_{t+1}}{Q_t R^D_t}\left(R - R^{HB}_t - \frac{c\Upsilon_t Q_t}{p_t(1-l)\left(\mathcal{P}^{ABS}_t - \varkappa\right)V^e_{t+1}}\right)$$

which can be rewritten as the leverage ratio:

$$\kappa^B_t = \frac{Q_t L^S_t}{K^B_t} = \frac{1}{1 + c\Upsilon_t - \frac{p_t V^e_{t+1}}{Q_t R^D_t}\left(R - R^{HB}_t - \frac{c\Upsilon_t Q_t}{p_t(1-l)\left(\mathcal{P}^{ABS}_t - \varkappa\right)V^e_{t+1}}\right)}. \tag{3.25}$$

For probability of success, we assume a functional form of the type:

$$p_t(\Upsilon_t) = \bar{p} + \frac{\chi_p}{p}\left(\Upsilon_t - \bar{\Upsilon}\right) \tag{3.26}$$

where $\bar{p}$ is the steady state probability of success of the project, Υ_t is the screening effort and $\bar{\Upsilon}$ its steady-state value, and $\chi_P > 0$ is the elasticity of the screening intensity.

The evolution of commercial bank capital

To derive an expression for the evolution of the aggregate banking net worth available in the economy, it is necessary to account for the four possible scenarios that have been realized, which depend on the profitability of the loan commitments as well as the arrival of the alternative investment opportunity. The four scenarios and their respective outcomes in period $t-1$ are:

1. The bank had a successful project with probability p_t but did not get the outside opportunity occurring with probability l and did not issue any ABS. The joint probability of such an event is $p_{t-1}(1-l)$. Accounting for this probability, the bank's net worth in this scenario is

$$K^B_{1,t} = p_{t-1}(1-l)V_t R^L_t L^S_t.$$

2. With probability $p_{t-1}l$ the bank received a profitable outside opportunity and securitized the loan (regardless of whether it is successful or not) to invest the

proceeds at the rate λ. The net worth in this case is

$$K^B_{2,t} = p_{t-1} l \lambda \mathcal{P}^{ABS}_t V_t R^L_t ABS_t.$$

3. With probability $(1 - p_{t-1})(1 - l)$ the bank did not received a profitable alternative investment opportunity but sold nevertheless the loan (because of the knowledge that it was ultimately going to be a failure). In this case the net worth is

$$K^B_{3,t} = (1 - p_{t-1})(1 - l) \mathcal{P}^{ABS}_t V_t R^L_t ABS_t.$$

4. With probability $(1 - p_{t-1})l$ the bank received a profitable alternative investment opportunity and sold the loan (which was going to fail in any case) to invest the proceeds at the more convenient rate of return λ. In this scenario, the rate of return is given by

$$K^B_{4,t} = (1 - p_{t-1}) l \lambda \mathcal{P}^{ABS}_t V_t R^L_t ABS_t.$$

Taking into account these four possible scenarios, the aggregate level of banking net worth available in the economy reads as:

$$K^B_t = \tau_B [K^B_{1t} + K^B_{2t} + K^B_{3t} + K^B_{4t} + W^B_t]. \tag{3.27}$$

where τ_B is the fraction of surviving banks at the end of each period.[15] The above expression can be expanded with the regulation constraint binding in equilibrium and the aggregate evolution of bank capital reads as

$$K^B_t = \tau_B \left[\left((1 - p_{t-1})(1 - l) + l \lambda \varkappa \mathcal{P}^{ABS}_{t-1} + p_{t-1}(1 - l) \right) V_t R^L_{t-1} L^S_t + W^B_t \right]. \tag{3.28}$$

The above relation implies that securitization through $\varkappa$ exerts a positive effect on the accumulation of banking capital.

[15]Note that W^B_t is the wage of the risk-neutral bankers, which derives from the assumption that they provide a very small amount of work in the productive sector in order to provide them with an initial amount of wealth at the beginning of each period. However, W^B_t is virtually zero as the elasticity α_B is set to a very small number.

3.2.2 Shadow intermediaries

Shadow intermediaries are financial institutions that operate outside the traditional banking system. The shadow sector is assumed to be competitive.

Shadow intermediaries are not burdened with regulatory costs, thus their activities are not covered by a safety net. Their activity consists in a classic intermediation function, carried out by collecting deposits from households to extend both financial and non-financial corporate lending, and a function of credit transformation participating in the secondary market for loans. While interbank lending can be seen as a short-term funding through which shadow intermediaries optimize their liquidity management, corporate bonds are relatively more illiquid assets but more profitable in the long run. We assume that there are quadratic management costs involved with investing either in the interbank market and in corporate loans, so that $\mathcal{P}_{\mathrm{t}}^{\mathcal{B}} = \frac{\chi^{SB}}{2}(B_t)^2$ and $\mathcal{P}_{\mathrm{t}}^{\mathcal{IB}} = \frac{\chi^{IB}}{2}(IB_t)^2$. This choice is in line with studies in the macro-finance literature, such as Andrés et al. (2004) or Chen et al. (2012), and the micro-banking literature such as Freixas and Rochet (2013). Given that shadow intermediaries face a trade-off between liquidity and return when making the portfolio decision, we capture this imperfect substitution by assuming that $\chi^{SB} > \chi^{IB}$. Unlike commercial banks, shadow intermediaries finance their activity by issuing liabilities to households on which they offer a variable gross return, R_t^{SB}.

The timing of the events is such that the funds obtained by the shadow intermediary from household at time t are employed to extend credit to commercial banks and large firms, and to pay the respective portfolio adjustment costs. The resource constraint at time t is thus

$$D_t^{SB} = R_t^L V_{t+1} ABS_t \mathcal{P}_t^{ABS} + B_t + IB_t + \frac{\chi^{SB}}{2}(B_t)^2 + \frac{\chi^{IB}}{2}(IB_t)^2 . \tag{3.29}$$

with $\chi^{SB} > \chi^{IB}$. Condition (3.29) states that the household's deposits –which are the only source of funding for shadow intermediaries are used to purchase asset-backed securities on the secondary market, to provide corporate and interbank lending, and to pay the respective portfolio adjustment costs. At time $t+1$, the shadow intermediary receives the revenues both from corporate bond investment, interbank lending and the payoff incorporated into the ABSs, and pays back household's funds plus interest. Thus the flow-of-funds is given by

$$B_t R_{t+1}^B + IB_t R_{t+1}^{IB} + \varpi R_t^L V_{t+1} ABS_t = D_t^{SB} R_t^{SB} \tag{3.30}$$

with $\varpi_t = (p_t l) / (p_t l + 1 - p_t)$.

Both (3.29) and (3.30) can be combined to obtain the profit function, which is maximized by the shadow bank by choosing B_t, IB_t and ABS_t. Therefore,

$$\max_{B_t, IB_t, ABS_t} \quad B_t R_t^B + IB_t R_t^{IB} + \varpi R_t^L V_{t+1} ABS_t = \tag{3.31}$$

$$\left(R_t^L V_{t+1} ABS_t \mathcal{P}_t^{ABS} + B_t + IB_t + \frac{\chi^B}{2} (B_t)^2 + \frac{\chi^{IB}}{2} (IB_t)^2 \right) R_t^{SB} \tag{3.32}$$

The first order-conditions to maximize profits are:

$$R_t^B = \left(1 + \chi^B B_t\right) R_t^{SB} \tag{3.33}$$

$$R_t^{IB} = \left(1 + \chi^{IB} IB_t\right) R_t^{SB} \tag{3.34}$$

$$\mathcal{P}_t^{ABS} = \frac{\varpi_t}{R_t^{SB}}. \tag{3.35}$$

It is worthwhile noting that the price of asset-backed securities depends positively on both the probability of success and the probability of the alternative opportunity, and negatively on the interest rate on shadow intermediaries deposits. The price of asset-backed securities, in turn, affects both the interbank rate and the interest rate on corporate loans through R_t^{SB}.

3.3 The production sector

The production side is characterized by two types of representative firms owned by entrepreneurs. In line with empirical patterns observed in the euro area, we assume that production is strongly characterized by the presence of small and medium enterprises, which typically resort to traditional business loans to finance their activity. In our model, these firms produce the intermediate good, which is used by large corporate firms as input to produce the wholesale good. Retailers are in charge of transforming the wholesale good into the final consumption good. In contrast to small and medium enterprises, large firms benefit of a greater variety of external funding. Most importantly, they can have full access to the capital market financing. Our vertically integrated economy linking small and large firms in a production chain is a key feature of the model and plays an important role in the transmission mechanism of shocks originating both in the real and the financial sectors, and it represents a tractable way to study the real effects of macroprudential regulation.

3.3.1 Large firms Entrepreneurs

Entrepreneurs manage large firms and operate in a perfectly competitive environment to produce output that is sold to monopolistically competitive retailers.

The technology of the large firm is described by a Cobb-Douglas production function that employs capital, labor and the intermediate good produced by SMEs as inputs:

$$Y_t^L = A_t \left(K_t^L\right)^{\alpha_L} \left(Y_t^S\right)^{\gamma_S} \left(N_t^L\right)^{1-\gamma_S-\alpha_L} \tag{3.36}$$

where N_t^L is labor input, α_L and γ_S are the elasticity of output to capital and to the intermediate good, respectively. At the end of each period, large firms purchase capital K_t^L to be used in the production process in the subsequent period at the real price Q_t. Capital acquisition is financed by a combination of internal and external finance, so that the demand of external finance is defined by:

$$B_t = Q_t K_t^L - NW_t^L. \tag{3.37}$$

where NW_t^L denotes large firm's net worth. The interest rate charged by shadow intermediaries to large firms on funding B_t is denoted with R_t^B.

3.3.2 Optimal debt contract

The optimal debt contract signed between the large entrepreneur and the shadow intermediary follows Bernanke et al. (1999) and Christiano et al. (2007), which is based on the costly state verification framework (CSV) of Townsend (1979). In particular, the entrepreneurial activity involves risk. The entrepreneur of the large firm is thus exposed to a private idiosyncratic risk shock, denoted with ω^L, which affects the intertemporal transformation of capital, such that $K_t^L = \omega^L K_{t-1}^L$. The shock is assumed to be $\omega^L \sim ln\mathcal{N}(\mu_\omega, \sigma_\omega)$, whose parameters are chosen in order to obtain $\mathbb{E}[\omega^L] = 1$ and to match the desired steady state default rate on loans. As customary, we assume that a fraction $(1-\nu_L)$ of large entrepreneurs exits at the end of each period. Thus, the probability that an entrepreneur will survive is ν_L. This assumption ensures that large firms' net worth is never sufficient to self-finance new capital acquisition. Each period they issue debt, B_t, to finance their desired investment expenditure in excess of net worth.

As Bernanke et al. (1999) have shown, due to a demand-side friction, an external finance premium results from the financial contract signed between the entrepreneur and the financial intermediary that maximizes the payoff to the entrepreneur subject to the required rate of return of the lender. It is shown that given parameter values associated with the cost of monitoring the borrower, characteristics of the distribution of the entrepreneurial returns, and the expected life span of firms, the implied external finance premium depends on the entrepreneur's leverage ratio. Dib (2010) implemented a likewise financial contract in a framework with a banking sector wherein the marginal external financing cost is equal to an external finance premium plus the gross prime lending rate. The size of this markup depends on the ratio of the market value over firm's net worth. Hilberg and Hollymayar (2011) also incorporate a similar framework, allowing for the possibility of bubbles in the price of capital. We rule out the possibility of bubbles in the price of capital; the expected gross return to holding a unit of capital from t to $t+1$ is given by:

$$R_t^Q = \frac{R_t^{K^L} + (1-\delta)Q_t}{Q_{t-1}}, \tag{3.38}$$

and the markup is

$$\frac{R_{t+1}^Q}{R_t^B} = \left(\frac{Q_t K_t^L}{NW_t^L}\right)^{\psi_L}, \tag{3.39}$$

This means that the expected marginal external financing costs equal the expected marginal return on capital. The external finance premium $\left(Q_t K_t^L / NW_t^L\right)^{\psi_L}$ depends on the firm's leverage ratio, a relation that embeds financial acceleration as put forward by Bernanke and Gertler (1989) and the size of which is governed by the parameter $\psi_L > 0$.

Moreover, the demand for entrepreneurial labor is found by equating the marginal product with the wage:

$$(1-\alpha_L)\frac{Y_t^L}{N_t^L} = W_t^L \tag{3.40}$$

Combining (3.36) with (3.40) yields a difference equation for the aggregate net worth position of large firm:

$$\begin{aligned} NW_t^L \;&=\; \nu_L \left[R_t^Q Q_t K_t^L - \left(\mathcal{R}_t^M + \frac{\mu \int \omega dF(\omega) R_t^Q Q_{t-1} K_t^L}{Q_{t-1} K_{t-1}^L - NW_t} \right) \left(Q_{t-1} K_t^L - NW_{t-1}^L \right) \right] \\ &\quad +(1-\alpha_L) A_t \left(K_t^L\right)^{\alpha_L} \left(Y_t^S\right)^{\gamma_S} \left(N_t^L\right)^{(1-\alpha_L-\gamma_S)}. \end{aligned} \tag{3.41}$$

Note that the policy rate, $\mathcal{R}_t^M$, is considered as the risk-free interest rate in the economy, under the assumption that firms may always invest into exogenously given safe assets that pay a risk-less rate that equals the policy rate.

3.3.3 Small Firms Entrepreneurs

A continuum of firms produce the intermediate good in a perfect competitive environment according Cobb-Douglas production function:

$$Y_t^S = A_t \left(K_{t-1}^S\right)^{\alpha_S} \left(N_t^S\right)^{1-\alpha_S}, \tag{3.42}$$

where A_t is an aggregate technology shifter common to both large and small firms, N_t^S is labor input, $\alpha_S < \alpha_L$ denotes the share of the capital input with respect to the intermediate good.

Entrepreneurs managing small firms have no net worth available to start production.

As such, they apply for loans to commercial banks to finance their risky projects. The amount of loan equals the market value of capital:

$$L_t^S = Q_t K_t^S.$$

Capital transformation is subject to idiosyncratic risk and to aggregate risk. The idiosyncratic shock $\omega^S \in \{0, R\}$ implies that the project generates $K_{t+1}^S = RK_t^S$ if succesful, while if unsuccessful $K_{t+1}^S = 0$.

Profit maximization delivers the following demand for inputs:[16]

$$W_t = (1-\alpha_S)\frac{Y_t^S}{N_t^L}, \tag{3.43}$$

$$r_t^{K^S} = \frac{\alpha_S Y_t^S}{K_{t-1}^S} \tag{3.44}$$

3.3.4 Retailers

Following the framework of Bernanke and Gertler (1999) and Iacoviello (2005), we assume that retailers of mass one have some monopoly power and set prices in a Calvo-staggered manner. Scattered price adjustment implies that prices of some goods differ for firms that periodically adjust their prices, which implies differences in demands for these goods and consequently in labor demand across firms. We assume a continuum of retailers of mass 1, indexed by z, who purchase the wholesale goods from large firms at price P_t^w, differentiate them at no cost into $Y_t(z)$, and sell $Y_t(z)$ at the price $P_t(z)$. Final goods are $Y_t^f = \left(\int_0^1 Y_t(z)^{1-\epsilon} dz\right)^{\epsilon/\epsilon-1}$ where $\epsilon > 1$. Given this aggregate output index, the price index is $P_t = \left(\int_0^1 P_t(z)^{1-\epsilon} dz\right)^{1/1-\epsilon}$, so that each retailer faces an individual demand curve of $Y_t(z) = (P_t(z)/P_t)^{-\epsilon} Y_t^f$.

Each retailer chooses a sale price $P_t(z)$ taking P_t^w and the demand curve as given. Using the standard Calvo (1983) pricing mechanism, a randomly selected fraction of retailers $(1-\theta_P)$ can adjust their prices while the remaining fraction θ_P does not adjust. Denote with $P_t^*(z)$ the "reset" price and with $Y_{t+k}^*(z) = (P_t^*(z)/P_{t+k})^{-\epsilon} Y_{t+k}$ the corresponding demand. The optimal $P_t^*(z)$ solves:

$$\sum_{k=0}^{\infty} \theta_P^k \mathbb{E}_t \left\{ \Lambda_{t,k} \left(\frac{P_t^*(z)}{P_{t+k}} - \frac{X}{X_{t+k}} \right) Y_{t+k}^*(z) \right\} = 0,$$

[16] We assume that the wage rate is equalized across the two sector, thus $W_t^S = W_t^L$.

where $\Lambda_{t,k}$ is the household's discount factor and X_t is the markup of final over wholesale goods, which in steady state equals $\epsilon/(\epsilon-1)$. Profits $F_t = (1 - 1/X_t)Y_t$ are finally rebated to households.

Due to the nominal rigidity, the aggregate price level evolves according to:

$$P_t = \left(\theta_P P_{t-1}^{1-\epsilon} + (1-\theta_p)\left(P_t^*\right)^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}. \tag{3.45}$$

3.3.5 Capital producers

Capital good firms are owned by households. They operate in a perfectly competitive environment and use a linear technology to produce new capital both from old capital and with investment goods. While old capital can be transformed at no cost into new capital, the conversion of investment goods into new capital is subject to a convex adjustment cost.

Capital producers maximize the following objective function:

$$\max_{I_t} \quad Q_t I_t - \left[1 + \frac{\kappa_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t \tag{3.46}$$

The aggregate capital stock evolves according to:

$$K_t = (1-\delta)K_{t-1} + \left(1 - \frac{\kappa_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) I_t. \tag{3.47}$$

where δ is the depreciation rate and investment is subject to a quadratic adjustment cost with κ_i denoting the parameters of such costs.

Maximization of this problem delivers the following capital supply:

$$Q_t = 1 + \frac{\kappa_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \frac{I_t}{I_{t-1}}\kappa_i\left(\frac{I_t}{I_{t-1}} - 1\right) - \mathbb{E}_t\left[\beta\Lambda_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 \kappa_i\left(\frac{I_{t+1}}{I_t} - 1\right)\right]. \tag{3.48}$$

which is the standard Tobin's **Q** equation relating the price of capital to marginal adjustment costs, with $\kappa_i > 0$ governing the size of the investment-adjustment cost.

3.4 Monetary policy

We set an endogenous monetary policy rule in which the central bank controls the risk-free interest rate according to a Taylor (1993) rule with interest-rate smoothing:

$$R_t^M = \left(R_{t-1}^M\right)^{\phi_r}\left(R^M\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi}\left(\frac{Y_t}{Y}\right)^{\phi_y}\right)^{(1-\phi_r)} \zeta_{\iota,t}, \tag{3.49}$$

with $\zeta_{\iota,t}$ being the monetary policy shock.

3.5 Aggregation and market clearing

First, we turn to the aggregation in investment projects. As discussed in Section 2.3, there are three cases in which the bank securitizes loans. In these cases, the bank redeploys the capital freed up by this transaction towards a technology that produces final goods in the current period. Thus, aggregating all the cases, there is an extra portion of consumption goods created by the redeployment of capital, which sums up to:

$$\mathit{\Gamma}_t = [l\lambda + (1 - p_{t-1})(1 - l)]\, \mathcal{P}^{ABS}_{t-1} V_t R^L_{t-1} \varkappa L^S_{t-1}. \tag{3.50}$$

As for the other aggregate variables, these are simply given by the weighted average of the corresponding variables for each type of firm. Thus,

$$K_t = \omega K^S_t + (1 - \omega) K^L_t \tag{3.51}$$

$$N_t = \omega N^S_t + (1 - \omega) N^L_t \tag{3.52}$$

$$R^K_t = \omega R^{K^S}_t + (1 - \omega) R^{K^L}_t \tag{3.53}$$

Moreover, market clearing for goods requires that:

$$Y_t + \Gamma_t = C^H_t + C^B_t + I_t \left(1 - \frac{\kappa_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) + c\Upsilon_t Q_t L^S_t + D_t \tag{3.54}$$

3.6 Exogenous perturbations

The exogenous shocks follow an AR(1) process of the type:

$$log(\zeta_{j,t}) = \rho_z log(\zeta_{j,t-1}) + \epsilon_{j,t}, \tag{3.55}$$

with $\rho_j \in (0,1)$ and $\epsilon_{j,t}$ is i.i.d. with mean 0 and standard deviation σ_j and with $j = [A, \kappa^B, \varkappa, \iota]$ identifying the shock to technology, leverage ratio, securitization ratio and to monetary policy, respectively.

3.7 Equilibrium

The equilibrium is characterized by a sequence of endogenous variables: $\{C^H_t$, λ^H_t, N^S_t, N^L_t, N_t, D_t, Y^S_t, K^S_t, L^S_t, Y^L_t, B_t, NW_t, I_t, K_t, Γ_t, K^B_t, ABS_t, IB_t, p_t, Υ_t, W_t, R^D_t, R^{SB}_t R^L_t, R^{IB}_t, $R^{K^S}_t$, $R^{K^L}_t$, R^M_t , R^B_t, Π_t, Q_t, $V_t\}^{\infty}_{t=0}$, and exogenous processes for shocks satisfying the optimality conditions as well as technology and resource constraints.

4 Quantitative analysis

4.1 Parameterization

The model parameters are set to match key quarterly features of the Euro area. We set $\delta = 0.025$ to match an annual rate of depreciation of 10% of capital with respect to output. We set $\alpha_L = 0.43$ for large firms and $\alpha_S = 0.25$ for SMEs implying an elasticity of labor $(1 - \alpha_L) = 0.55$ and $(1 - \alpha_S) = 0.75$, respectively. The weighted average elasticity of capital with respect to total output is therefore $\alpha = 0.33$ implying an aggregate weighted elasticity of labor with respect to output of $(1-\alpha) = 0.66$. These differences capture the idea that small firms are characterized by a higher labor-to-capital ratio than large firms. Euro area data suggest suggest a fraction of SMEs over total firms in the range $(0.95 - 0.99]$ depending on definitions; thus we set it to $\omega = 0.95$ implying a share of large corporate firms $(1-\omega) = 0.04$. The share of SME's output used in large firms production reflects the average share of intermediate good employed across sector based on EU data. In particular, Eurostat states that the EU-27's wholesaling of intermediate goods sector (NACE Group 51.5) consists of approximately one in seven of all wholesaling (NACE Division 51) enterprises; thus we set $\gamma_S = 0.15$. The size of the elasticity parameter $\psi_L = 0.05$ and the survival rate of entrepreneurs, $\nu_L = 0.05$, follows from Bernanke et al. (1999).

In line with Gerali et al. (2010), the discount factor of the households is set $\beta_H = 0.9943$ in order to obtain the average of the steady-state interest rate on deposits (average of both commercial and shadow intermediaries) slightly above 2 per cent on an annual basis, in line with the average monthly rate on M2 deposits in the euro area from the years 1998-2009. The weight on leisure ψ is chosen to match a steady-state work effort of households of 0.3; the labor supply elasticity, $\eta = 1$, follows from Christiano et al. (2005).

The monetary policy rule is calibrated with conventional values adopted in the literature. In particular, $\phi_r = 0.69$ and $\phi_\pi = 1.35$ and $\phi_y = 0.26$. As for the exogenous perturbations, we assume that each type of shock follows the same AR(1) stochastic process $\zeta_{j,t} = \rho_j \zeta_{j,t-1} + e_{j,t}$, with $j \in \left[A, \kappa^B, \varkappa, \iota\right]$ and where A identifies the technology shock, κ_B the shock to the bank's leverage ratio, $\varkappa$ the shock to the securitization ratio, ι identifies the monetary policy shock. We set $\rho_j = 0.95$ and $\sigma_{e_j} = 1$. As for the banking sector, the survival rate of bankers $\tau_B = 0.95$ adopts the value set by Gertler and Karadi (2011). Following Meh and Moran (2015), the parameter λ is set to 1.01, which indicates that capital redeployed generates just enough excess return to be valuable. The probability of the outside investment opportunity to occur is kept to $l = 0.25$ in the analysis. The leverage ratio κ^B is set to 5.0 in the baseline exercises, but we also explore the interval $\kappa^B \in [3, 6]$. As for the securitization ratio, we set to $\varkappa = 0.5$ in most scenarios, but we also experiment for values in the interval $\varkappa \in [0.4, 0.6]$ to examine the effects of loosening this regulatory tool. The range of values chosen for the leverage ratio and the securitization ratio is the state-space in which equilibrium determinacy is ensured in all the scenarios we examine.

Table (1) summarizes the parameterization.

Table 1: Parameters value

Parameter	Description	Value
α_L	Output elasticity of capital for large firms	0.45
α_S	Output elasticity of capital for small firms	0.25
α	Average output elasticity of capital	0.33
α_B	Elasticity of deposit in loans production function	0.01
β_H	Subjective discount factor of households	0.99
h	Habit in household consumption	0.6
δ	Depreciation rate of capital	0.025
γ_S	Elasticity of intermediate input to large firm output	0.22
$\varkappa$	Securitization ratio	[0.5,1]
κ^B	Leverage ratio	[5,7]
ν_L	Large firms survival probability	0.97
μ	Shadow intermediaries monitoring cost	0.12
ρ_r	Persistence term of the Taylor rule	0.69
ϕ_π	Response of interest rate to inflation	1.35
ϕ_y	Response of nominal interest rate to output growth	0.26
σ_j	Standard deviation of the $j-th$ type of shock	1
θ_P	Price stickiness	0.75
η	Labor supply elasticity	1
ψ_L	Parameter governing financial accelerator for large firms	0.05
ϵ	Elasticity of substitution	10
κ_i	Investment-adjustment cost parameter	1.5
ω	Share of SMEs	0.95
λ	Return outside investment opportunity	1.01
l	Probability of outside investment opportunity	0.25
τ_B	Survival probability of commercial bankers	0.95

4.2 Steady state

We present the steady state obtained numerically for key macroeconomic variables under standard parameterization.

Table 2: Steady state of the selected macroeconomic variables economy

Variable	Description	Value
Y	GDP	0.69
C	Consumption	0.32
γ	Screening intensity	2.42
R^D	Deposit rate commercial banks	0.012
R^{SB}	Deposit rate shadow intermediaries	0.07
R^B	Interest rate on corporate loans	0.2
R^L	Return on project commercial banks	0.19
$\mathcal{P}^{ABS}$	Price of ABS	0.36
p	Probability of success	0.96

4.3 Impulse responses to shocks and business cycle amplification

In this section, we provide the results of the model under different types of shocks. We illustrate how business cycle amplification is affected by the heterogeneity of firms and by regulation in the financial sector. We take the technology shock as a benchmark, as it represents one of the main drivers identified by the DSGE literature on the business cycle.

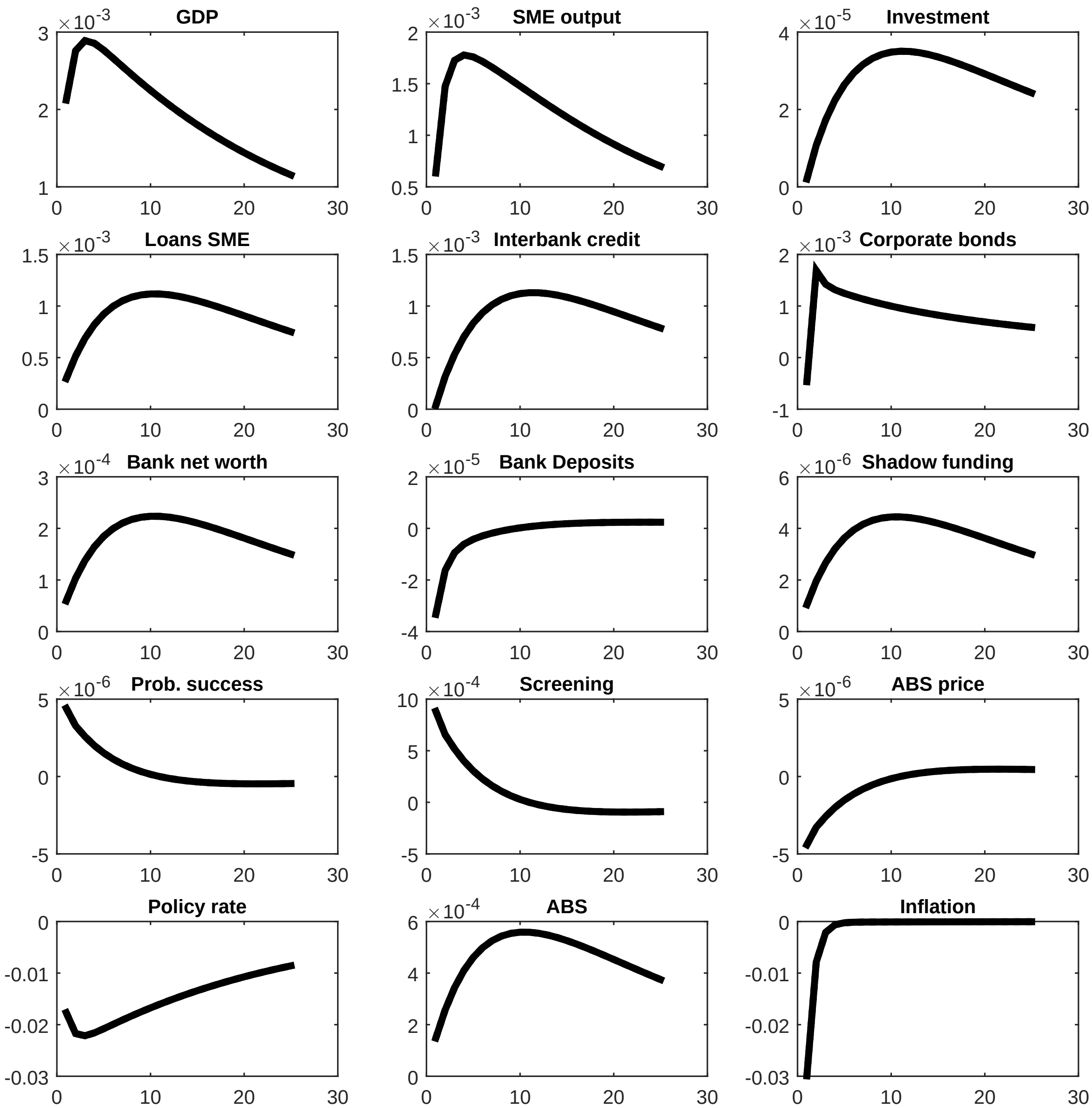
4.3.1 Technology shock

We consider a technology shock as the benchmark to describe the main transmission mechanism at work in the model. In response to a positive technology shock, both small and large firms would like to produce more and increase their demand for loans. In absence of regulation constraints on the leverage ratio, commercial banks would accommodate this higher demand and increase their exposure towards small firms. The obligation to comply with leverage regulation, instead, forces banks to raise own capital in order to increase loan supply, setting the stage for regulatory arbitrage. To allow faster capital accumulation after the shock, banks increase the intensity at which they screen projects so as to limit capital disruption stemming from risky and likely non-performing loans.

This raises the success probability of the projects, which has a direct, positive, effect on the price of asset-backed securities. The latter depends, in contrast, negatively on the gross interest rate on shadow intermediaries deposits, which increases after the technology shock. Since the increase of the interest rate on shadow intermediaries deposit is stronger than the increase of ω_t, the price of asset-backed securities falls. It is important to stress that the fall of the price of securitized loans on the secondary market reflects the higher opportunity cost that banks incur when liquidating loans after having increased the intensity of costly screening effort.

The possibility opened by the presence of a secondary market for loans, thus, allows banks to redeploy capital, to accumulate net worth, and to increase loans. It is worthwhile noting that this channel, although active, exerts a limited force due to the securitization cap. The cap limits the ability of commercial banks to securitize loans on the secondary market and thus the severity of the regulatory arbitrage externality.

Figure 4.1: **Technology shock.** Baseline impulse responses of selected key macroeconomic variables. The leverage ratio is set to $\kappa^B = 5$, the securitization ratio to $\varkappa = 0.5$

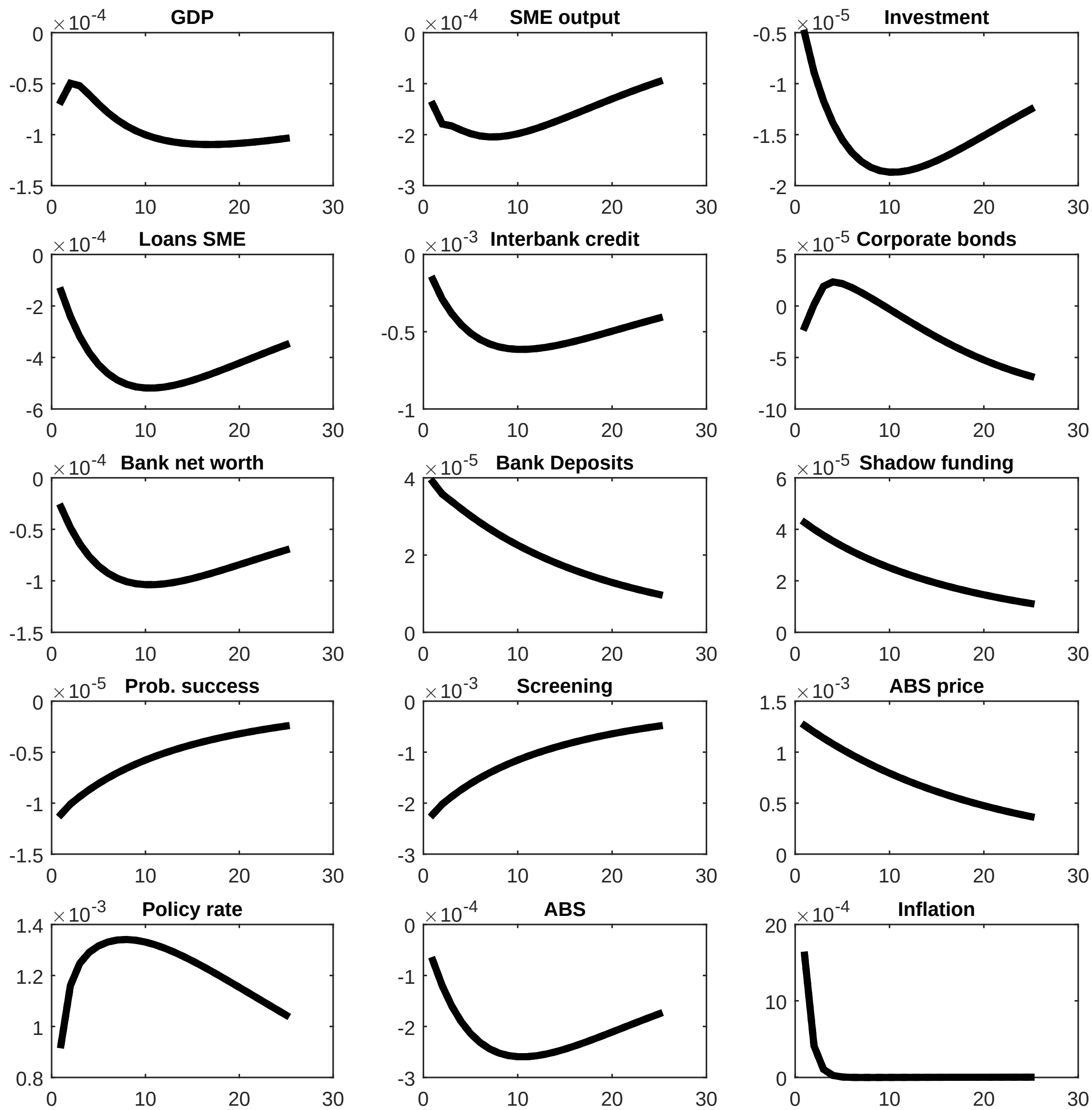


4.3.2 Financial shock

The financial shock consists of a one per cent decrease to the probability of receiving the alternative investment opportunity for the commercial bank. Figure (4.2) shows the impulse response functions.

Most of the transmission mechanism holds as in the technologic shock. The key mechanism at work still goes through the incentives for commercial banks to screen and thus to influence the probability of the projects to be successful, through banking capital accumulation and the consequent credit availability for small firms. Intuitively, a negative shock to the probability of obtaining an alternative investment opportunity reduces capital redeployment opportunities for commercial banks. This has a direct, negative effect on banking capital accumulation. Because of the leverage regulation ratio, the fall in banking capital needs to be accommodated by a reduction in the amount of projects financed (to keep complying with regulation), which translated in a fall of projects screened and consequently of their probability of success. This has a direct effect on the price of ABSs (as prescribed by condition (3.35)), which increases to reflect the lower opportunity cost faced by commercial banks when securitization on the secondary market for loans takes place.

Figure 4.2: **Financial shock.** Impulse response of selected key macroeconomic variables conditional on the realization of the adverse shock to the probability of the alternative investment opportunity. Leverage ratio set at $\kappa^B = 5$, and the securitization cap at $\varkappa = 0.5$.



4.3.3 Regulation shocks

We consider two types of regulation shocks. This first one is a one percent tightening in the leverage regulation κ_t^B, while the second shock is a one percent tightening of the securitization ratio $\varkappa_t$.

A tightening of regulation, put in practice by lowering leverage in the traditional banking sector, exerts a positive effect on the screening effort by commercial banks. The severity of the moral hazard behavior is dampened and the probability of incurring into non-performing loans decreases. In fact, a tighter leverage ratio regulation implies that banks need to increase own capital to keep loans supply unchanged. Thus, increasing screening is the only way to ensure capital accumulates faster. Exerting costly effort to ensure that project failures are less likely makes them less willing to sell loans on the secondary market. Therefore, the quantity of ABS drops, as well as the price of ABS to reflect the higher opportunity cost faced by commercial banks. On impact, the supply of loans drops as a consequence of the partial ability of commercial banks to meet the regulation constraint solely by increasing the screening effort. As a consequence, the adjustment to the regulation ratio passes through the reduction of loans to small firms as well. Importantly, the presence of large firms dampens the fall in capital demand, as the downward pressure on its price triggered by small firms makes more convenient to purchase the capital good to be employed in the large firm's sector. This mechanism sustains investment and the demand of intermediate good by large firms.

A similar dynamics holds for a tightening in the securitization ratio, which makes regulatory arbitrage opportunities less likely for commercial banks. The consequent limited capital redeployment opportunities forces commercial banks to increase screening, and reduces the positive effects on banking capital accumulation induced by securitization. Banking capital drops, so that commercial banks cut on the loans supply to small firms, feeding downward pressures on the price of the investment good. The initial drop of small firms investment, however, is counteracted by the increase in large firm's demand of capital good, which increase their loan demand thereby sustaining the demand of intermediate good and aggregate output.

Figure 4.3: **Regulation shock.** Impulse response of selected key macroeconomic variables conditional on the realization of a 1% tightening of the leverage ratio the for commercial banks) with the capital requirement initially set at 20% (or leverage $\bar{\kappa}^B = 5$), and the securitization cap at $\varkappa = 0.5$.

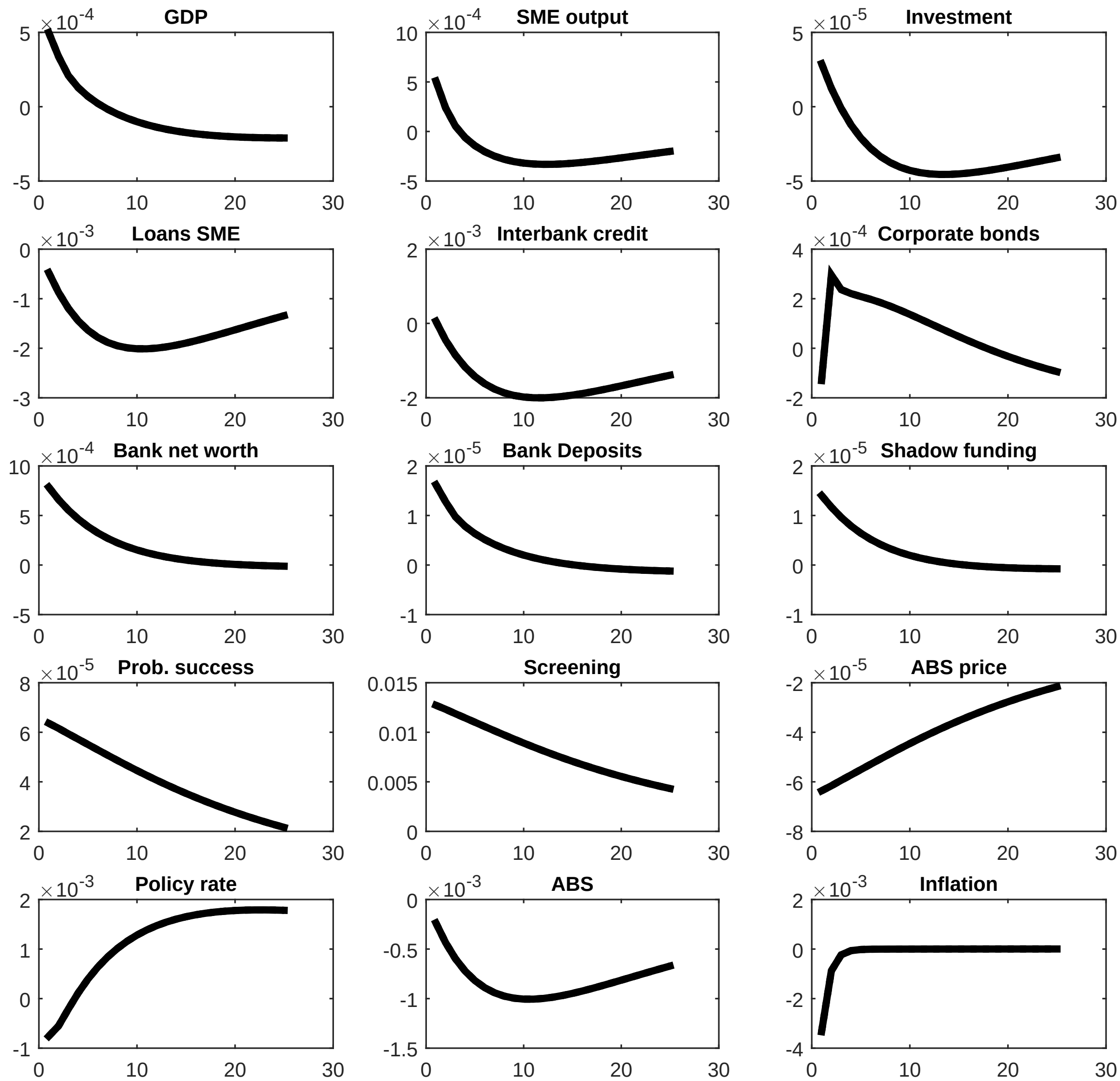
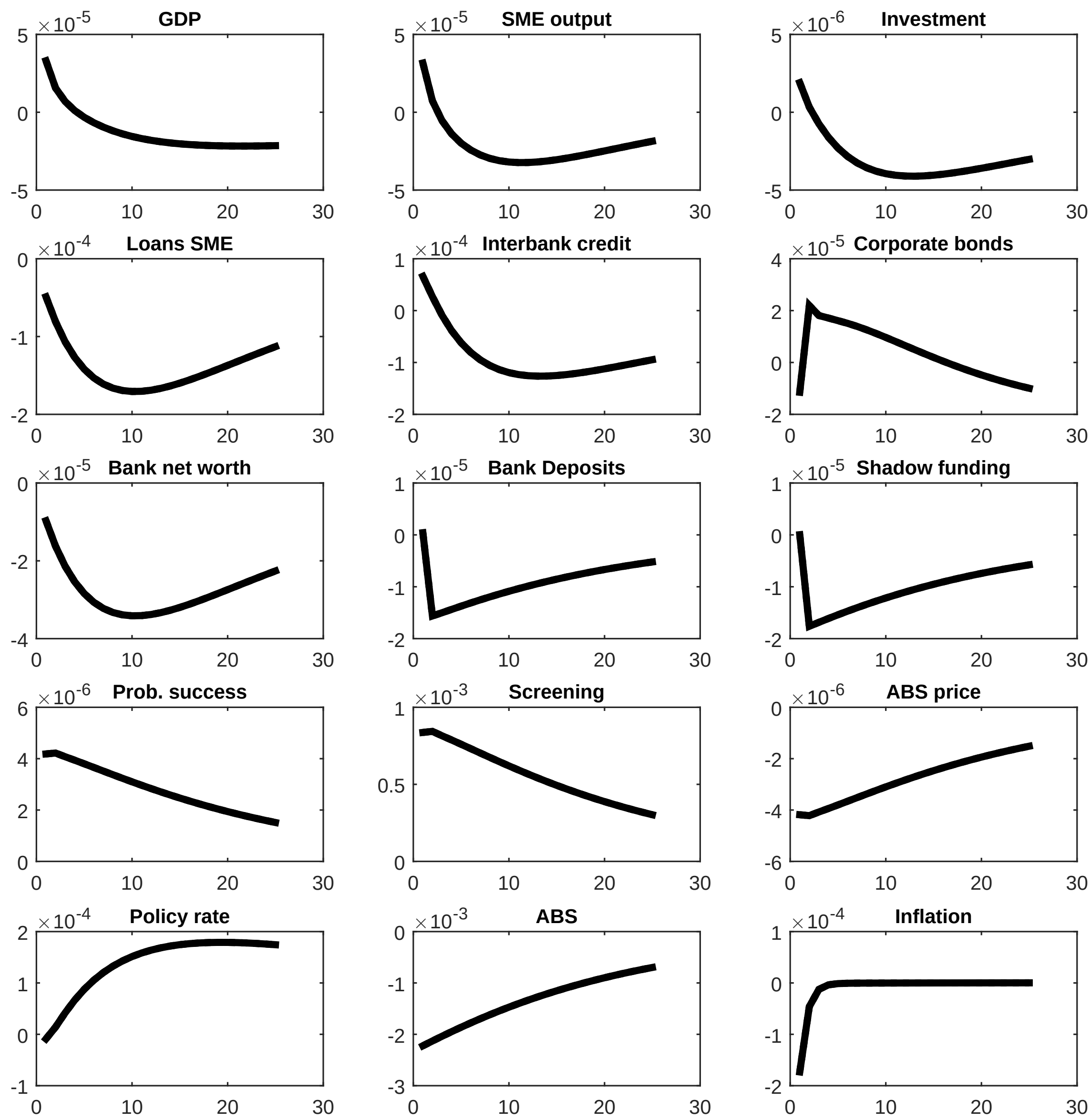


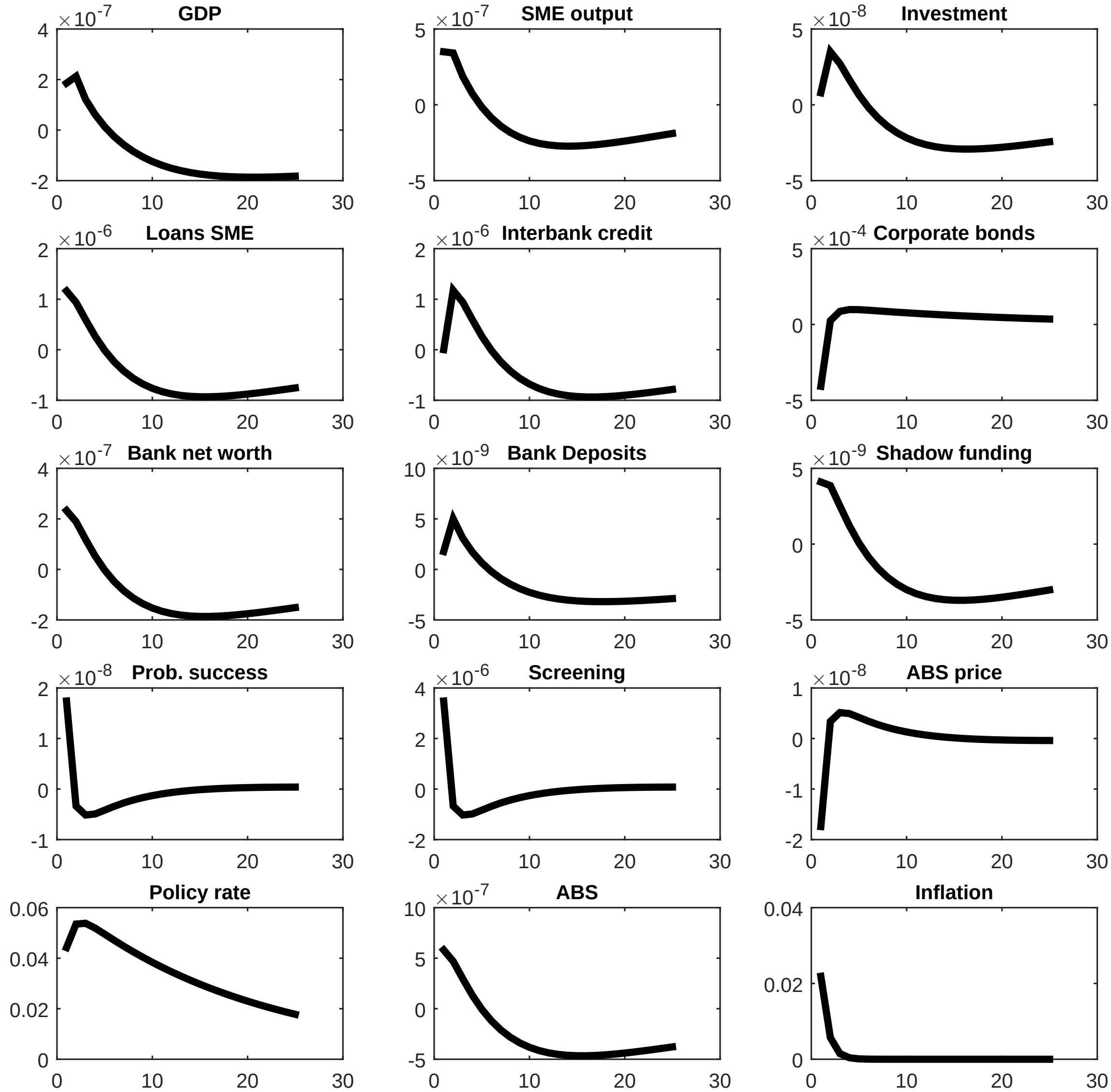
Figure 4.4: **Regulation shock.** Impulse response of selected key macroeconomic variables conditional on the realization of a 1% tightening of the securitization ratio.



4.3.4 Monetary policy shocks

A tightening of monetary policy has a direct effect on the net worth of large firms as the monetary policy interest rate is used as the risk-free interest rate. Thus, an increase in the policy rate has a negative impact on large firms' net worth, which worsens their ability to finance capital purchases via internal finance. As a consequence, large firms' demand of credit to shadow intermediaries increases, which increases the lending rate and improves the intermediation prospects of shadow intermediaries . This attracts more deposits towards shadow intermediaries, but also to commercial banks due to the fact that the latter increase their interest rate to keep households engaging in the financial contract. To cope with the increase in the cost of funding, commercial banks increase screening to improve the likelihood of project to be successful. Thus, as described above, the price of ABSs falls to reflect the higher opportunity cost when securitization on the secondary market for loans takes place.

Figure 4.5: **Monetary policy shock.** Impulse response of selected key macroeconomic variables conditional on the realization of a 1% tightening of monetary policy.



5 The role of firm heterogeneity

In this section, we explore the role played by firms' heterogeneity in the transmission and amplification mechanism of shocks.[17] We start the analysis by assuming a drop in the number of SMEs from 95% (as in the baseline parameterization) to 70%, conditional on the realization of a favorable productivity shock. Figure (5.1) shows the respective impulse response functions. It is worth noting how the presence of small-medium enterprises generally brings an amplification effect in response to the technology shock, as shown by the more volatile solid line than the dotted line. Moreover, the share of SMEs also affects the magnitude of the financial variables due to sectoral inter-linkages mainly working through the ability of banks of accumulating capital and extending loans, as well as by securitization incentives incorporated in the financial contract. Similar results are obtained when changes take place in the parameter γ_S, that is when changing the intensity at which the intermediate good produced by SMEs is employed by large firms as input in the production process. The intuition underlying the increasing volatility when the importance of SMEs increases rests in the presence of riskier projects of SMEs, which may be non performing loans for the commercial banks. The effects of financial frictions, such as the costly screening intensity interacting with moral hazard, and the default probability of projects in the SMEs' sector make the whole economy more vulnerable to aggregate shocks due to the inter-linkages in the production chain as well as in the financial sector.

[17] We leave to a next version possible quantitative experiments that relax nominal rigidities in order to assess their specific contribution to business cycle amplification.

Figure 5.1: Impulse response of selected key macroeconomic variables conditional on the realization of the productivity shock with leverage ratio at $\bar{\kappa}^B = 5$ $\varkappa = 0.5$ and the share of SMEs $\omega = 0.95$ (solid line) and $\omega = 0.7$ (dotted line).

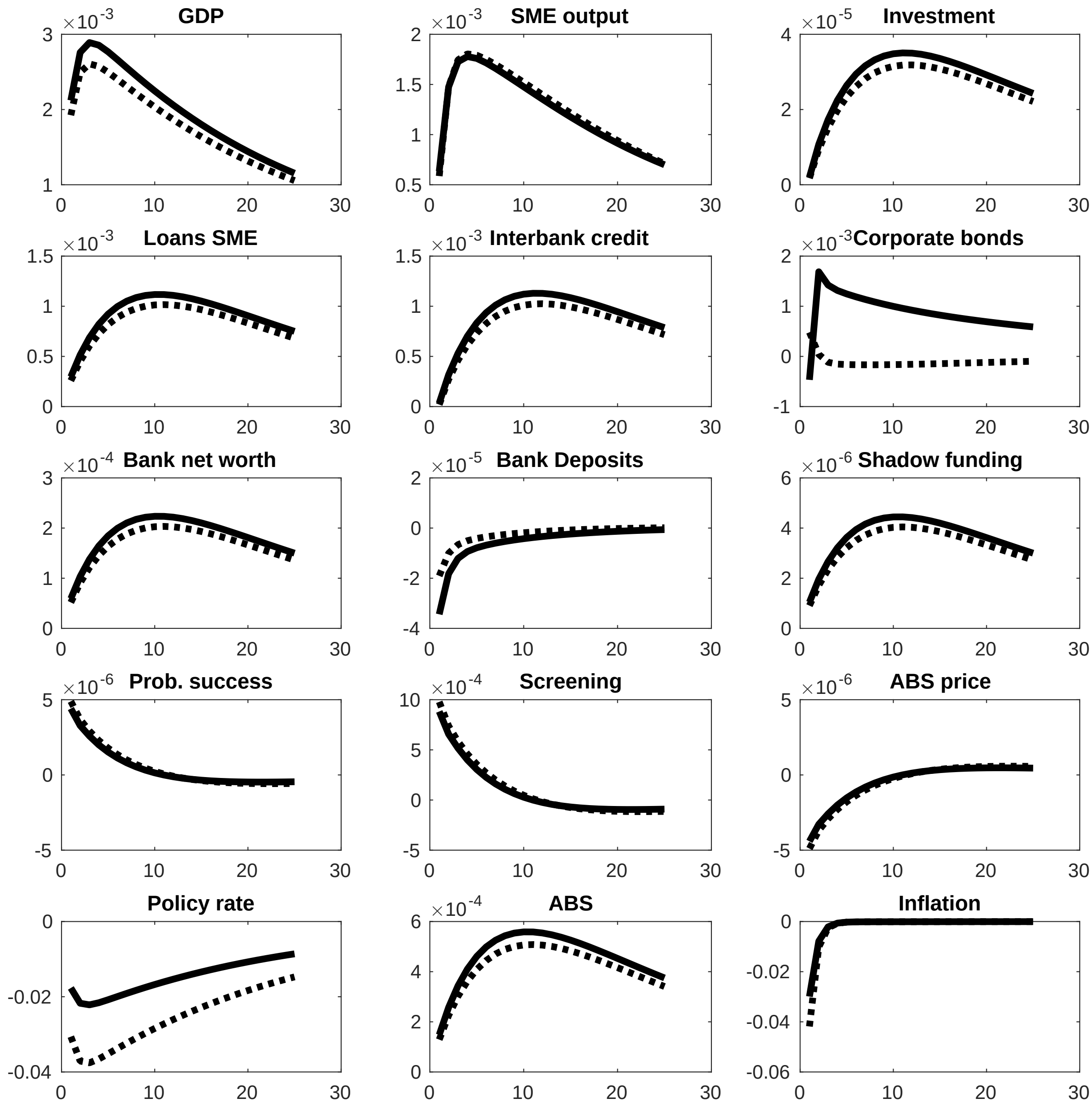
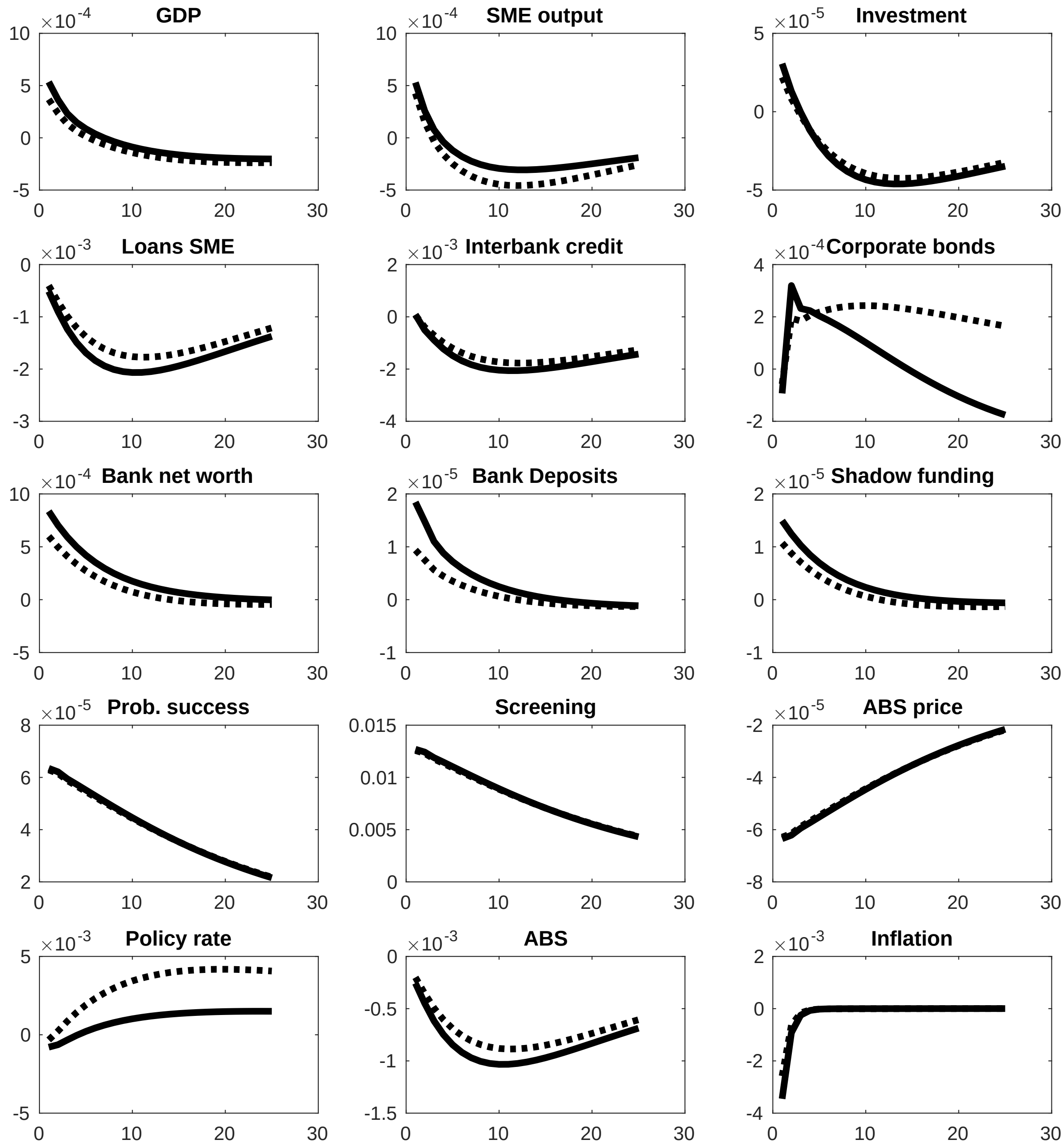


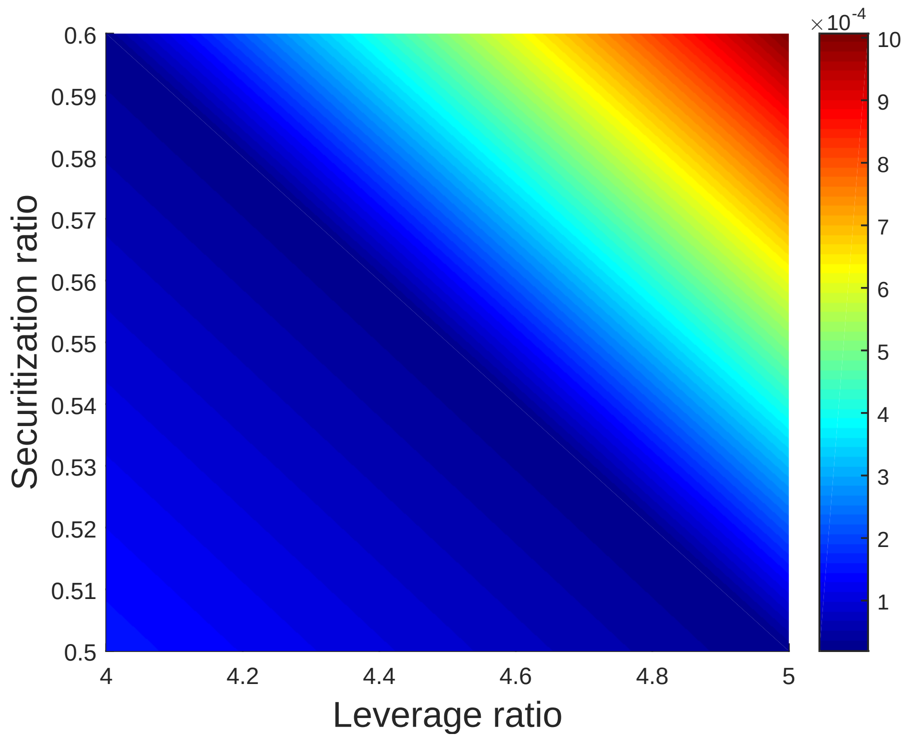
Figure 5.2: Impulse response of selected key macroeconomic variables conditional on the realization of a 1% tightening of the leverage ratio, with the share of SMEs set at $\omega = 0.95$ (solid line) and $\omega = 0.7$ (dotted line).



6 Macroprudential policy and welfare

To obtain a quantification of the effectiveness of the macroprudential policy tools, we study the effects of different policy regimes on output volatility and welfare. To this end, we first compute output volatility for each combination of the parameters representing the two macroprudential policy tools (i.e., caps to the leverage ratio and the securitization ratio). The results are graphically reported in Fig. (6.1), over the state-space parameterization that ensures equilibrium determinacy.

Figure 6.1: Macroprudential policy and output volatility conditional on the realization of a positive technology shock



As it can be observed, loosening simultaneously both macroprudential policy tools dramatically worsens the volatility of output. The positive analysis conducted in Fig. (6.1) suggests that when the banking sector is highly leveraged in a context of a loose securitization regulation, a macroprudential regulator may successfully induce macroeconomic stabilization by tightening both banking leverage and securitization.

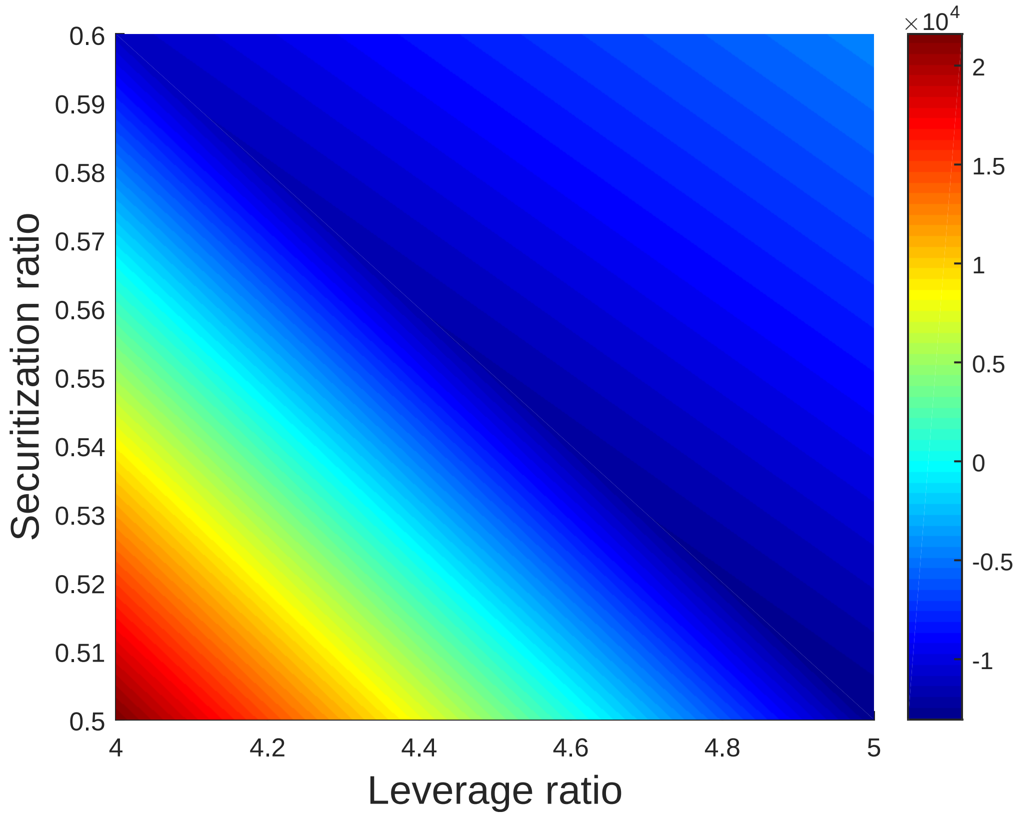
To assess this point from a normative point of view, we conduct welfare analysis following the approach found in Schmitt-Grohe and Uribe (2004) or, more recently, in Wolff and Sims (2017). For the purpose, we define a recursive formulation of as social welfare as:

$$\text{welfare} = \mathbb{W}_t = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \mathbb{U}_t \left(C_t, N_t\right) + \beta \mathbb{E}_t \mathbb{W}_{t+1}, \tag{6.1}$$

where $\mathbb{U}_t(C_t, N_t)$ is the households felicity function defined in (3.1) and β is their subjective discount factor. We then solve the model by performing a second order approximation around the non-stochastic steady-state. When solving the model, we include (6.1) as equilibrium condition and analyze how $\mathbb{W}_t$ behaves when changing simultaneously the two policy parameters.

The result of this welfare exercise is reported in Fig. (6), which shows that tightening securitization is generally welfare improving.

Figure 6.2: Welfare



7 Concluding remarks

The recent financial crisis and the subsequent Great Recession have changed the way economists think about the importance of the shadow financial system and its interaction with the rest of the economy. Only recent standard DSGE models have started to incorporate a fully-fledged financial sector with banks assumed to be the only financial intermediary.

In this paper, we take a step forward by bringing shadow financial intermediaries into a standar NK-DSGE model. The objective is to study the pass-through of shocks between the real sector and the financial sector within a heterogeneous agent model economy in which small and large firms are vertically linked in a production chain. Small firms' risky projects are financed by commercial banks, whose behavior may be subject to moral hazard that induces them to securitize loans and sell them to shadow intermediaries upon the arrival of a more remunerative investment alternative. Large firms' projects are financed by shadow intermediaries, which also provide interbank credit to commercial banks. Macroprudential policy is imposed both as a limit to the leverage ratio in the traditional banking sector and as a cap to the fraction of loans that can be securitized. The adopted normative analysis suggests that loosening the limits to securitization and to leverage ratio in the banking sector may be harmful for financial stability as it dramatically increases the size of output volatility. The welfare analysis confirms that containing leverage and securitization is welfare-improving following a technology shock.

The first key result is that macroprudential policy helps reducing the severity of the moral hazard problem by inducing banks to increase the screening intensity of the projects they finance. The possibility of securitization helps limiting the drop of credit potentially available to small firms resulting from tight regulation. As shown by the banking capital accumulation equation, in fact, higher securitization increases bank capital and therefore the potential availability of credit supply to small firms. Moreover, securitization allows the pass-through of risk of potentially non-performing loans from the traditional banking sector to shadow intermediaries, generally more specialized in the management of risky assets.

However, if the moral hazard problem is very severe, resorting to securitization may ultimately result in a worsening of aggregate volatility due to feedback effects that are in place through the shadow financial intermediation system and impact the real economy through the financing channel of large firms. Shadow intermediaries, in fact, are interconnected both with the banking sector and with the productive sector, as they provide credit both to commercial banks and to large firms. The transfer of risk from traditional banks to shadow intermediaries, that might be beneficial at a first glance, feeds back into the former sector through the interbank market and into the productive sector through corporate loans, making the effects of securitization controversial.

As shown by the impulse responses to a financial shock, an increase in the probability of banks to receive a better outside investment opportunity and, thus, a worsening of the moral hazard problem leads to a drop in the screening intensity, bank net worth, investment and output. A regulator might help smooth business cycle amplification and improve social welfare by implementing a set of macroprudential policy tools as a macroeconomic stabilization policy, whose simultaneity may be powerful. In particular, our results find that both macroprudential policy tools are effective in smoothing business cycle volatility and increase welfare following the shock. On the contrary, the simultaneous loosening of both limits undermines financial stability. In our model, therefore, securitization offers potentially large benefits especially for targeting resources towards more efficient redeployment. however, they might come at the cost of higher volatility when the banking sector is already highly leveraged and in welfare costs. In these situations, tighter securitization caps together with limits to leverage ratio should be activated.

References

Acemoglu, D., V. M. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi (2012). The network origins of aggregate fluctuations. *Econometrica 80*(5), 1977–2016.

Acharya, V. V., I. Gujral, N. Kulkarni, and H. S. Shin (2011). Dividends and bank capital in the financial crisis of 2007-2009. Technical report, National Bureau of Economic Research.

Acharya, V. V., P. Schnabl, and G. Suarez (2013). Securitization without risk transfer. *Journal of Financial economics 107*(3), 515–536.

Andrés, J., J. D. López-Salido, and E. Nelson (2004). Tobin's imperfect asset substitution in optimizing general equilibrium. *Journal of Money, Credit, and Banking 36*(4), 665–690.

Angeloni, I. and E. Faia (2013). Capital regulation and monetary policy with fragile banks. *Journal of Monetary Economics 60*(3), 311–324.

Artola, C. and V. Genre (2011). Euro area smes under financial constraints: Belief or reality? Technical report, CESifo Group Munich.

Ashcraft, A. B., T. Schuermann, et al. (2008). Understanding the securitization of subprime mortgage credit. *Foundations and Trends® in Finance 2*(3), 191–309.

Beck, T. and A. Demirguc-Kunt (2006). Small and medium-size enterprises: Access to finance as a growth constraint. *Journal of Banking and Finance 30*, 2931–2943.

Begenau, J. and T. Landvoigt (2017). Financial regulation in a quantitative model of the modern banking system. *Mimeo*.

Benes, J. and M. Kumhof (2015). Risky bank lending and countercyclical capital buffers. *Journal of Economic Dynamics and Control 58*(C).

Bernanke, B. and M. Gertler (1989). Agency costs, net worth, and business fluctuations. *American Economic Review 79*(1), 14–31.

Bernanke, B. and M. Gertler (1999). Monetary policy and asset price volatility. *Federal Reserve Bank of Kansas City Economic Review* (Q IV), 17–51.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle framework. In J. B. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1 of *Handbook of Macroeconomics*, Chapter 21, pp. 1341–1393. Elsevier.

Brunnermeier, M. K. and Y. Sannikov (2014). A macroeconomic model with a financial sector. *The American Economic Review 104*(2), 379–421.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics 12*(3), 383–398.

Chen, H., V. Cúrdia, and A. Ferrero (2012). The macroeconomic effects of large-scale asset purchase programmes. *The economic journal 122*(564).

Christiano, L., R. Motto, and M. Rostagno (2007). Financial factors in business cycles.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (1997). Sticky price and limited participation models of money: A comparison. *European Economic Review 41*(6), 1201–1249.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy 113*(1), 1–45.

Clerc, L., A. Derviz, C. Mendicino, S. Moyen, K. Nikolov, L. Stracca, J. Suarez, and A. P. Vardoulakish (2015). Capital regulation in a macroeconomic model with three layers of default. *International Journal of Central Banking*.

Curdia, V. and M. Woodford (2010). Credit spreads and monetary policy. *Journal of Money, credit and Banking 42*(s1), 3–35.

De Walque, G., O. Pierrard, and A. Rouabah (2010). Financial (in) stability, supervision and liquidity injections: a dynamic general equilibrium approach. *The Economic Journal 120*(549), 1234–1261.

Diamond, D. W. and R. G. Rajan (2000). A theory of bank capital. *The Journal of Finance 55*(6), 2431–2465.

Dib, A. (2010). Banks, credit market frictions, and business cycles. Technical report, Bank of Canada working paper.

Dotsey, M. and P. Ireland (1996). The welfare cost of inflation in general equilibrium. *Journal of Monetary Economics 37*(1), 29–47.

Farhi, E. and J. Tirole (2017). Shadow banking and the four pillars of traditional financial intermediation. *NBER Working Paper No. 23930*.

Fazzari, S. M., R. G. Hubbard, B. C. Petersen, A. S. Blinder, and J. M. Poterba (1988). Financing constraints and corporate investment. *Brookings papers on economic activity 1988*(1), 141–206.

Ferrando, A. and N. Griesshaber (2011). Financing obstacles among euro area firms: Who suffers the most?

Ferrante, F. (2018). A model of endogenous loan quality and the collapse of the shadow banking system. Technical report.

Freixas, X. and J.-C. Rochet (2013). Taming systemically important financial institutions. *Journal of Money, Credit and Banking 45*(s1), 37–58.

Gabaix, X. (2011). The granular origins of aggregate fluctuations. *Econometrica 79*(3), 733–772.

Gennaioli, N., A. Shleifer, and R. W. Vishny (2013). A model of shadow banking. *The Journal of Finance 68*(4), 1331–1363.

Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010). Credit and banking in a dsge model of the euro area. *Journal of Money, Credit and Banking 42*(s1), 107–141.

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of monetary Economics 58*(1), 17–34.

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

Goodhart, C. A., A. K. Kashyap, D. P. Tsomocos, and A. P. Vardoulakis (2012). Financial regulation in general equilibrium. Technical report, National Bureau of Economic Research.

Gorton, G. and A. Metrick (2010). Regulating the shadow banking system. *Brookings papers on economic activity 2010*(2), 261–297.

Hilberg, O. and B. Hollymayar (2011). Asset prices, collateral and unconventional monetary policy in a dsge model. *ECB Working Papers Series No. 1373*.

Houston, J. F., C. Lin, and Y. MA (2012). Regulatory arbitrage and international bank flows. *The Journal of Finance 67*(5), 1845–1895.

Huang (2014). Banking and shadow banking. Mimeo, National University of Singapore.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review 95*(3), 739–764.

Keys, B. J., T. Mukherjee, A. Seru, and V. Vig (2009). Financial regulation and securitization: Evidence from subprime loans. *Journal of Monetary Economics 56*(5), 700–720.

Malatesta, F., S. Masciantonio, and A. Zaghini (2016). The shadow banking system in the euro area: Definitions, key features and the funding of firms. *Italian Economic Journal 2*(2), 217–237.

Martinez-Miera, D. and J. Suarez (2014). Banks' endogenous risk taking. *CEPR Discussion Paper No. 9134, September 2012*.

Meeks, R., B. Nelson, and P. Alessandri (2017). Shadow banks and macroeconomic instability. *Journal of Money, Credit and Banking 49*(7), 1483–1516.

Meh, C. and K. Moran (2015). Shadow banking and regulation: A quantitative assessment. *Bank of Canada Workig Paper*.

Meh, C. A. and K. Moran (2010). The role of bank capital in the propagation of shocks. *Journal of Economic Dynamics and Control 34*(3), 555–576.

Moscarini, G. and F. Postel-Vinay (2012). The contribution of large and small employers to job creation in times of high and low unemployment. *The American Economic Review 102*(6), 2509–2539.

Ordoñez, G. (2017). Sustainable shadow banking. *American Economic Journal: Macroeconomics 10*(1), 35–56.

Plantin, G. (2014). Shadow banking and bank capital regulation. *The Review of Financial Studies 28*(1), 146–175.

Schmitt-Grohe, S. and M. Uribe (2004). Optimal simple and implementable monetary and fiscal rules. *National Bureau of Economic Research*.

Smets, F. and R. Wouters (2002). Openness, imperfect exchange rate pass-through and monetary policy. *Journal of Monetary Economics 49*(5), 947–981.

Stein, J. C. (2010). Securitization, shadow banking & financial fragility. *Daedalus 139*(4), 41–51.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy 39*, 195–214.

Townsend, R. M. (1979). Optimal contracts and competitive markets with costly state verification. *Journal of Economic theory 21*(2), 265–293.

Van den Heuvel, S. J. (2008). The welfare cost of bank capital requirements. *Journal of Monetary Economics 55*(2), 298–320.

Verona, F., M. Martins, I. Drumond, et al. (2013). (un) anticipated monetary policy in a dsge model with a shadow banking system. *International Journal of Central Banking 9*(3), 78–124.

Wolff, J. and E. Sims (2017). The output and welfare effects of government spending shocks over the business cycle. *International Economic Review*.

Appendix (not for publication)

A Derivation of the incentive compatibility constraint of the commercial bank

In this appendix, we will derive the condition ensuring that the bank has an incentive to screen projects at intensity Υ_t. To this end, we compute the benefits from screening and from not screening to obtain the overall incentive compatibility constraint.

Benefits from screening

Let us remind that there exist four possible scenarios to be analyzed:

1. The project is successful with probability p_t, and the bank receives a better outside investment opportunity with probability l carrying a gross rate of return λ. The bank decides to securitize loans and sell them on the secondary market to the shadow bank at price $\mathcal{P}_t^{ABS}$. This transaction generates revenues

$$s_{1t} = p_t l \lambda R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t. \tag{A.1}$$

2. The project is successful with probability p_t but the banks does not get any outside opportunity. The bank decides to hold the loans until they come to fruition, so securitization does not take place. The revenue in this scenario is simply given by the expected return on lending

$$s_{2t} = p_t(1-l) R_t^L V_{t+1}^e L_t^S. \tag{A.2}$$

3. The project is unsuccessful, which occurs with probability $(1-p_t)$. The bank gets the outside opportunity with probability l carrying the gross return λ. The bank securitizes the loan commitments. This transaction generates revenues

$$s_{3t} = (1-p_t) l \lambda R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t. \tag{A.3}$$

4. The project is unsuccessful, which occurs with probability $(1-p_t)$, the bank does not get any outside opportunity but securitized in any case the loan commitments. The revenue deriving from this transaction is:

$$s_{4t} = (1-p_t)(1-l) R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \tag{A.4}$$

Aggregating conditions (A.1), (A.2), (A.3), and (A.4) delivers the overall benefit from screening for the commercial bank, which after some trivial algebra can be written as

$$R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \left(l\lambda + (1-p_t)(1-l) \right) + p_t(1-l) R_t^L V_{t+1}^e L_t^S \tag{A.5}$$

Benefits from not screening

Let us remind that exerting screening effort entails a cost for the bank. Therefore, if the bank does not screen as agreed in the financial contract the screening cost is saved, which is proportional to the amount of a loan priced at the market value of capital: $c\Upsilon_t Q_t L_t^S$. Not screening guarantees that the bank's loan will be non-performing. However, the bank may still decide to securitize the loans on the secondary market raising $V_{t+1}^e R_t^L \mathcal{P}_t^{ABS} ABS_t$. With probability l this amount can be invested in the alternative investment opportunity at the return λ, while with probability $(1-l)$ it delivers a unit return. Taking both scenarios, the expected benefit of not screening is:

$$c\Upsilon_t Q_t L_t^S + R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \left(\lambda l + (1-l) \right). \tag{A.6}$$

Condition (A.6) represents the benefit of not screening.

To derive the overall commercial bank's incentive to screen, it must be the case that the benefit of screening must be greater or equal to the benefit of not screening, that is (A.5) $\geq$ (A.6). This leads to

$$\begin{aligned} R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \left(l\lambda + (1-p_t)(1-l) \right) + p_t(1-l) R_t^L V_{t+1}^e L_t^S \\ \geq \\ c\Upsilon_t Q_t L_t^S + R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \left(\lambda l + (1-l) \right). \end{aligned}$$

After rearranging and simplifying the overall incentive compatibility constraint can be rewritten as

$$R_t^L V_{t+1}^e \mathcal{P}_t^{ABS} ABS_t \left((1-p_t)(1-l) - (1-l) \right) \geq c\Upsilon_t Q_t L_t^S - p_t(1-l) R_t^L V_{t+1}^e L_t^S. \tag{A.7}$$

By Collecting term yields:

$$R_t^L V_{t+1}^e p_t (1-l) \left(L_t^S \mathcal{P}_t^{ABS} - ABS_t \right) \geq c\Upsilon_t Q_t L_t^S \tag{A.8}$$

and given that $ABS_t = \varkappa L_t^S$ we have:

$$R_t^L V_{t+1}^e p_t (1-l) \left(\mathcal{P}_t^{ABS} - \varkappa \right) \geq c\Upsilon_t Q_t L_t^S \tag{A.9}$$