# 1. CAPTURING MACRO-PRUDENTIAL REGULATION EFFECTIVENESS*

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## ABSTRACT

*Shadow intermediaries activities have registered a spectacular increase during the last decades. Recently, their market shares have rapidly been gaining momentum partially due to "regulatory arbitrage". Although their centrality to the credit boom in the early 2000s and to the collapse during the financial crisis of 2007-2009 is widely documented, the number of contributions studying the implications on the real economy and the underlying transmission mechanisms is surprisingly limited. We contribute to filling this gap and devise a new DSGE model whose productive sector captures key characteristics of the European economy by accounting for small and large firms vertically linked in a production chain. The adopted framework includes commercial banks and shadow financial intermediaries directly interconnected in the interbank market with specific and differentiated channels of financing to the real economy. The framework also incorporates moral hazard for commercial banks, which together with regulatory arbitrage might bring further incentives for banks to securitize part of their assets. An attempt to incorporate macroprudential policy is considered through the implementation of capital requirements and caps to securitization in the traditional banking sector. The results show that the complementarity of such tools devised by a macroprudential authority can be effective in dampening aggregate volatility and safeguarding financial stability.*

## 1 INTRODUCTION

The recent financial turmoils have unambiguously revealed the weaknesses of the pre-crisis regulation framework of traditional financial intermediaries and put under the spotlight the complex activities of the so-called "shadow banking" or "shadow financial intermediation system". At the same time, the growing concerns pertaining to the vulnerability of the global financial system in the aftermath of the 2007-2008 crises have led authorities worldwide to devise a regulatory response aimed at mitigating the undesirable consequences of insufficient capitalization and liquidity shortages in the banking system. Authorities' response to the crisis resulted in the introduction of more stringent capital requirements and liquidity requirements for credit institutions, and other provisions applicable to insurers.

Despite the necessity of such new measures, the costs induced by the burden of the new regulatory compliance has raised potential concerns for 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.[65]

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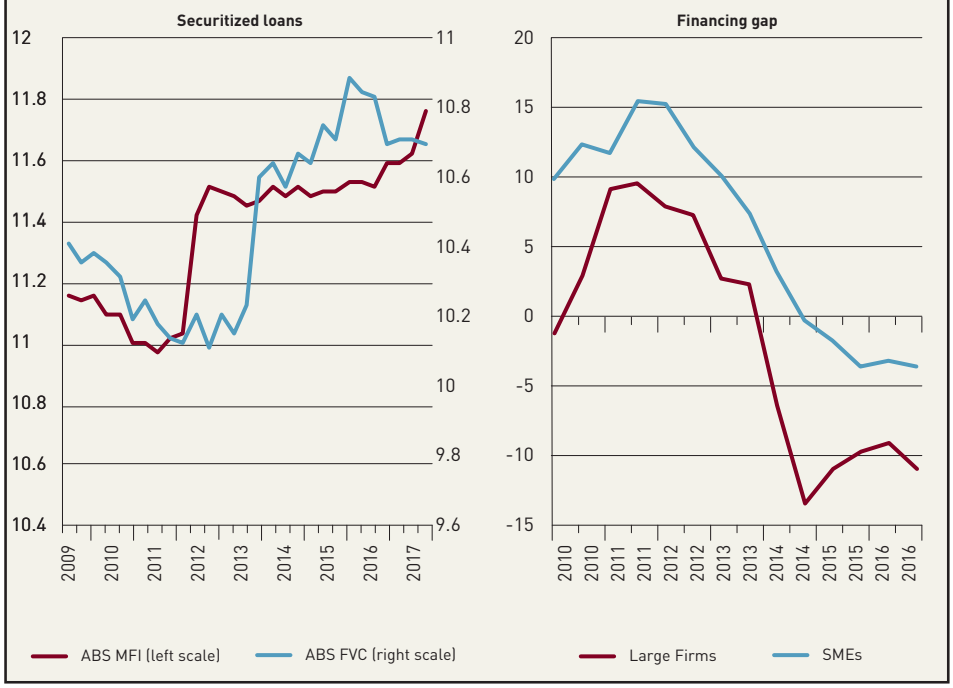
65 This type of behavior follows the so-called "regulatory arbitrage hypothesis". As described in Farhi and Tirole (2017), the regulatory arbitrage view includes two possible sub-views. In the first sub-view, retail banks evade capital requirements by providing liquidity support off-balance sheet to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

* This contribution is a shortened version of BCL Working paper n°114. The conclusions may not be shared by policymakers in the BCL or the Eurosystem.

Financial intermediation, in the non-bank sector 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 . The importance of the shadow financial intermediation system to the credit boom in the early 2000s and the turmoil during the financial crisis of 2007-2009 has been widely documented. Despite its contribution, the number of academic papers studying its implications for the real economy and the underlying transmission mechanisms of shocks in the presence of shadow financial institutions is surprisingly limited. This study contributes to filling this gap through the lens of a New Keynesian dynamic stochastic general equilibrium (DSGE) model, which includes macroprudential regulation as a tool for macroeconomic stabilization in the presence of shadow intermediaries. It aims at shedding new light on the important role played by the shadow financial intermediation system in the transmission of shocks. To display the connection between regulatory arbitrage and securitization activity, the left panel of Fig. 1 shows the developments in securitization during the implementation of the "Basel III" regulatory framework. The dark line represents the stock of loans that have been derecognized through securitization from the balance sheet of the euro area Monetary and Financial Institutions (MFIs), while the light line represents the stock of securitized loans reported on the asset side of Financial Vehicle Corporations (FVC) engaged in traditional securitization. Both series show a marked jump upwards corresponding to the start of the post-crisis regulatory regime. 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 asymmetries.[66]

In the present model, financial intermediaries operating in the traditional banking sector (or commercial banking) can originate risky loans, and can finance these loans both with own resources and with interbank credit obtained from the shadow financial system. Such loans are granted solely to small firms. This assumption is made to replicate the structural characteristics of the European economy. As shown in the right-hand panel of Fig 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.[67]

Figure 1
Securitization activity and firms' access to external finance




*Source : BCL calculations based on SDW data.*
*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. In the right panel, the perceived external financial gap for SMEs and large firms (percentage).*

66 See Ashcraft and Schuermann (2008) for an overview on the securitization process of subprime mortgage credit.

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

Commercial banks' behavior is subject to moral hazard. The possibility of capital redeployment, offered by the arrival of an alternative investment opportunity, provides commercial banks with incentives to liberate resources – and save screening costs associated with monitoring the borrower's project – by originating asset-backed securities that can be sold on the secondary market to shadow intermediaries. The key implication is that any transfer of risk from the traditional banking sector to the shadow intermediation sector via securitization feeds back into the former through the interbank market and into the productive sector through corporate loans.

Macroprudential instruments are implemented with the objective of mitigating the undesirable effects of securitization. The tools consist of the *leverage* ratio, which imposes the maximum level of exposure towards small firms for a given level of commercial banking capital, and the securitization ratio, which limits the maximum fraction of loans that can be securitized on the secondary market. The results of this paper show that the complementarity of such tools allows the macroprudential authority to pursue, successfully, macroeconomic stabilization after a shock, as their simultaneous activation is effective in dampening output volatility and improving welfare.

## 2 RELATED LITERATURE

The present paper is broadly related to the class of models that introduces financial intermediation into well-established New Keynesian DSGE frameworks, such as Goodfriend et al. (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 to improve welfare. The first study argues that regulators should impose restrictions on dividends and equity pay-offs, while the second study shows theoretically that a countercyclical capital 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.[68]

Later contributions find mixed results of bank capital regulation due to several emerging trade-offs. To mention a few, De Walque et al. (2010) find that moving from Basel I to Basel II regulation reduces financial instability but have ambiguous effects on the volatility of output. Meh et al. (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 normal times, generating non-trivial welfare trade-offs. Clerc et al. (2015) find that capital requirements reduce bank leverage, bank failure risk, but excessive capital requirements may unduly restrict credit availability, so that there exists an optimal level of bank capital requirements.

68 Keys et al. (2009) reach similar conclusions in relation with the mortgage market. They state that "findings caution against policies that impose stricter lender regulations which fail to align lenders' incentives with the investors of mortgage-backed securities".

The literature presented above 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' risk-taking thereby fostering regulatory arbitrage. In this respect, this paper strictly connects with two recent research strands. The first attempts to embed shadow intermediaries into otherwise standard general equilibrium models. For instance, Goodhart et al. (2012) construct a two-period model to study the efficacy of several regulatory tools in the presence of shadow intermediaries. Verona et al. (2013) 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) find that following a liquidity shock, stabilization policy aimed solely at the market in securitized assets is relatively ineffective. Gorton and Metrick (2010) propose principles for regulating the shadow intermediaries system and Meh and Moran (2015) 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. Houston et al. (2012) have investigated the regulatory arbitrage hypothesis empirically in a cross-country setting, although without a specific reference to the shadow financial system. They find find 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. Archarya (2013) shows that regulatory arbitrage was an important motive behind setting up these 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 risks for banks and shadow banking institutions. Huang (2016) models shadow intermediaries as an off-balance-sheet financing option for regular banks within the Brunnemaier and Sannikov (2014) framework and suggests that financial stability is a U-shaped function of financial regulation. Ordonez (2017) 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 (2016) 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 more resilient. 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 of the capital market for small firms compared with large firms) finds support in related research showing that small firms are severely credit constrained. Early 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 Greisshaber (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

In this study, the economy consists of households, large firms, small and medium enterprises (SMEs), commercial banks, 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 the intermediate good, which is used entirely by large firms as input to produce the wholesale good. We introduce retailers that transform the wholesale good at no cost into a final consumption good, in order to introduce price inertia in a tractable manner. 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, $KB_t$, to finance projects carried out by SMEs. On the contrary, shadow intermediaries solely finance large corporate firms. 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 generate a positive return. 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.

### 3.1 THE HOUSEHOLD SECTOR

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. Households' income derives from renting labor to producers at the competitive real wage, $W_t$. The available income serves 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 (2000), Christiano et al. (1997). In particular, households maximize the expected present discounted value of their utility:

$$U(C_t, N_t) = E_0 \sum_{t=1}^{\infty} log(C_t^H - hC_{t-1}^H) - \bar{\psi} \frac{N_t^{1+\eta}}{1+\eta} \quad (1)$$

where $C_t^H$ is non-durable consumption at time $t$, 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. Households can decide to direct their savings towards either a commercial bank or a shadow intermediary. 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 custody account for financial investment, for example in money-market funds or assimilated products offered by non-bank financial institutions.[69]

69 As argued by Ferrante (2015), 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 as risk-free assets.

To model the investment decision of households, we follow Dotsey et al. (1996) and Meh and Moran (2015), and assume that households are distributed along a unit interval, with $i \in [0,1]$ identifying a typical household. Commercial banks are located at point 0 and shadow intermediaries at point 1. If households deposit savings 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 $\phi(i) = \chi_1\left[\frac{1-i}{i}\right]^2$, 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:

$$C_t^H + D_t(i)[1+\phi(i)] = \left[(1-t^b)R_t^D\Phi_t(i) + R_t^{SB}\left(1-\Phi_t(i)\right)\right]D_{t-1}(i) + W_t^H + T_t\,, \quad (2),$$

where $D_t$ is the amount of deposits, $\Phi$ 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 $T_t$ represents lump-sum transfers, which includes profits from the retail sector, capital good producers and the banking sector.

### 3.2 THE FINANCIAL SECTOR

The financial sector consists of a continuum of risk neutral commercial banks and shadow intermediaries. Commercial banks are assumed to carry out traditional financial intermediation activities, which consists of pooling together resources collected from depositors and the interbank market (from shadow intermediaries) to finance the risky projects of SMEs. Commercial banks may engage in costly monitoring efforts in order to increase the likelihood of a project being successful. However, moral hazard may arise when an exogenous investment opportunity materializes, as commercial banks may decide to sell a portion of their loans to shadow intermediaries in the form of ABS thereby saving the monitoring cost. 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 on the securitization ratio. Shadow intermediaries, on the contrary, are non-bank financial institutions whose main activity consists in attracting resources from households. They use such resources to operate on the secondary market for loans, provide short-term finance to commercial banks, and finance large firms.

Following Meh and Moran (2015), we set up a financial contract between the commercial bank, depositors and the shadow intermediary. The contract ensures that all the agents have appropriate incentives to engage in the borrowing-lending relationship.

By taking into account all four possible scenarios –given by the combination of whether or not the commercial bank decides to sell ABSs both when obtaining and non-obtaining the alternative investment opportunity- the evolution of commercial banking capital in the economy is given by:

$$K_t^B = \tau_B\left[\left((1-p_t)(1-l) + l\lambda x P_t^{ABS} + p_{t-1}(1-l)\right)V_t R_{t-1}^L\, L_t^S\right] \quad (3)$$

where $\tau_B$ is the fraction of surviving banks at the end of each period, $p_t$ is the probability of the loan ($L_t^S$) to be successful, $R_t^L$ is the lending (gross) interest rate and $V_t$ is the aggregate return on capital.

Shadow intermediaries are financial institutions that operate outside the traditional banking system. The shadow sector is competitive. Shadow intermediaries are not subject to regulatory costs. Their activity consists of 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 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. To capture the imperfect substitution between interbank and corporate lending, we assume that there are quadratic management costs involved with investing in corporate loans. The profit maximizing behavior of the shadow intermediary leads to the first order conditions below:

$$R_t^B = (1 + \chi^B B_t) R_t^{SB}\,, \quad (4)$$

$$R_t^{IB} = (1 + \chi^{IB} IB_t) R_t^{SB}\,, \quad (5)$$

$$P_t^{ABS} = \frac{\overline{\omega}_t}{R_t^{SB}}. \quad (6)$$

### 3.3 THE PRODUCTION SECTOR

The productive sector is quite standard. Two types of representative firms owned by entrepreneurs characterize the production side. In particular, in line with empirical patterns observed in the euro area, we assume the presence of small and medium enterprises, which typically resort to traditional business loans to finance their activity, and by large corporate firms. In the model, these firms produce the intermediate good, which large corporate firms use as input to produce the wholesale good. Retailers operating in a monopolistic environment are in charge of transforming the wholesale good into the final consumption good and adjust prices as in Calvo (1983). In contrast to small and medium enterprises, large firms benefit a greater variety of external funding. Most importantly, they can have full access to capital market financing. Both sectors combine their productive factors in a standard Cobb-Douglas technology function to produce their output. To finance capital acquisition, small firms demand loans from commercial banks, while large firms demand loans from shadow intermediaries. The latter are involved with large firms in a financial contract based on the costly state verification framework of Townsend (1979).

## 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:

$$R_t^M = (R_{t-1}^M)^{\phi^r} \left( R^M \left(\frac{\Pi_t}{\Pi}\right)^{\phi_r} \left(\frac{Y_t}{Y}\right)^{\phi_y} \right)^{1-\phi_r}. \quad (7)$$

## 5 MACROPRUDENTIAL POLICY RULES

The macroprudential policy rules considered in the model are the leverage ratio and the securitization ratio. Respectively, they are given by:

$$\kappa_t^B = \frac{Q_t L_t^S}{K_t^B}, \quad (8)$$

$$x = \frac{ABS_t}{L_t}. \quad (9)$$

## 6 QUANTITATIVE ANALYSIS

### 6.1 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 elasticities 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 thus $\alpha = 0.33$, implying an aggregate weighted elasticity of labor with respect to output of $(1 - \alpha) = 0.66$. These differences capture the higher labor-to-capital ratio that generally characterizes small firms with respect to 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 $\omega = 0.95$ implying a share of large corporate firms $(1 - \omega) = 0.05$. The share of SME's output used in large firms' production is set to reflect the average share of intermediate good employed across sector based on EU data. In particular, according to Eurostat, 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 exit rate of entrepreneurs, $\nu_L = 0.05$, follow from Bernanke et al. (1999).

In line with Gerali et al. (2010), the discount factor of households is $\beta = 0.9943$ 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 $\psi$ 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, $\phi_r = 0.69$, $\phi_\pi = 1.35$ and $\phi_y = 0.26$. As for the exogenous perturbations, we assume that each type of shock follows the same AR(1) stochastic process: $\zeta_{j,t} = \rho_{j,t}\,\zeta_{j,t-1} + \epsilon_{j,t}$ with $j \in [A, \kappa^B, \varkappa, \iota]$, where A identifies the technology shock, $\kappa^B$ the shock to the bank leverage ratio, $\varkappa$ the shock to the securitization ratio, and $\iota$ the monetary policy shock. We set the persistence term $\rho_j = 0.95$ and the error term's standard deviation $\sigma_{\epsilon j} = 1$. 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 $\lambda$ 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 $\kappa^B$ 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 the model's equilibrium determinacy is ensured in all the scenarios we examine. Table 6.1 summarize the parameterization.

Table 6.1:
**Parameterization**

| | | |
|---|---|---|
| $\alpha_L$ | Output elasticity of capital for large firms | 0.45 |
| $\alpha_S$ | Output elasticity of capital for small firms | 0.25 |
| $\alpha$ | Average output elasticity of capital | 0.33 |
| $\beta$ | Subjective discount factor of households | 0.99 |
| $h$ | Habit in household consumption | 0.6 |
| $\delta$ | Depreciation rate of capital | 0.025 |
| $\gamma_s$ | Elasticity of intermediate input to large firm output | 0.22 |
| $\varkappa$ | Securitization ratio | [0.5,1] |
| $\kappa^B$ | Leverage ratio | [5,7] |
| $\nu_L$ | Large firms entrepreneurs exit rate | 0.95 |
| $\mu$ | Shadow intermediaries monitoring cost | 0.12 |
| $\rho_r$ | Persistence term of the Taylor rule | 0.69 |
| $\Phi_\pi$ | Response of interest rate to inflation | 1.35 |
| $\Phi_r$ | Response of nominal interest rate to output growth | 0.26 |
| $\sigma_j$ | Standard deviation of the j-th type of shock | 1 |
| $\theta_p$ | Price stickiness | 0.75 |
| $\eta$ | Labor supply elasticity | 1 |
| $\psi_L$ | Parameter governing financial accelerator for large firms | 0.05 |
| $\epsilon$ | Elasticity of substitution | 10 |
| $\kappa_i$ | Investment-adjustment cost parameter | 1.5 |
| $\omega$ | Share of SMEs | 0.95 |
| $\lambda$ | Return outside investment opportunity | 1.01 |
| $l$ | Probability of outside investment opportunity | 0.25 |
| $\tau_B$ | Survival probability of commercial bankers | 0.95 |

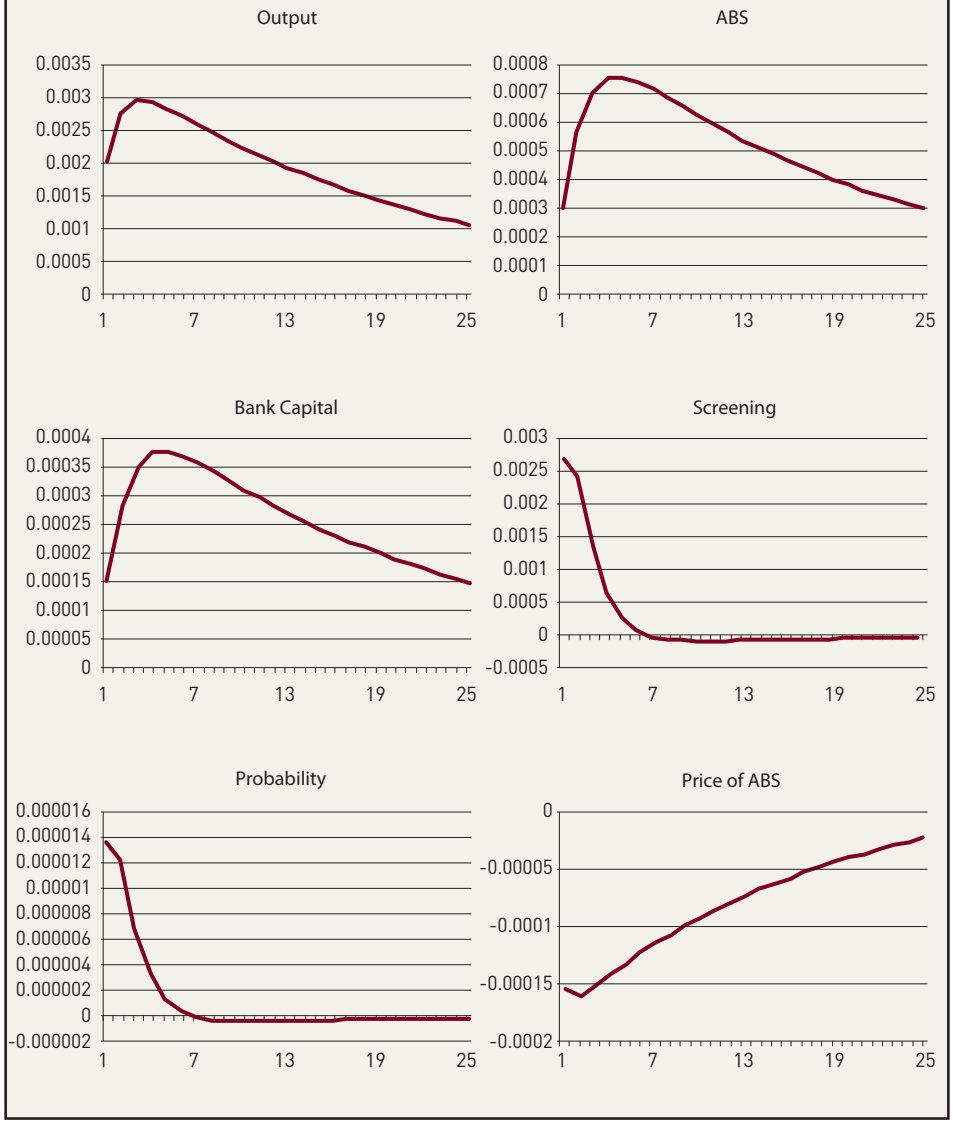
*Source: Parameterization details in subsection 6.1*

## 6.2 IMPULSE RESPONSE FUNCTIONS

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 the absence of regulatory 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 to limit capital disruption stemming from risky and potential non-performing loans. This raises the probability success of the projects, which has a direct, positive effect on the price of asset-backed securities. In contrast, the latter depends 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' deposits dominates the increase of $\bar{\omega}_t$, 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 efforts. The possibility opened by the 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 attenuates the severity of the regulatory arbitrage externality.

Figure 6.1
Impulse response functions of selected key macroeconomic variables conditional on the realization of a favorable technologic shock




*Source: Model simulations*

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).

Fig. 6.2 reports the results graphically over the state-space parameterization that ensures equilibrium determinacy. As can be observed, loosening both macroprudential policy tools simultaneously dramatically increases the volatility of output, while the effect is weaker when banking leverage is high conditional on a moderate securitization activity, or vice-versa. 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. The positive analysis conducted so far and reported in Fig. 6.2 suggests that loosening only the leverage ratio while keeping the securitization ratio tight might be preferable than the other way round. This is particularly true if the objective of the regulator is to safeguard financial stability, as the marginal decrease in output volatility implied by loosening leverage is greater than the marginal decrease of output volatility implied by a proportional loosening of the securitization ratio.

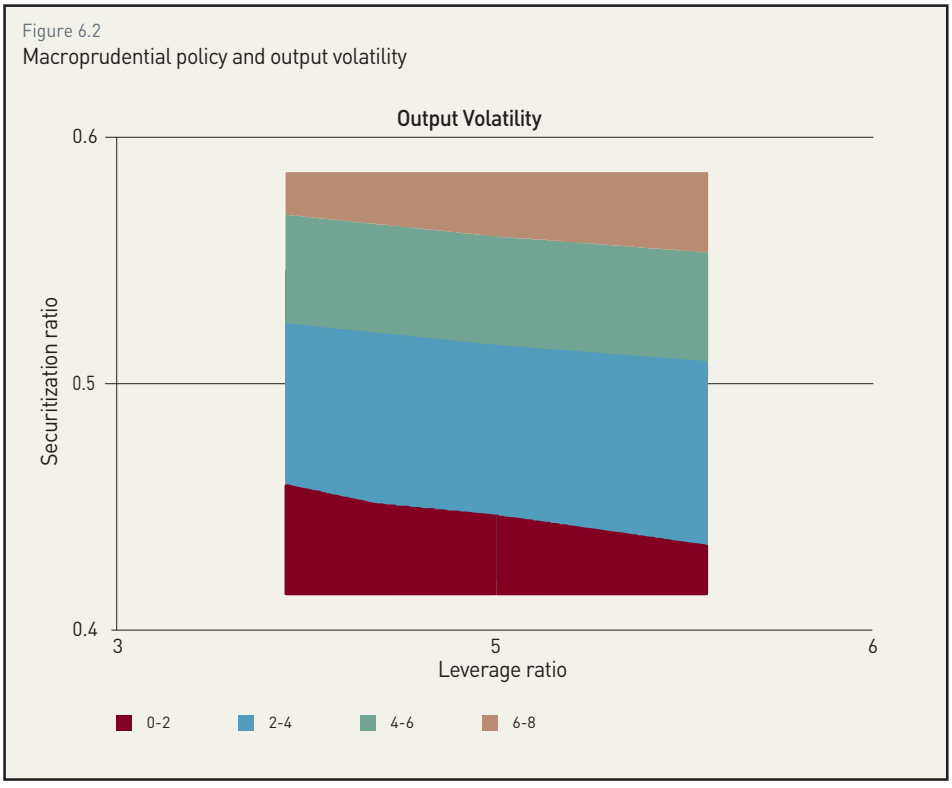
To assess this issue from a normative point of view, we conduct welfare analysis in the spirit of Uribe (2004). For this purpose, we define social welfare as:

$$Welfare = W_0 = E_t \sum_{t=0}^{\infty} \beta^t U_t(C_t, N_t). \quad (10)$$

$U_t(C_t, N_t)$ is the households felicity function and ß is their subjective discount factor. We then solve the model by performing a second order approximation around the non-stochastic steady state. We are interested in the conditional expectation of welfare, that is, the conditional expectation of lifetime utility computed as the infinite discounted sum of per period utilities. As in Uribe (2004), we choose to compute expected welfare conditional on the initial state being the non-stochastic steady state in order to ensure that the economy begins from the same initial point under all possible policies. The set of macroprudential policies in our framework can be defined as the pair of parameters governing the leverage ratio and securitization ratio. Formally, such policies are defined as $\mathbb{Z}_{ij} = (\kappa_i^B, x_j)$, with $i$ and $j$ indexing each policy parameters respectively. Therefore, our approach consists of evaluating $W_0$ of each pair $(i, j)$ of the policy.

The result of this welfare exercise is reported in Fig. 6.3, which shows that reducing leverage in the traditional banking sector while curbing securitization is generally welfare improving.

Figure 6.2
Macroprudential policy and output volatility




*Source : Authors' elaboration based on model simulations*

## 7. CONCLUSIONS

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 real and financial sector. Only recently have standard DSGE models started to incorporate a fully-fledged financial sector with banks assumed to be the only financial intermediary.

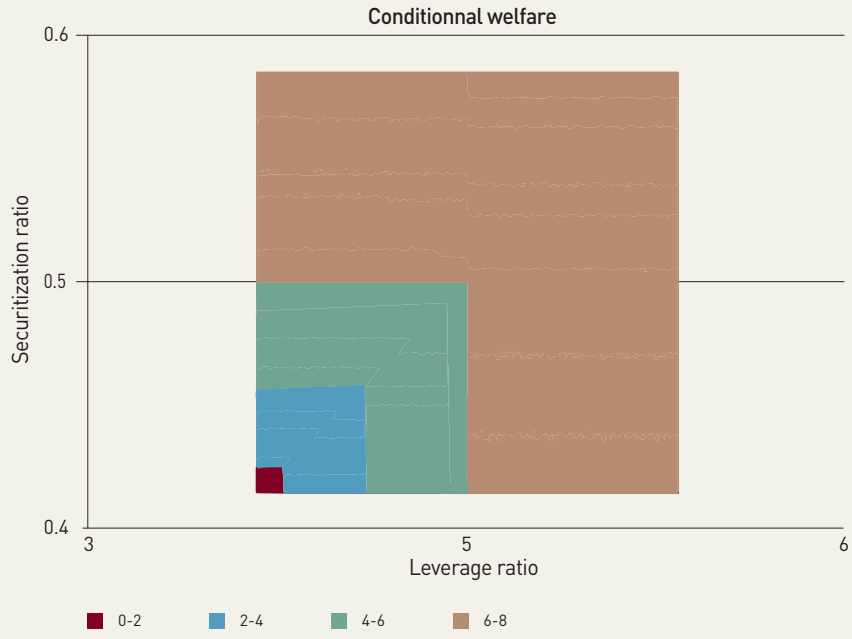
In this paper, we take a step forward by bringing shadow financial intermediaries into a standard New Keynesian DSGE model. The

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 profitable investment alternative. Large firms' projects are financed by shadow intermediaries, which also provide interbank credit to commercial banks. In our framework, 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 on 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 ensures a lower decline in welfare following a technology shock.

The first key result of this study is that macroprudential policy helps to reduce 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 to limit the restriction 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 risks related to potentially non-performing loans from the traditional banking sector to shadow intermediaries, that are 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. The volatility can subsequently 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 complex.

Figure 6.3
Macroprudential policy and output volatility




*Source : Authors' elaboration based on model simulations*

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 to 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 increaseing welfare following the shock. On the contrary, the simultaneous loosening of both limits undermines financial stability. Despite the potential benefits of securitization, especially in directing resources towards more efficient allocation, they come at the cost of higher volatility when the banking sector is already highly leveraged. In these situations, tighter securitization caps together with limits to leverage ratio should be activated.

REFERENCES

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

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

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

J. Andr´es, J. D. L´opez-Salido, and E. Nelson. Tobin's imperfect asset substitution in optimizing general equilibrium. Journal of Money, Credit, and Banking, 36(4):665–690, 2004.

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

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

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

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

J. Begenau and T. Landvoigt. Financial regulation in a quantitative model of the modern banking system. 2016.

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

B. Bernanke and M. Gertler. Monetary policy and asset price volatility. Federal Reserve

Bank of Kansas City Economic Review, (Q IV):17–51, 1999.

B. S. Bernanke, M. Gertler, and S. Gilchrist. The financial accelerator in a quantitative business cycle framework. In J. B. Taylor and M. Woodford, editors, Handbook of

Macroeconomics, volume 1 of Handbook of Macroeconomics, chapter 21, pages 1341-1393. Elsevier, 1999.

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

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

H. Chen, V. C´urdia, and A. Ferrero. The macroeconomic effects of large-scale asset purchase programmes. The Economic Journal, 122(564), 2012.

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

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

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

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

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

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

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

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

E. Farhi and J. Tirole. Shadow banking and the four pillars of traditional financial intermediation. Mimeo, 2017.

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

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

F. Ferrante. A model of endogenous loan quality and the collapse of the shadow banking system. Technical report, Board of Governors of the Federal Reserve System (US), 2015.

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

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

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

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

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

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

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

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

J. F. Houston, C. Lin, and Y. MA. Regulatory arbitrage and international bank flows. The Journal of Finance, 67(5):1845–1895, 2012. ISSN 1540-6261.

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

M. Iacoviello. House prices, borrowing constraints, and monetary policy in the business cycle. The American economic review, 95(3):739–764, 2005.

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

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

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

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

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

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

G. Moscarini and F. Postel-Vinay. 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, 2012.

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

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

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

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

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

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

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

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

F. Verona, M. Martins, I. Drumond, et al. (un)anticipated monetary policy in a DSGE model with a shadow banking system. International Journal of Central Banking, 9(3):