

When Could Macroprudential and Monetary Policies Be in Conflict?

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ABSTRACT

This paper aims to provide a comprehensive analysis of the potential conflicts between macroprudential and monetary policies within a DGSE model with financial frictions. The identification of conflicts is conditional on different types of shocks, policy instruments, and policy objectives. We first find that conflicts are not systematic but are fairly frequent, especially in the case of supply-side and widespread shocks such as investment efficiency and bank capital shocks. Second, monetary policy and countercyclical capital requirements generate conflicts in many circumstances. By affecting interest rates, they both “get in all the cracks”, albeit with their respective targets generally moving in opposite directions. Nonetheless, monetary policy could reduce its adverse financial side effects by responding strongly to the output gap. Third, countercyclical loan-to-value caps, as sector-specific instruments, cause fewer conflicts. Thus, they can be more easily implemented without concerns about generating spillovers, whereas smooth coordination is required between state-contingent capital requirements and monetary policy.

Keywords: Macroprudential Policy, Loan-to-Value, Countercyclical Buffer, Monetary Policy, Conflicts, DSGE Model.

JEL classification: E44, E58, E61

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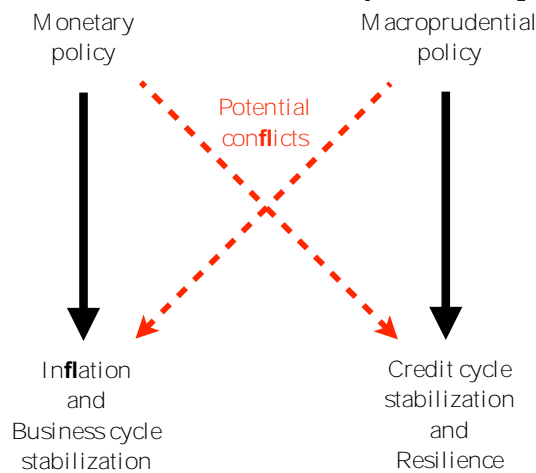
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NON-TECHNICAL SUMMARY

Macroprudential policy has become a fully-fledged tool of economic policy in recent years, as shown by the prompt relaxation of financial requirements in response to the COVID-19 crisis in many countries. This development is supported by both theoretical foundations and empirical evidence of effectiveness.

Nevertheless, these new policy arrangements raise the question of potential conflicts arising between macroprudential and monetary policies. As shown in Figure 1 below, macroprudential measures may have adverse side-effects in terms of inflation and output stabilization, which are the main objectives of monetary policy. Similarly, monetary policy can prevent macroprudential policy from achieving its objectives of ensuring financial stability and resilience, which in practice often involves dampening the credit cycle. However, the literature on these conflicts is still scarce.

Figure 1. Potential conflicts between monetary and macroprudential policies



Hence, this research aims to provide a comprehensive analysis of the conditions under which such policy conflicts may arise. These conditions are evaluated based on:

- (i) Different types of shocks (real vs financial, demand vs supply-side, sectoral vs economy-wide);
- (ii) Different policy instruments (interest rate, countercyclical loan-to-value limits and capital requirements);
- (iii) Different policy objectives (volatilities of the output gap, inflation, and the credit gap).

Our theoretical investigation builds on a DSGE model embedding a banking sector and featuring financial frictions. Moreover, we introduce in this model three macroprudential rules pursuing two common and representative regulatory objectives, i.e., building buffers and taming lending practices. The first instrument is a regulatory countercyclical capital buffer (CCyB) that supplements, conditionally on the context, the regulatory fixed capital that banks are required to hold. In addition, we include two state-dependent loan-to-value (LTV) caps, for households and firms, which aim to dampen the credit cycle by reducing procyclical feedback between asset prices and credit. In line with regulatory recommendations, we assume that these three macroprudential instruments react to excess credit (i.e., the credit-to-GDP gap). Finally, we model monetary policy as a standard interest rate rule.

To identify conflicts between monetary and macroprudential policies, we follow a descriptive approach, which relies on the variance of variables that generally enter the welfare-based loss functions of policymakers: inflation, output and credit-to-GDP gap. We examine the sensitivity of these variances to the reaction parameters of the macroprudential and monetary policy rules. Concretely, a conflict is identified when increasing the strength of the response of macroprudential (monetary) policy rules leads to higher inflation volatility and/or a larger output gap (resp., credit-to-GDP gap) in the contexts depicted by four different and representative shocks.

We find that conflicts between macroprudential and monetary policies are fairly frequent but not systematic. They are especially likely to arise in cases of investment efficiency and bank capital shocks. These two supply-side shocks have a more widespread impact on the economy than sector-specific shocks such as housing shocks. Regarding policy instruments, it appears that CCyB and monetary policy generate conflicts in many cases. While they both “get in all the cracks” by widely impacting the economy through adjustments to retail rates, their respective main targets often move in opposite directions. However, it appears that the stronger the monetary policy response to the output gap, the less frequent are the conflicts stemming from monetary policy. On the contrary, LTV caps, as sector-specific instruments, cause few conflicts.

These results suggest that, from the perspective of spillover effects, LTV limits can be more easily implemented than countercyclical banks’ capital buffers, which require smooth coordination with monetary policy. Furthermore, the latter could respond more strongly to the output gap to mitigate the adverse side effects it otherwise causes on the credit cycle.

Quand les politiques macroprudentielles et monétaires peuvent-elles être en conflit ?

RÉSUMÉ

Cet article propose une analyse des conflits d’objectifs pouvant survenir entre les politiques macroprudentielle et monétaire, fondée sur un modèle DGSE avec frictions financières. Nous trouvons que ces conflits sont assez fréquents, surtout en cas de chocs d’offre et de chocs sur le capital des banques. La politique monétaire et les exigences en fonds propres contracycliques en particulier génèrent des conflits dans de nombreuses circonstances. Alors que ces deux politiques ont un fort impact sur l’économie, leurs cibles respectives évoluent souvent en sens opposé. La politique monétaire pourrait toutefois réduire ses effets de débordement négatifs sur la sphère financière en répondant fortement à l’output gap. Enfin, les instruments plus ciblés que sont les limites contracycliques sur les ratios de prêt/valeur génèrent moins de conflits. Ils peuvent donc être plus facilement mis en œuvre, alors qu’une coordination étroite entre les coussins de fonds propres contracycliques et la politique monétaire s’avère nécessaire.

Mots-clés : politique macroprudentielle, ratio prêt/valeur, fonds propres contra-cycliques, politique monétaire, conflits, modèle DSGE.

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1 Introduction

Macroprudential policy has become a full-fledged tool of economic policy in recent years, as shown by the prompt relaxation of financial requirements in response to the COVID-19 crisis in many countries. This development is supported by theoretical foundations (Gersbach and Rochet, 2017; Bianchi and Mendoza, 2018), including when monetary policy is stuck at the zero lower bound (Rubio and Yao, 2020; Farhi and Werning, 2016; Korinek and Simsek, 2016), as well as by empirical evidence of effectiveness (Claessens et al., 2013; Cerutti et al., 2017; Altunbas et al., 2018; Galati and Moessner, 2018). Nevertheless, these new policy arrangements raise the question of potential conflicts arising between macroprudential and monetary policies. Macroprudential measures may have adverse side effects in terms of inflation and output stabilization, which are the main objectives of monetary policy. Similarly, monetary policy can prevent macroprudential policy from achieving its objectives of ensuring financial stability and resilience, which in practice often involves dampening the credit cycle. However, literature on these conflicts is still scarce.

Hence, the aim of this paper is to provide a comprehensive analysis of the conditions under which such policy conflicts may arise. These conditions are evaluated based on (i) different types of shocks (real vs financial, demand vs supply-side, sectoral vs economy-wide), (ii) different policy instruments (interest rate, countercyclical loan-to-value limits and capital requirements) and (iii) different policy objectives (volatility of the output gap, inflation, and the credit gap).

Our theoretical investigation builds on a realistic DSGE model with nominal and real rigidities. This model embeds a banking sector that provides intermediation between lenders and borrowers. Moreover, it features financial frictions stemming from collateral constraints à la Iacoviello (2005). Such constraints may generate a debt-deflation mechanism that makes the financial sector amplify the severity of shocks. Last, the banking sector in the model duly reproduces the sluggish adjustment of bank interest rates. This is important for assessing the effects of monetary policy, as well as those of capital requirements, which both impact retail interest rates, as we will see.

In this model, we introduce three macroprudential rules pursuing two common and representative regulatory objectives, i.e., building buffers and taming lending practices. In line with the Basel III framework¹ and the recommendations of the European Systemic Risk Board (ESRB/2014/1)², the first policy is a regulatory countercyclical capital buffer (CCyB) that supplements, conditionally on the context, the regulatory fixed capital that banks are required to hold. This lender-based instrument has been increasingly used by regulators in recent years. It consists of building and releasing buffers to safeguard the banking sector's resilience and ability to function effectively under any circumstances. The optimality of capital requirements and their effectiveness in lowering credit supply is supported both by theoretical and empirical evidence (Benes and Kumhof, 2015; Vandenbussche et al., 2015; Mendicino et al., 2018; De Jonghe et al., 2020). This may have prompted the vast majority of countries with a positive CCyB before year-end 2019 to rapidly cut them in March 2020 to cope with the adverse economic effects of the COVID-19 pandemic. Macroprudential authorities have explicitly advised banks to use the additional space created by relaxing the buffer to address increases in expected losses and support credit. In addition, we incorporate in the model two state-dependent loan-to-value (LTV) caps, for households and firms. LTV limits are the most commonly used borrower-based measures. They aim to dampen the credit cycle by reducing procyclical feedback between asset prices and credit.

¹<https://www.bis.org/bcbs/ccyb/index.htm>.

²See also the transposition of the Basel III standards on bank capital adequacy into the Capital Requirements Directive (Art. 136 CRD IV) of European Union law (2013/36/EU).

They have been found to be both theoretically welfare-improving (Rubio and Carrasco-Gallego, 2014; Alpanda and Zubairy, 2017) and empirically effective (Alam et al., 2019). In line with regulatory recommendations, we assume that these three macroprudential instruments react to excess credit. Finally, we model monetary policy as a standard interest rate rule.

Next, we follow a descriptive approach, which relies on the volatility of some key variables that generally enter the usual linear-quadratic approximation of an aggregate welfare function. However, our approach is agnostic regarding policymakers' preferences. One reason for not prioritizing these objectives is that there is no consensus in the literature on the sharing of the objectives between monetary and macroprudential authorities. Some analyses are based on ad hoc loss functions (Angelini et al., 2014). Others rely on a welfare-based loss function arbitrarily split into two parts, assigning ad hoc objectives to both policy authorities (See, e.g., Rubio and Yao, 2020; De Paoli and Paustian, 2017). A second - corollary - reason is that the aim of our analysis is not to determine optimal monetary and macroprudential policies per se. Instead, we conduct an upstream investigation that seeks to identify cases in which conflicts may spontaneously arise. To this end, we separately focus on several variables that are likely to enter policymakers' objective functions (inflation, output gap, credit-to-GDP gap), without imposing policy preferences.³ We examine the sensitivity of each of these variables to the reaction parameters of the macroprudential and monetary policy rules. This approach is better suited to identifying the source of policy conflicts in a shock-by-shock analysis. More precisely, a conflict is identified when increasing the strength of the response of macroprudential (resp., monetary) policy rules leads to higher inflation volatility and/or a larger output gap (resp., credit-to-GDP gap) in the contexts depicted by four different and representative shocks.

We find that conflicts between macroprudential and monetary policies are fairly frequent but not systematic. They are especially likely to arise in cases of investment efficiency and bank capital shocks. These two supply-side shocks have a more widespread impact on the economy than sector-specific shocks such as housing shocks. Regarding policy instruments, it appears that CCyB and monetary policy generate conflicts in many cases. While they both "get in all the cracks" by widely impacting the economy through adjustments to retail rates, their main respective targets often move in opposite directions. However, it appears that the stronger the monetary policy response to the output gap, the less frequent are the conflicts from monetary policy. LTV caps, as sector-specific instruments, cause fewer conflicts. This suggests that they can be easily implemented without concerns about potential spillovers. In contrast, the implementation of CCyB and monetary policy may require smooth coordination.

Hence, our paper contributes to the emerging literature on macroprudential-monetary policy interactions. This literature is still in its infancy and includes only a few studies. On the one hand, empirical analyses is rather mixed. Some of them do not find significant interactions (Aiyara et al., 2016). Others conclude that the two policies are complementary (Bruno et al., 2017; Garcia Revelo et al., 2020; Gambacorta and Murcia, 2020). On the contrary, another part of the literature highlights the potential existence of conflicts (Kim and Mehrotra, 2018). Richter et al. (2018), for instance, show that a decrease in the LTV ratio reduces output. Fraisse et al. (2020), Juelsrud and Wold (2020) and Gropp et al. (2018) find that capital requirements negatively affect investment, consumption and employment. In this vein, many studies validate the adverse side effects of monetary policy through a risk-taking channel (See, e.g., Colletaz et al., 2018; Jimenez et al., 2014). On the other hand, the-

³Nonetheless, as robustness checks, we show in Section 6 that conflicts between inflation and credit cycle that are identified following our approach give rise to policy trade-offs in the optimizing framework proposed by Angelini et al. (2014).

oretical evidence are very scarce. Eventually, the contributions of [Angelini et al. \(2014\)](#), [Silvo \(2019\)](#) and [Aikman et al. \(2019\)](#) can be appreciated through the lens of the potentially adverse side effects of macroprudential policy. They tend to indicate that conflicts may exist with monetary policy. This is what we want to explore in depth in this paper.

More precisely, we contribute to this scarce theoretical literature by providing a comprehensive assessment of the conditions under which each policy may prevent the other from achieving its objectives. We consider this as a prerequisite to the analysis of optimal coordination.⁴ To this end, we adopt an original way of identifying conflicts, based on the effects of the strength of monetary (resp., macroprudential) policy response to its targets on the macroprudential (resp., monetary) objectives, shock by shock. Furthermore, we propose a more global assessment of conflicts than what can be found in the existing literature. We first go a step further than other analyses by considering several countercyclical macroprudential rules, reacting to model-consistent credit-to-GDP gaps. In addition, we cover a wider set of representative shocks. Moreover, we depart from the usual ad hoc split of the welfare-based loss function by considering a large range of plausible calibrations for the policy rules. Finally, the originality of our contribution also lies in the new results that we obtain. We identify the instruments and circumstances that are most prone to conflicts, and we provide explanations based on the transmission channels of these different policy tools. This overall assessment may enlighten monetary and prudential authorities on the potential spillovers of their policies and the need for coordination.

The remainder of this paper is structured as follows. Section 2 presents the most important equations in our DSGE model to understand the design and the transmission of macroprudential and monetary policies. Section 3 motivates the choice of four representative shocks made to cover a set of representative configurations. Section 4 is devoted to the identification of conflicts. Section 5 provides an assessment of the results and discusses the implications for macroprudential and monetary policies. Section 6 is dedicated to a sensitivity analysis. Finally, Section 7 concludes.

2 The model

2.1 Overview

Our analysis builds on the model developed by [Gerali et al. \(2010\)](#), which offers both tractability and realism. It embeds the usual nominal and real rigidities as well as financial frictions in an explicit banking sector. In this section, we describe the main features of the model that are necessary to understand the main mechanisms at stake as well as the effects of macroprudential and monetary policies.

The economy is populated by two groups of households (patient P and impatient I) of unit mass, who consume final goods, work and accumulate housing, in fixed supply.⁵ The discount factor of patient households is higher than that of impatient households. This implies positive financial flows in equilibrium, with patient households as savers and impatient households as net borrowers. The latter

⁴In this perspective, [Collard et al. \(2017\)](#) analyse the optimal assignment of instruments to objectives. A demonstration of the gains from cooperation is provided by [Lazopoulos and Gabriel \(2019\)](#) and [Bodenstein et al. \(2019\)](#). On the contrary, [Rubio and Carrasco-Gallego \(2014\)](#), [De Paoli and Paustian \(2017\)](#) and [Gelain and Ilbas \(2017\)](#) find that a non-cooperative setting may be superior. Our contribution is upstream of this coordination/cooperation issue, as we do not investigate how coordination should be managed but under which circumstances it may be needed.

⁵Following [Iacoviello \(2005\)](#), [Angelini et al. \(2014\)](#) and [Iacoviello \(2015\)](#), among others, this hypothesis echoes the strong rigidity of real estate supply in the short and medium run. This implies that property prices in the model only change in response to changes in demand for housing, which is influenced by the loan-to-value policy, inter alia. However, the impact of this policy is not overstated, because it influences not only the demand for housing but all household spending, as shown by the impatient household's budget constraint (See Eq. 3 below).

face a loan-to-value (LTV) constraint imposed by the macroprudential authority. Households supply their differentiated labour services through unions that set nominal wages. Labour services are finally sold to competitive employment agencies that assemble them into a homogenous labour input and sell it to entrepreneurs.

Entrepreneurs produce homogenous intermediate goods using labour and capital bought from capital-good producers. They are net borrowers, with the same discount factor as impatient households. They also face an LTV constraint.

The banking sector is made up of monopolistically competitive banks, which set interest rates on deposits and loans to maximize their profits. The amount of loans offered to households and entrepreneurs is financed by deposits and bank capital. The latter comes from retained profits. Banks must comply with a regulatory capital to risk-weighted assets ratio and with a statutory leverage ratio imposed by the macroprudential authorities.

The programmes of the households, entrepreneurs and wholesale branches of banks are detailed below, whereas the rest of the model, namely, the unions (the source of wage rigidity), the retail goods sector (the source of price rigidity), the final goods sectors, and the banks' retail branches (the source of interest rate rigidity) is presented in Appendix A. The full set of equations is provided in an online appendix.

2.2 Households

The representative household j maximizes its expected utility given by

$$E_0 \sum_{t=0}^{\infty} \beta_i^t \left[(1 - a^i) \log (c_t^i(j) - a^i c_{t-1}^i) + \log h_t^i(j) - \frac{l_t^i(j)^{1+\phi}}{1+\phi} \right], \text{ for } i \in \{P, I\} \quad (1)$$

where E_t denotes the mathematical expectation operator upon information available at t , $a^i \in [0, 1]$ denotes the degree of habit formation, and $\phi > 0$ is the inverse of the Frisch labour supply elasticity. $c_t^i(j)$ denotes individual consumption, c_{t-1}^i is lagged aggregate consumption, $h_t^i(j)$ is housing services and l_t^i represents hours worked. The subjective discount factor for the patient households (P) is higher than that of the impatient (I) ones, i.e., $\beta_P > \beta_I$.

Patient household budget constraint is given by

$$c_t^P(i) + q_t^h \Delta h_t^P(i) + d_t^P(i) \leq w_t^P l_t^P(i) + (1 + r_{t-1}^d) d_{t-1}^P(i) / \pi_t + \tau_t^P(i). \quad (2)$$

Its expenses include consumption, accumulation of housing with q_t^h designating the real house price, and real deposits in period t . Its resources consist of real wage earnings, gross interest income on the last period's deposits, with $\pi_t \equiv P_t/P_{t-1}$ as gross inflation, and lump-sum transfers (τ_t^P). The latter include labour union membership net fees and dividends from firms and banks (of which patient households are the only owners).

Impatient household budget constraint is given by

$$c_t^I(i) + q_t^h \Delta h_t^I(i) + (1 + r_{t-1}^{bH}) b_{t-1}^I / \pi_t \leq w_t^I l_t^I(i) + b_t^I(i) + \tau_t^I(i), \quad (3)$$

where the flow of expenses is partly composed of gross reimbursement of the last period's borrowing b_{t-1}^I , with r_{t-1}^{bH} being the corresponding lending rate. Its resources include new loans, as well as lump-sum transfers $\tau_t^I(i)$ that are only composed of union membership net fees. In addition, impatient

households face a borrowing constraint stating that they cannot borrow more (in terms of repayment amount plus interest) than a given proportion LTV_t^H of the expected value of their housing:

$$(1 + r_t^{bH})b_t^I(i) \leq LTV_t^H \mathbb{E}_t \left[q_{t+1}^h h_t^I(i) \pi_{t+1} \right] \varepsilon_t^m \quad (4)$$

where LTV_t^H is a mandatory time-varying loan-to-value limit on mortgages to households imposed by the macroprudential authority. At the macroeconomic level, this LTV cap determines the amount of credit that banks can provide to impatient households for a given (discounted) value of their housing stock. This policy instrument follows a countercyclical rule that depends on a measure of excess mortgage credit (see details below). As in [Iacoviello \(2005\)](#), $1 - LTV_t^H$ can be interpreted as the proportional cost of collateral repossession for banks in case of default. The value of collateral is subject to a stochastic shock denoted ε_t^m , which follows an AR(1) process. It can be interpreted as a non-fundamental shock to housing price expectations, in line with [Burlon et al. \(2018\)](#) and [Dupor \(2005\)](#). Optimistic (pessimistic) expectations on the future price of housing loosen (tighten) the lending constraint. This gives scope for representing a financial demand-side shock.

2.3 Entrepreneurs

Entrepreneur i 's utility only depends on her own consumption $c_t^E(i)$ and on lagged aggregate consumption:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_E^t \log (c_t^E(i) - a^E c_{t-1}^E) \quad (5)$$

where a^E measures the degree of consumption habits and the discount factor β_E is assumed to be strictly lower than β_P . Entrepreneur i maximizes her lifetime utility under the budget constraint:

$$c_t^E(i) + w_t^P l_t^{E,P}(i) + w_t^I l_t^{E,I}(i) + (1 + r_{t-1}^{bE})b_{t-1}^E(i)/\pi_t + q_t^k k_t^E(i) \leq \frac{y_t^E(i)}{x_t} + b_t^E(i) + q_t^k (1 - \delta)k_{t-1}^E(i) \quad (6)$$

where expenses are composed of consumption, labour inputs from patient $l_t^{E,P}(i)$ and impatient households $l_t^{E,I}(i)$, gross repayment of the last period's borrowing $b_{t-1}^E(i)$, with r_{t-1}^{bE} being the corresponding lending rate, and physical capital k_t^E bought to capital producers, whose price in terms of consumption is denoted q_t^k . Her resources consist of new loans, non-depreciated physical capital resold to capital producers, with δ being the depreciation rate of physical capital, and wholesale good y_t^E , which is sold at the inverse relative competitive price $x_t = P_t/P_t^W$ and produced according to the following technology: $y_t^E(i) = [k_{t-1}^E(i)]^\alpha [l_t^E(i)]^{1-\alpha}$. The labour of the two types of households is combined as $l_t^E = (l_t^{E,P})^\mu (l_t^{E,I})^{1-\mu}$, where μ measures the labour income share of patient households. Importantly, like mortgage borrowers, entrepreneurs are subject to a regulatory borrowing constraint, given by

$$(1 + r_t^{bE})b_t^E(i) \leq LTV_t^E \mathbb{E}_t \left((1 - \delta)\pi_{t+1} q_{t+1}^k k_t^E(i) \right), \quad (7)$$

which states that the gross borrowing of entrepreneur i cannot exceed a proportion LTV_t^E of the expected value of her (depreciated) physical capital. The macroprudential instrument LTV_t^E is set with respect to a countercyclical rule that depends on a measure of firms' excess credit (see details below).

Finally, note that the competitive capital producer j combine last period's undepreciated capital and i_t units of the final goods to produce new capital $k_t(j)$, subject to quadratic adjustment costs,

such as:

$$k_t(j) = (1 - \delta)k_{t-1}(j) + \left[1 - \frac{\kappa_i}{2} \left(\frac{i_t(j) \varepsilon_{qk}}{i_{t-1}(j)} - 1 \right)^2 \right] i_t(j), \quad (8)$$

where κ_i denotes the cost of adjusting investment and ε_t^{qk} is an investment efficiency shock that follows an AR(1) process. It represents a supply-side cost-push shock. According to the literature, this is an important shock to consider (see, e.g., [Justiniano et al., 2010](#)). Last, we note that $k_t^E = k_t$ at the equilibrium. The complete capital producer optimization programme is provided in the Appendix A.

2.4 The banking sector

The banking sector is composed of a continuum of banking groups, indexed by $j \in [0, 1]$, which carry out their intermediation activities under monopolistic competition. Each group is made up of a wholesale unit (management branch) and two retail branches. The retail loan and deposit branches are in charge of granting loans to impatient households and firms and collecting deposits from patient households, respectively, for the group. In doing so, they endure adjustment costs, which are at the origin of bank lending and deposit rates rigidity. The programmes of these retail banks are provided in Appendix A. In this section, we focus on the management branch, to which capital requirements apply, and which pass them on to wholesale credit conditions.

The management branch combines bank capital (K_t^b) with total deposits $D_t(j)$ on the liability side and total wholesale funds $B_t(j)$ to the retail loan branch, on the asset side. This unit manages the capital position of the group. Indeed, following the Basel III regulation, each bank is supposed to meet capital adequacy ratio (CAR) requirements. More precisely, banks' capital to risk-weighted assets ratio must be equal to v_t , a contingent mandatory level set by the macroprudential authority (see details below). Any deviation of the capital-to-risk weighted assets ratio from this target induces quadratic costs, denoted $\mathcal{D}_t^v(K_t^b(j))$, parametrized by κ_{car} , and proportional to outstanding bank capital, such as

$$\mathcal{D}_t^v(K_t^b(j)) \equiv \frac{\kappa_{car}}{2} \left(\frac{K_t^b(j)}{\omega_t^H B_t^H(j) + \omega_t^E B_t^E(j)} - v_t \right)^2 K_t^b(j), \quad (9)$$

with ω_t^H and ω_t^E being the risk weights relative to households loans ($B_t^H(j)$) and entrepreneurs loans ($B_t^E(j)$), respectively. As such, the management unit pre-allocates wholesale funds for mortgage loans and corporate lending, depending on these risk weights, with $B_t(j) = B_t^H(j) + B_t^E(j)$. Following [Angelini et al. \(2014\)](#), these weights are procyclical, decreasing (increasing) when annual output growth ($Y_t - Y_{t-4}$) increases (decreases):

$$\omega_t^s = (1 - \rho_s) \omega^s + (1 - \rho_s) \chi_s (Y_t - Y_{t-4}) + \rho_s \omega_{t-1}^s \quad \text{with } s \in \{H, E\} \quad \text{and } \chi_s < 0, \quad (10)$$

where χ_s is the sensitivity of risk weights to the business cycle, ρ_s is the parameter of persistence, and ω^s (without time subscript) is the steady state value of the corresponding weights.⁶

For the sake of realism, we also include requirements for the leverage ratio of banks. Any deviation from the regulatory level (lev) implies a quadratic cost parametrized by κ_{lev} , proportional to outstanding bank capital and denoted $\mathcal{D}_t^{lev}(K_t^b(j))$.⁷

⁶In case of negative deviations the adjustment costs can be viewed as a penalty. In the case of positive deviations, they may capture the fact that it is costly and inefficient to have idle capital.

⁷Details on the leverage ratio and its link with the CAR are provided in the online appendix B.

Bank capital is accumulated out of retained earnings, following

$$\pi_t K_t^b(j) = (1 - \delta^b) \frac{K_{t-1}^b(j)}{\varepsilon_t^{Kb}} + \mathcal{P}_t^b(j), \quad (11)$$

where δ^b measures the resources used in managing bank capital and \mathcal{P}_t^b represents overall bank profits. ε_t^{Kb} is an AR(1) stochastic shock affecting bank capital. It represents a financial supply-side shock that is important to consider in a policy conflicts analysis, as we will see.

Finally, we assume a monetary policy environment of fixed-rate full allotment, with policy rate denoted r_t . Thus, by arbitrage, the wholesale deposit rate paid by the management branch to the retail deposit unit, $R_t^d(j)$, is equal to r_t , $\forall t$. In this context, the first-order conditions of the wholesale bank's program give the internal wholesale loan rates to the households (R_t^{bH}) and firms (R_t^{bE}) retail loan branches, respectively:⁸

$$\begin{aligned} R_t^{bs}(j) = r_t - \kappa_{car} & \left(\frac{K_t^b(j)}{\omega_t^E B_t^E(j) + \omega_t^H B_t^H(j)} - v_t \right) \left(\frac{K_t^b(j)}{\omega_t^E B_t^E(j) + \omega_t^H B_t^H(j)} \right)^2 \omega_t^s \\ & - \kappa_{lev} \left(\frac{K_t^b(j)}{B_t^E(j) + B_t^H(j)} - lev \right) \left(\frac{K_t^b(j)}{B_t^E(j) + B_t^H(j)} \right)^2, \text{ for } s \in \{H, E\}. \end{aligned} \quad (12)$$

We can see that these wholesale credit conditions depend on the policy rate and the capital requirements. They are finally passed on to retail lending rates to households and entrepreneurs (r^{bs}) through the retail branches of the banking groups, as indicated in the retail banks' programme given by Eq. (A6) in Appendix A. This is the way bank capital shocks and macroprudential requirements ultimately transmit to credit conditions for households and firms.

2.5 Macroprudential and monetary policy rules

We consider that the objective of macroprudential policy is to dampen the credit cycle. To this end, the macroprudential authority can rely on lender- and borrower-based instruments, by setting countercyclical CAR requirements and loan-to-value caps on agents' borrowing, respectively.

Countercyclical capital requirements consist of forcing banks to accumulate a capital buffer during good times, which they can draw down to absorb losses in bad times to ensure that credit supply does not collapse during a crisis. In line with the transposition of the Basel III standards on bank capital adequacy into the Capital Requirements Directive (CRD IV) of European Union law, the *CAR* requirements in the model are defined by a fixed component denoted v and by a state-contingent component that is equivalent to a countercyclical buffer (CCyB). This time-varying buffer is increased or decreased with respect to the credit-to-GDP gap, or "Basel gap", denoted $\widetilde{\frac{B_t}{Y_t}}$. Hence, the CAR rule is given by

$$v_t = (v_{t-1})^{\rho_v} \left[v \left(\frac{\widetilde{B}_t}{Y_t} \right)^{\chi_{ccyb}} \right]^{(1-\rho_v)}, \quad (13)$$

where $\chi_{ccyb} > 0$ represents the strength of the response of the CAR requirements to the Basel gap. The parameter ρ_v captures the gradual adjustment of *CAR* requirements that is observed in practice. In the steady state, the CAR requirement is equal to the fixed component v . One original feature of our approach is to consider a model-consistent Hodrick-Prescott (HP) filter for computing the credit-

⁸See details in Appendix A and in the online appendix. Note that $B_t^H(j) = B_t^E(j)$ and $R_t^{bH}(j) = R_t^{bE}(j) = R_t^b$ if $\omega_t^E = \omega_t^H$, as in Gerali et al. (2010).

to-GDP gap. Technical details are provided in the online appendix D.

In addition, the macroprudential package in the model includes two state-dependent loan-to-value (LTV) caps: one for households and one for firms. Time-varying LTV caps for mortgage and business loans aim to dampen the credit cycle by reducing the procyclical link between asset (housing and physical capital) prices and credit. Hence, the caps are supposed to react countercyclically to the sectorial HP-based credit-to-GDP gap as follows:

$$LTV_t^s = (LTV_{t-1}^s)^{\rho_{ltv}^s} \left[LTV^s \left(\frac{\widetilde{B}_t^s}{\widetilde{Y}_t} \right)^{\chi_{ltv}^s} \right]^{(1-\rho_{ltv}^s)}, \quad (14)$$

where χ_{ltv}^s is the reaction parameter assigned to the respective sectorial credit-to-GDP gap, with $s \in \{H, E\}$. $\chi_{ltv}^s < 0$, such that a positive sectorial credit-to-GDP gap would tighten the corresponding loan-to-value limit. The parameter ρ_{ltv}^s captures the gradual adjustment of LTV that is observed in practice. Note that the regulatory constraints are binding, as in most of the existing studies (see, e.g., [Mendicino et al., 2018](#); [Alpanda and Zubairy, 2017](#)). It is crucial that macroprudential constraints are actually operational to identify potential conflicts.

Finally, the objective of monetary policy is to stabilize inflation and the business cycle. To this end, the central bank sets the nominal policy rate r_t following a Taylor-type rule such as

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r} \right)^{\rho_r} \left(\frac{\pi_t}{\pi} \right)^{\chi_\pi(1-\rho_r)} \left(\frac{\widetilde{Y}_t}{\widetilde{Y}} \right)^{\chi_y(1-\rho_r)} \varepsilon_t^r \quad (15)$$

where χ_π and χ_y are the response parameters to deviations of inflation π_t from its steady state π and to the model-consistent HP-based output gap \widetilde{Y}_t , respectively. The parameter ρ_r captures the degree of interest-rate smoothing, and r is the steady state value of the policy rate. Last, ε_t^r represents a white noise monetary policy shock.

2.6 Calibration

The calibration of the model is largely based on the estimates of [Gerali et al. \(2010\)](#), which are reported in Table C1 in Appendix C. A few exceptions concern the parameters related to the macroprudential framework, which are absent from the original model. Nonetheless, we calibrate these parameters according to empirical evidence, official regulations and previous studies that include macroprudential policy (See, e.g., [Iacoviello and Neri, 2010](#); [Rubio and Carrasco-Gallego, 2014](#); [Iacoviello, 2015](#)).

The calibration of the policy framework is reported in Table 1. Following empirical evidence, the steady state of the loan-to-value caps for households and firms can be set equal to 0.8 and 0.9, respectively. Moreover, following policy recommendations, the steady state capital adequacy ratio (v) is set to 8%.⁹ This implies a steady state leverage ratio equal to 6.91%. Similarly, according to the standardized approach promoted by the Basel Committee on Banking Supervision, the steady state risk weights for claims on residential property and corporations, ω^H and ω^E , are equal to 0.35 and 1.0, respectively.¹⁰

Furthermore, as our analysis consists of identifying some adverse policy side effects conditionally on the strength of the reactions of policymakers, we do not set unique values but rather ranges of

⁹Setting a CAR to 8% means that the capital conservation buffer of 2.5% is ignored. However, this does not affect the dynamics of the model and hence the results that we find later on.

¹⁰See https://www.bis.org/basel_framework/chapter/CRE/20.htm?inforce=20191215.

Table 1: Baseline calibration of the policy framework

Parameter	Description	Value
ω^H	Steady state risk weight on household credit	0.37
ρ_H	Persistence of the risk weight on household credit	0.94
χ_H	Sensitivity of ω^H to the business cycle	-15
ω^E	Steady state risk weight on entrepreneur credit	1.0
ρ_E	Persistence of the risk weight on entrepreneur credit	0.92
χ_E	Sensitivity of ω^E to the business cycle	-10
v	Steady state of capital adequacy ratio	0.08
lev	Steady state of leverage ratio	0.069
ρ_v	Smoothing parameter in the capital adequacy ratio rule	0.99
χ_v	Reaction parameter in capital adequacy ratio rule	[0, 20]
LTV^H	Steady state LTV ratio for impatient households	0.7
ρ_{ltv}^H	Smoothing parameter in LTV rule for households	0.99
χ_{ltv}^H	Reaction parameter in LTV rule for households	[-20, 0]
LTV^E	Steady state LTV ratio for entrepreneurs	0.8
ρ_{ltv}^E	Smoothing parameter in LTV rule for entrepreneurs	0.99
χ_{ltv}^E	Reaction parameter in LTV rule for entrepreneurs	[-20, 0]
ρ_r	Smoothing parameter in monetary policy rule	0.768
χ_π	Reaction parameter to inflation in monetary policy rule	[1.7, 5]
χ_y	Reaction parameter to output gap in monetary policy rule	[0, 5]

values for the reaction parameters of the policy rules. For the monetary policy rule, the range covers most of the empirical and optimized values found in the literature, namely, [1.7; 5.0] for χ_π and [0; 5.0] for χ_y . Given the scarcity of studies, benchmarks are lacking for macroprudential policy parameters.¹¹ Hence, we consider wider intervals to be as exhaustive as possible: χ_{ccyb} varies between [0; 20], while χ_{ltv}^s lies in the range [-20; 0], as in [Lambertini et al. \(2013\)](#). Last, the parameters ρ_v and ρ_{ltv}^s are set to 0.99, in accordance with the very high gradualism of macroprudential decisions that is observed in practice¹², and in line with [Burlon et al. \(2018\)](#).

Finally, a few parameters are less common in the literature (χ_H , χ_E , κ_{car} , κ_{lev} , ε^{bE} , ε^{bH}). Following [Gambacorta and Karmakar \(2018\)](#), we set the adjustment cost parameters related to the leverage ratio (κ_{lev}) and to the CAR requirements (κ_{car}) to 7.63 and 50, respectively. Next, following [Angelini et al. \(2014\)](#), the sensitivities of household and firm risk weights to the business cycle (χ_H and χ_E) are set to -15 and -10, respectively. The parameters of persistence (ρ_H and ρ_E) are calibrated to 0.94 and 0.92, respectively.¹³ Finally, markups on lending rates $\varepsilon^{bs} / (\varepsilon^{bs} - 1)$ are set to 1.15. In the absence of consensus on the underlying elasticities, this value prevents the exaggeration of banks' reaction to monetary and macroprudential policies.

Importantly, as a robustness check, we will change the calibration of these six parameters in Section 6. We will show that alternative values do not qualitatively change the results.

¹¹[Angelini et al. \(2014\)](#) find an optimal value of χ_{ccyb} between [2.2 – 7.0], depending on the policy preferences and shocks. [Lozej et al. \(2018\)](#) and [Gelain and Ilbas \(2017\)](#) set this parameter to between [0; 2] and [2.5; 7.2], respectively. [Rubio and Carrasco-Gallego \(2014\)](#) find an optimal value of 0.8 for χ_{ltv}^H , while [Burlon et al. \(2018\)](#) set a value equal to 0.5.

¹²See Figure B1 in the online appendix for an illustration of the gradual adjustment of CCyB and LTV caps.

¹³Combining the expressions for banks' capital and profits implies a steady state consistent value of 0.084 for the proportion of resources used in managing bank capital (δ^b). See Eq. (A29) and (A33) in the online appendix.

3 Responses of the model to a selection of representative shocks

The potential conflicts between monetary and macroprudential policies are analyzed in the context of the four types of shocks that are embedded in the model: collateral shock (ε_t^m), investment efficiency shock (ε_t^{qk}), bank capital shock (ε_t^{Kb}) and monetary policy shock (ε_t^r). There are three reasons for this choice.

First, these shocks have distinct characteristics in terms of origin, nature and scope, as reported in the first part of Table 2. The investment efficiency shock is a real shock, while the collateral and bank capital shocks are more financially oriented. This distinction is important given the nature of the objectives of monetary policy and macroprudential policies. From another perspective, investment efficiency and bank capital shocks are supply-side shocks, with widespread impacts on the economy. In contrast, collateral shocks are demand-side shocks. Moreover, they can be viewed as sectoral shocks, as they initially concern housing market prices. Last, by simultaneously impacting credit supply conditions and demand behavior, monetary policy shocks can be viewed as both supply and demand-side oriented. In addition, they are economy-wide shocks, as they are passed on by banks to lending rates to both households and firms (see Eq. 12 and A6).

Table 2: Characteristics of the shocks and correlations between the policy targets

Shock type	Main characteristics of shocks			Correlations		
	Origin	Nature	Scope	Output Inflation	Output Basel gap	Inflation Basel gap
Collateral	Financial	Demand-side	Sectoral	–	–	–
Investment efficiency	Real	Supply-side	Wide	–	–	+
Bank capital	Financial	Supply-side	Wide	+	–	–
Monetary policy	Monetary	Both	Wide	+	+	+

Note: “Wide” refers to economy-wide shock, as opposed to sectoral shock. The last part of the table provides the signs of the theoretical correlations between pairs of the three key variables in the model with macroprudential rules. +/– refer to a positive / negative correlation.

Second, as reported in the last part of Table 2, each of these four shocks provides a singular set of theoretical correlations between the three policy targets (inflation, output, Basel gap). As can be seen in Table B1 in Appendix B, these four configurations are representative of all the correlations that it is possible to obtain with the twelve shocks considered in the original model of Gerali et al. (2010).

Third, the empirical importance of these four shocks has been widely documented in the literature. Gauthier and Becard (2021) for example find that collateral shocks are the most important force driving the business cycle. Regarding the significance of bank capital shocks, Sandri and Valencia (2013) show that exogenous net worth loss involves a much larger GDP contraction if it falls on the balance sheets of banks rather than on households or real firms.¹⁴ In this vein, Gerali et al. (2010) finds that financial shocks (collateral and bank capital shocks) largely explain most of the 2006-2009 boom-bust business cycle. Investment efficiency shocks are important too, as shown in the Real Business Cycle literature. For example, Justiniano et al. (2010) find that they explain most of the variability of output and hours at business cycle frequencies. Finally, the significance of monetary policy shocks is well established.¹⁵

¹⁴Note that the bank capital shock has the same properties as the financial shock considered by Ajello (2016), which is found to explain about 25% of the variance in output.

¹⁵Many studies, like Smets and Wouters (2003) and Ajello (2016), to name but a few, find that monetary policy shock is among the most important structural shock driving variations of output. Similarly, Mouabbi and Sahuc (2019) show that monetary policy shocks significantly contribute to explain inflation over the 2008-2017 period in the euro area.

Figures D1 to D4 in Appendix D report the impulse response functions (IRFs) that are obtained with these four shocks. For a better understanding of the effects of the policies and for an easier comparison with the existing studies based on the Gerali et al. (2010) framework¹⁶, two versions of the model are considered, namely, one with and one without countercyclical macroprudential rules (i.e., $\chi_{ltv}^E = \chi_{ltv}^H = \chi_{ccyb} \neq 0$ or $= 0$ in Eq. 13 and 14). Beyond the information that the IRFs provide on the dynamics of the model, they can deliver preliminary indications on potential policy conflicts.

Collateral shock Figure D1 represents the IRFs of the model following a positive collateral shock ($\varepsilon_t^m > 0$ in Eq. 4). As it is equivalent to a *de facto* increase in LTV, this shock stimulates lending to households. In the absence of countercyclical macroprudential policy, the inherent stimulating macroeconomic effects induces a tightening of monetary policy. In the presence of countercyclical macroprudential rules, the policymaker can immediately offset the effects of the collateral shock by restricting the mortgage LTV and tightening the CCyB in response to the rise in the Basel gap. Meanwhile, impatient households reduce their labour supply, which lowers production. Hence, producers invest and consume less. The inherent contraction of economic activity pushes inflation down. As a consequence, monetary policy is relaxed. Therefore, implementing countercyclical macroprudential rules can induce changes in the dynamics of the economy and in the stance of monetary policy, with consequences for the volatility of monetary policy targets (i.e., inflation and output).

Investment efficiency shock Figure D2 reports the response of the model to a decrease in the investment efficiency, corresponding to an increase in investment adjustment costs ($\varepsilon_t^{eq} > 0$ in Eq. 8). This supply-side shock induces an increase in inflation, which leads to a policy rate hike. However, as loans decrease less than output, the credit-to-GDP gap rises. This entails a tightening of the macroprudential instruments when state-contingent macroprudential rules are activated. As a result, loans significantly decrease. Then, the sharp fall in output brings inflation down. The policy rate is cut in this case. Overall, the real (financial) side of the economy seems to be more (less) volatile when macroprudential rules are implemented. This already suggests that conflicts are possible following such a supply-side shock.

Bank capital shock As shown by Figure D3, banks have to raise their profits by hiking their retail rates, to meet the regulatory CAR in the wake of an exogenous decrease in bank capital (i.e., $\varepsilon_t^{Kb} > 0$ in Eq. 11). This provokes a significant reduction in loans to entrepreneurs, which in turn leads to a decrease in investment and consumption. Then, firms increase their labour demand to offset the decrease in capital. Benefiting from higher labour incomes, households consume and invest more in housing, which implies more collateral and ultimately more mortgage loans. However, this does not compensate for the fall in corporate lending. Finally, output and the aggregated Basel gap decrease. Simultaneously, monetary policy is slightly restrictive to fight inflation. Turning now to active macroprudential policies, we see that the CCyB is diminished in response to the declining Basel gap. Moreover, LTV caps contribute to significantly smoothing the credit cycle and supporting firms' investment and consumption. As a consequence, total consumption does no longer decrease. Monetary policy is initially more restrictive as the output gap and inflation increase. Nonetheless, the policy rate is cut in the medium run, which makes output higher, whereas inflation remains subdued for a while.

¹⁶See, in particular, Gambacorta and Karmakar (2018); Chen and Columba (2016); Angelini et al. (2014).

Monetary policy shock Last, the response of the model to an exogenous policy rate hike ($\varepsilon_t^r > 0$ in Eq. 15), is represented in Figure D4. This shock is passed on to lending rates by banks. This makes total loans and credit-to-GDP gap decrease. As a result, output and inflation decline. The looser stance of macroprudential policy, in the presence of countercyclical rules, contributes to mitigate the rise in lending rates. In turn, this dampens the decrease in loans and the variability of the Basel gap. Therefore, the decline in consumption, investment and output is less severe. In this way, macroprudential measures reduce the recessionary effects of the monetary policy shock.

4 Identifying conflicts

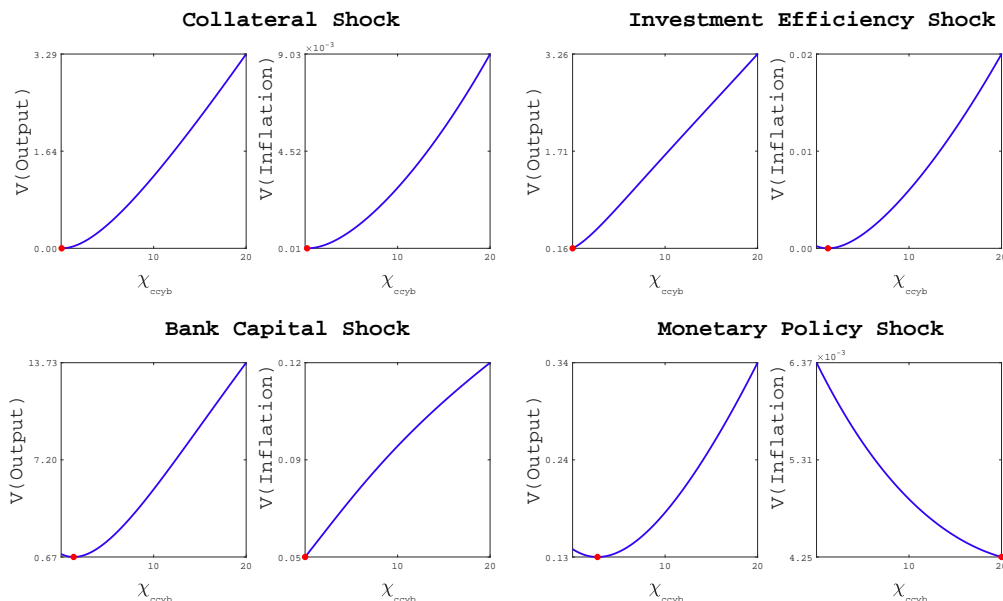
This section aims to reveal more formally the existence of policy conflicts. To this end, we examine the volatility of the three main objective variables (output, inflation, Basel gap) as the reaction parameters of the macroprudential and monetary policy rules ($\chi_{ccyb}, \chi_{ltv}^E, \chi_{ltv}^H, \chi_\pi, \chi_y$) are gradually increased, one by one. We consider a conflict to be a situation in which the theoretical variance of output or inflation increases as the reaction parameter of any macroprudential rule goes up, other reaction parameters being unchanged. In the same way, monetary policy is considered to be at the origin of conflicts when the theoretical variance of the Basel gap increases as the reaction parameters of the monetary policy rule rise, *ceteris paribus*.

Considering the volatility of some key variables as the main objectives of policymakers refers to the usual linear-quadratic approximation of an aggregate welfare function. The latter usually includes the volatility of inflation and output (See, e.g. Woodford, 2003), as well as financial stability concerns through the volatility of asset prices, interest rate spreads or lending volumes (Cúrdia and Woodford, 2016; De Paoli and Paustian, 2017; Rubio and Yao, 2020). Although, from this point of view, we follow the existing literature, we do not prioritize these objectives. Indeed, by focusing on the variance of each key variable, we do not have to make assumptions about the preferences of policymakers, i.e., about the relative weights assigned to the objectives in the welfare function. This is an advantage for our analysis since there is no consensus in the literature on the sharing of the welfare function between monetary and macroprudential authorities. Indeed, even the studies relying on a micro-founded loss function usually split it into two parts, assigning ad hoc weights to the objectives of the policy authorities. Moreover, the aim of our analysis is not to determine optimal monetary and macroprudential policies per se. Hence, the issue of goals settings and assignments is beyond the scope of this paper.

4.1 Conflicts stemming from countercyclical capital requirements

Figure 1 reveals the potential conflicts arising from using the CCyB, by increasing the policy parameter χ_{ccyb} from 0 to 20. We observe that implementing a state-contingent CAR is detrimental to the stabilization of output and inflation in most cases: the higher χ_{ccyb} , the higher the variances of inflation and output. The only exception concerns the variance of inflation in the case of a monetary policy shock. Moreover, a moderate response of the CCyB to the Basel gap, i.e., χ_{ccyb} lower than 2.5, could be beneficial for the stabilization of output in the case of a monetary policy shock. However, this gain is tiny relative to the large increase in the variance of output that is observed as χ_{ccyb} goes up beyond 2.5.

Figure 1: Side effects of the CCyB



Note: Each plot represents the evolution of the theoretical variance of output or inflation as the reaction parameter χ_{ccyb} in the *CAR* rule increases from 0 to 20 in increments of 0.01, while the policy parameters in the other macroprudential policy rules are equal to zero ($\chi_{ltv}^H = \chi_{ltv}^E = 0$) and those in the monetary policy rule remain constant ($\chi_{\pi} = 1.98, \chi_y = 0.34$)

Figure 2: Conflict with CCyB under a negative investment efficiency shock

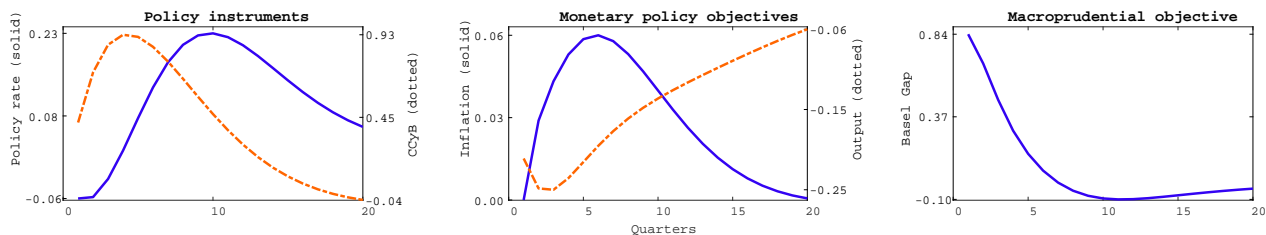
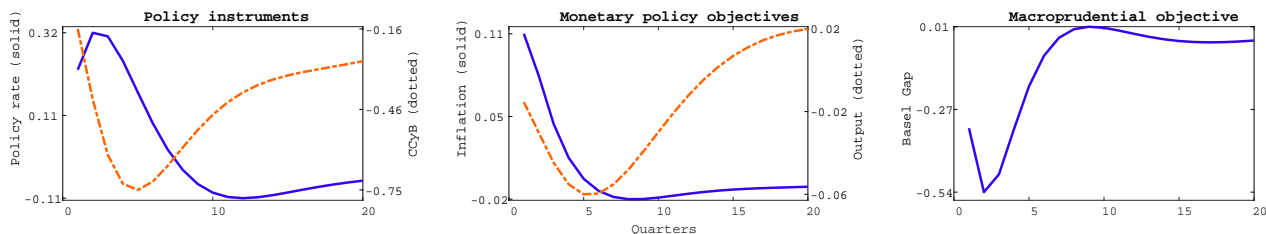


Figure 3: Conflict with CCyB under a negative bank capital shock



IRFs can help us understand the source of these numerous conflicts.¹⁷ For instance, in Figure 2, we observe that following a negative investment efficiency shock, the CCyB is tightened in response to the increase in the Basel gap. The tightening of bank balance sheet constraints is intended to encourage banks to hike their retail rates. In contrast, monetary policy turns out to be accommodative as

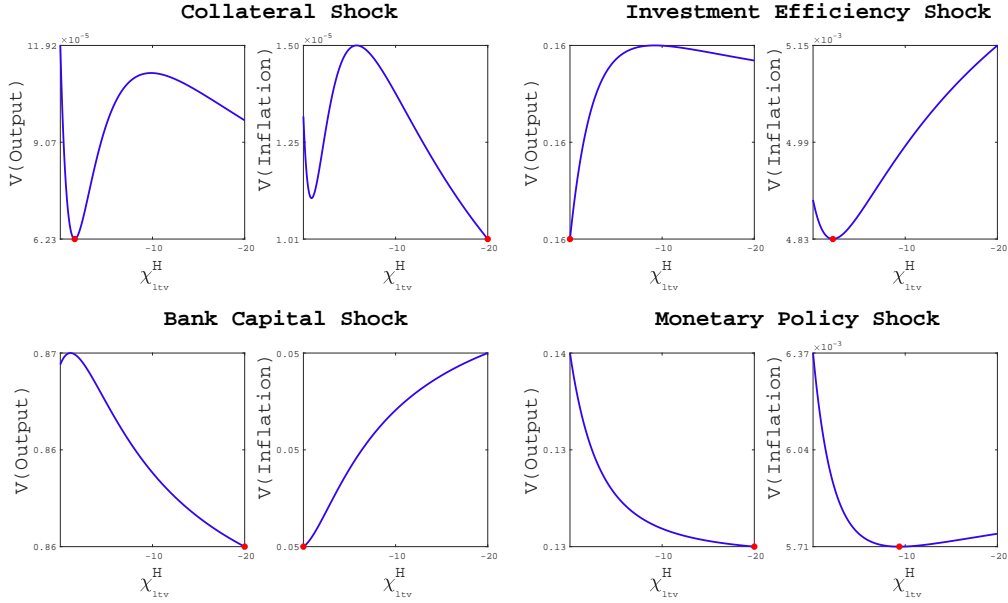
¹⁷In line with Figures 1, 4 and 7, IRFs in this section are computed considering only one macroprudential policy rule. The policy parameters in the two other macroprudential rules are set to zero.

the output declines, which should make retail rates decrease. Hence, the two policies go in opposite directions. Similarly, Figure 3 illustrates the conflict arising in the case of a negative bank capital shock. According to Figure 1, these conflicts are even more important when the CCyB responds much more strongly to financial imbalances.

4.2 Conflicts stemming from loan-to-value caps

Figure 4 reports the evolution of the variances of output and inflation as the reaction parameter χ_{ltv}^H in the mortgage loan-to-value rule moves from 0 to -20. Generally speaking, we observe less conflicts than with the CCyB.

Figure 4: Side effects of the LTV cap for households



Note: Each plot represents the evolution of the theoretical variance of output or inflation as the reaction parameter χ_{ltv}^H in the LTV^H rule evolves from -20 to 0 in increments of 0.01, while the policy parameters in the other macroprudential policy rules are equal to zero ($\chi_{ccyb} = \chi_{ltv}^E = 0$) and those in the monetary policy rule remain constant ($\chi_\pi = 1.98, \chi_y = 0.34$).

Certainly, the variances of output and inflation globally increase in the case of an investment efficiency shock when χ_{ltv}^H rises (especially when χ_{ltv}^H exceeds 2 in absolute value for inflation). Similarly, the variance of inflation increases as χ_{ltv}^H rises following a bank capital shock. This case is illustrated in Figure 5, where we can see that the LTV constraint to households is tightened (i.e., lowered below 0.7) in response to the increase in the mortgage credit gap. This is intended to discourage demand for housing, which in turn tends to drive down interest rates. This is conflicting with the monetary policy, which is restrictive in response to rising inflation and output. However, some spillover effects are clearly favourable: for example, Figure 6 illustrates complementarity found in the case of a monetary policy shock, a situation in which both policy instruments aim to increase the retail rates.

Figure 4 shows that the paths of variances are less clear-cut under the collateral shock. Nonetheless, we can see that having an LTV limit activated (i.e., $\chi_{ltv}^H \neq 0$) is always preferable for the stabilization of output (compared to a situation such as $\chi_{ltv}^H = 0$), which suggests complementarity. The stabilisation of inflation can also benefit from the LTV cap, but provided that this instrument reacts strongly to its target (i.e. for χ_{ltv}^H greater than 10 in absolute value). Otherwise, a conflict is likely to occur.

Figure 5: Conflict with LTV cap for households under a negative bank capital shock

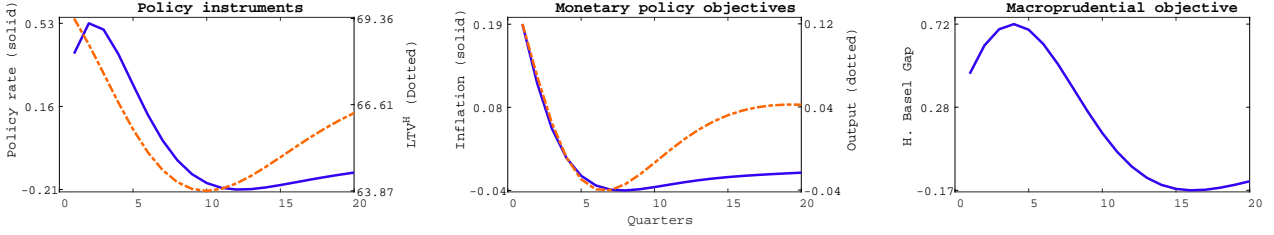


Figure 6: Complementarity with LTV cap for households under a positive monetary policy shock

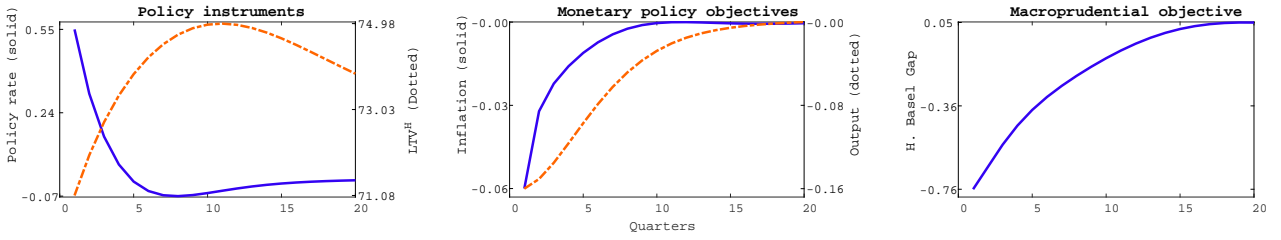
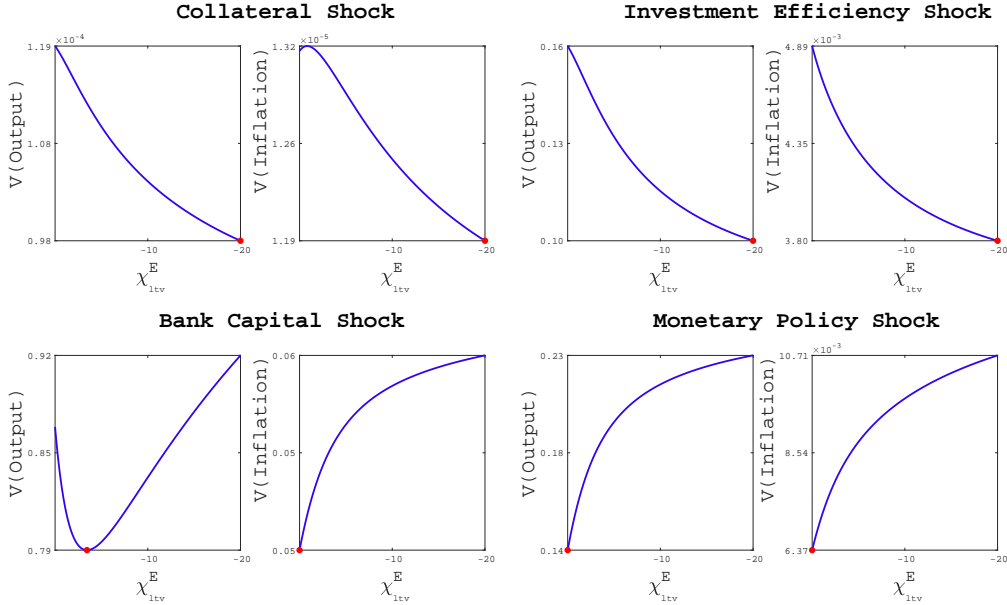


Figure 7: Side effects of the LTV cap for firms



Note: Each plot represents the evolution of the theoretical variance of output or inflation as the reaction parameter χ_{ltv}^E in the LTV^E rule evolves from -20 to 0 in increments of 0.01, while the policy parameters in the other macroprudential policy rules are equal to zero ($\chi_{ccyb} = \chi_{ltv}^H = 0$) and those in the monetary policy rule remain constant ($\chi_{\pi} = 1.98, \chi_y = 0.34$).

Next, in light of Figure 7, we find that the LTV cap for entrepreneurs also causes fewer conflicts than CCyB. Adverse side effects arise in particular in the case of a bank capital shock (but only for high values of χ_{ltv}^E concerning output) and in a context of a monetary policy shock. For example, as shown in Figure 8, the corporate LTV is tightened (i.e., cut below 0.8) in response to the rise in the entrepreneurs' sectoral Basel gap, following a positive monetary policy shock. This intends to

discourage loan demand and should push lending rates down, which is inconsistent with the restrictive monetary policy stance. Nevertheless, there are many situations leading to complementarities between the two policies. This is the case, for example, under a positive collateral shock, as illustrated in Figure 9, where both policies are intended to raise interest rates.

Figure 8: Conflict with LTV cap for firms under a positive monetary policy shock

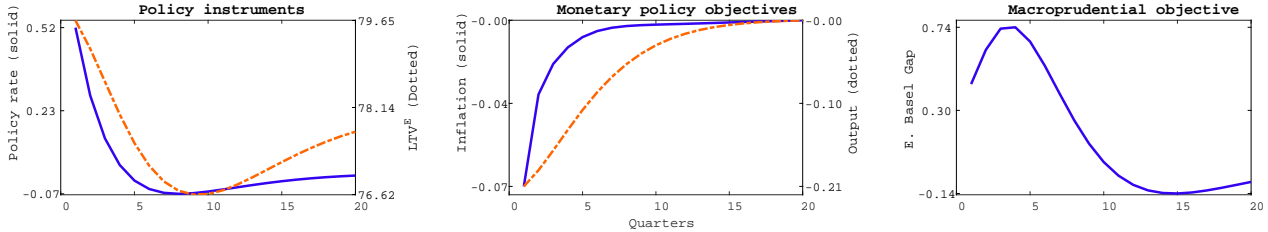
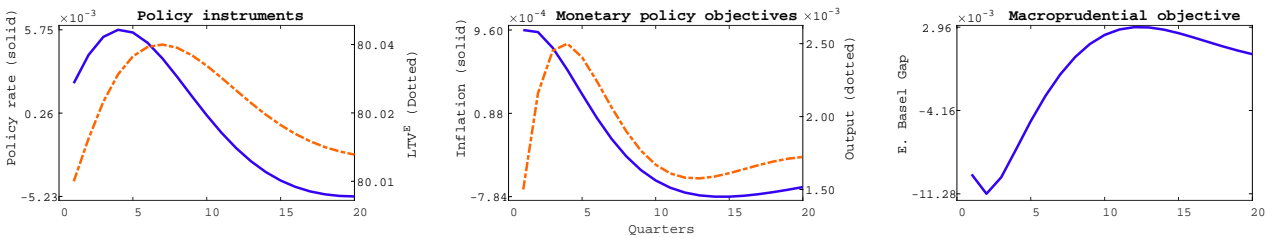


Figure 9: Complementarity with LTV cap for firms under a positive collateral shock

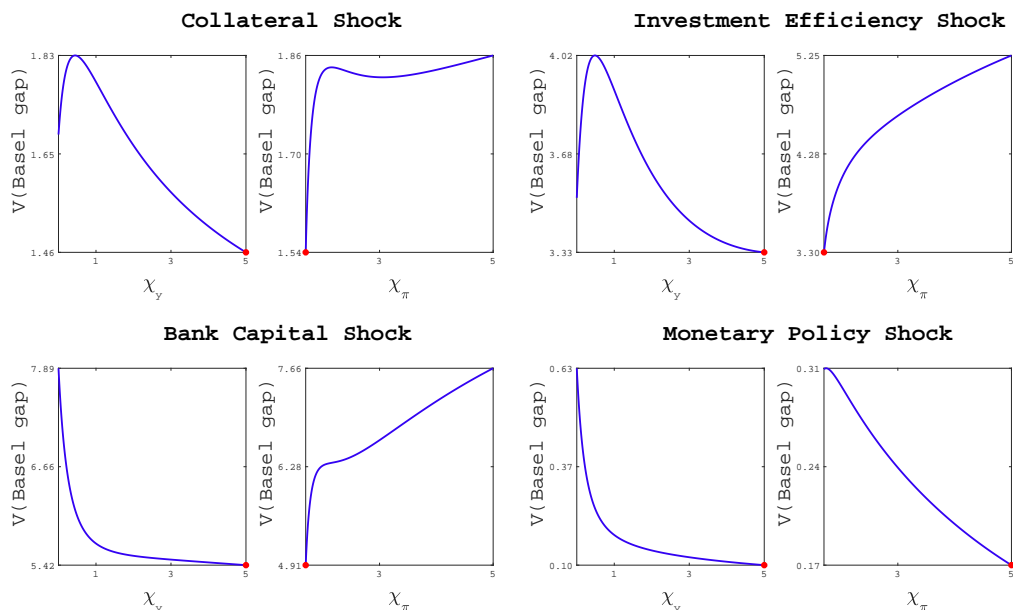


4.3 Conflicts stemming from monetary policy

Figure 10 represents the sensitivity of the variance of the credit gap, i.e. the macroprudential objective, to the two policy parameters of the monetary policy rule. We first notice that the reaction to inflation changes creates conflicts in all cases, except under a monetary policy shock. For example, let us consider a positive collateral shock, as illustrated by Figure 11. The monetary policy rate is cut to support inflation. This accommodative monetary policy stance is likely to decrease retail rates and stimulate loans. However, the macroprudential policy becomes more restrictive in response to the increase in the Basel gap. This aims to raise lending rates and reduce excess loans, which is opposite to the monetary policy stance. Note that Figure 3 also illustrates such a conflict under a negative bank capital shock, where the easing of capital requirements is counteracted by the policy rate hike.

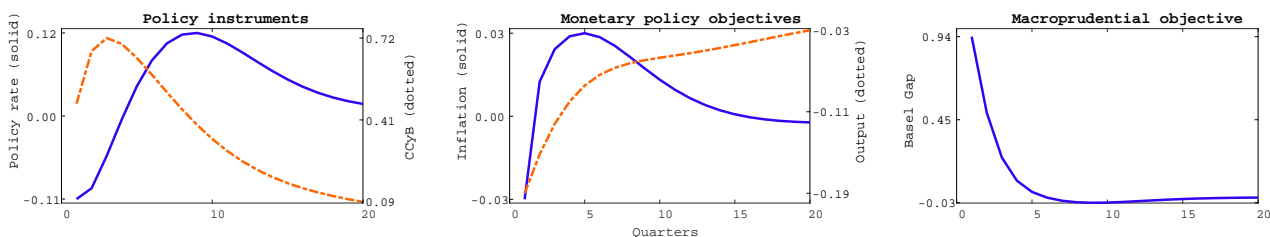
According to Figure 10, these conflicts worsen as policymakers react more strongly to inflation. In contrast, the reaction to output changes seems to be not very detrimental to the stabilization of credit. Complementarities are even found in the case of bank capital and monetary policy shocks, as well as following investment and collateral shocks, provided that the reaction parameter to output is higher than 0.5. Precisely, we can see that inflation and output react in opposite directions in the cases described in Figures 3 and 11, which suggests that conflicts would be reduced if the weight assigned to output were greater in the monetary policy rule. Thus, contrary to the reaction to inflation, a strong reaction to output movements would be beneficial for the stabilization of credit.

Figure 10: Side effects of monetary policy



Note: Each plot represents the evolution of the theoretical variance of the Basel gap as the reaction parameters χ_π or χ_γ in the monetary policy rule evolve over $[1.70, 5.0]$ and $[0, 5.0]$, respectively, in increments of 0.01, while the policy parameters in the macroprudential policy rules remain constant ($\chi_{ltv}^H = \chi_{ltv}^E = -1.0$, $\chi_{ccyb} = 5.0$).

Figure 11: Example of conflict stemming from monetary policy under a positive collateral shock



5 Assessment and discussion

This section aims to assess and discuss the results obtained so far. First, Table 3 reports all the conflicts originating with macroprudential policy. We observe that the macroprudential instruments may be particularly detrimental to the stabilization of inflation and output in the case of investment and bank capital shocks. Both are supply-side and economy-wide shocks. It is as if the simultaneous and uncoordinated reaction of all the policy instruments to such shocks triggers cacophony.

From the perspective of the instruments, we observe that the CCyB generates negative side effects in most cases. In contrast, LTV caps cause less conflicts.¹⁸ State-contingent borrowing cap for households is even found complementary to monetary policy in the context of monetary and collateral shocks (provided that the related reaction parameter is high). Similarly, countercyclical LTV for firms seems to be complementary to monetary policy in cases of collateral and investment shocks.

¹⁸Notice that a supply of housing less rigid and inelastic than assumed in the model would dampen the impact of the LTV cap on the real estate market, and thus may reduce even more the risk of conflicts.

Table 3: Summary of the conflicts stemming from macroprudential policies

Shock:	Collateral		Invest. efficiency		Bank capital		Monetary policy	
	$V(Y)$	$V(\pi)$	$V(Y)$	$V(\pi)$	$V(Y)$	$V(\pi)$	$V(Y)$	$V(\pi)$
χ_{ccyb}	●	●	●	●	●	●	●	●
χ_{ltv}^H		●	●	●		●		
χ_{ltv}^E					●	●	●	●

Note: ● indicates conflicts, i.e., an increase in the variance of inflation or output as the concerned macroprudential policy parameter increases. ● means that a conflict exists only above a given value of the concerned policy parameter. ● indicates negative side effects only below a certain threshold of the concerned policy parameter. No symbol means no conflict.

Next, Table 4 reports the conflicts originating with the monetary policy rule. We can see that the reaction to inflation is always detrimental to the credit cycle, except in the case of monetary policy shock. In contrast, the response to the output gap can induce complementarity, especially if the central bank responds strongly to this target.¹⁹ However, as monetary policy is primarily driven by the objective of inflation, a trade-off between monetary and macroprudential policies is likely to occur most of the time.

Table 4: Summary of the conflicts stemming from monetary policy

Shock:	Collateral	Invest. efficiency	Bank capital	Monetary policy
	$V(\text{Basel gap})$	$V(\text{Basel gap})$	$V(\text{Basel gap})$	$V(\text{Basel gap})$
χ_y	●	●		
χ_π	●	●	●	

Note: ● indicates conflicts, i.e., an increase in the variance of the Basel gap as the concerned monetary policy parameter increases. ● indicates negative side effects only below a certain threshold for the concerned policy parameter. No symbol means no conflict.

Hence, our comprehensive assessment reveals that monetary policy and state-contingent capital asset requirement policies are responsible for conflicts in many circumstances. To understand why, it is worth noting that these two instruments share the same main transmission channel. Indeed, by influencing the wholesale deposit rate, the policy rate impacts banks' balance sheets, which in turn implies variations in retail interest rates. In the same way, CCyB activation demands adjustment of banks' balance sheets through the adjustment of the interest margin. Then, by impacting retail rates, these two policies "get in all the cracks" of the economy.²⁰ Furthermore, as shown by the IRFs in Figures D1 to D4 and in the second part of Table 2, the monetary and macroprudential targets often move in the opposite directions from each other. Thus, most of the time, the side effects turn out to be conflicts.

In contrast, mortgage and corporate LTV caps can be viewed as targeted measures. They can be set independently to regulate either household or corporate financing. Moreover, they affect credit volumes through agents' credit affordability (and not interest rates directly). Thus, these sectoral policies are less likely to generate conflicts. This clearly appears in Table 3, where we can see that the

¹⁹This result can be related to that of Gelain and Ilbas (2017), who conclude that monetary policy should place a high weight on the output gap to achieve the best possible outcome in the absence of policy coordination.

²⁰This is the way that J. Stein, the former Fed governor, describes the widespread transmission of monetary policy rate changes, which "may reach into the corners" of the economy and the financial markets through the impact on all market rates (Stein, 2013).

LTV rules do not generate adverse real effects when the shocks are specific to the housing market (i.e., collateral shocks). Therefore, from this perspective, it seems that taming lending practices provokes fewer conflicts than managing capital buffers.

6 Sensitivity analysis

6.1 Sensitivity to the calibration

A first robustness check deals with the parametrization of the model. As stated in Section 2.6, parameters values are those estimated by Gerali et al. (2010), with a few exceptions primarily concerning parameters related to the macroprudential policy framework. More precisely, there may be uncertainty concerning χ_H , χ_E , κ_{car} , κ_{lev} , ε^{bE} and ε^{bH} . In order to have a clear idea of the sensitivity of the results to the calibration, we proceed to the identification of conflicts with these six parameters being halved. The different side effects found under this alternative calibration are reported in Figures E1 to E4 in the online appendix. Unsurprisingly, the amplitude of variation of the variances is lower than that found with the baseline parameterization. However, the shapes of the curves are not really affected by this change in the calibration.

Regarding the macroprudential instruments, only two results are changed in comparison with the baseline configuration. They both concern the spillovers stemming from the LTV to households, in the case of a bank capital shocks: the variance of the output gap increases as the policy parameter χ_{ltv}^H rises – which confirms that this shock is more prone to conflicts, whereas complementarity is found between the objectives of financial stabilization and inflation stabilization for moderate values of χ_{ltv}^H (against systematic conflict found in the baseline configuration).

Concerning monetary policy, the only changes concern the volatility of the credit-to-GDP gap conditional on the policy parameter assigned to the output gap (χ_y). While conflicts are possible in the event of collateral and investment shocks for low values of χ_y according to the baseline analysis, we now find that the response of monetary policy to the output gap is always beneficial to the stabilization of credit, irrespective of the value of χ_y . This confirms that the response to the output gap is consistent with the macroprudential objective.

Thus, changing significantly the values of the parameters subject to uncertainty does not change the conclusions.

6.2 Sensitivity to optimal policy rules

In this section, we check whether the baseline results still hold if the policy rules are optimized. If so, then the conflicts previously found are really due to deep structural motives and not to potential sub-optimal settings of the two policies.

To this end, we follow the optimization framework proposed by Angelini et al. (2014), in which both the monetary policy rule (through χ_y and χ_π) and the macroprudential rule under review (through χ_{ltvH} , χ_{ltvE} or χ_{ccyb}) are optimized. To assess the robustness of the results to different configurations, and because there is no consensus on the relative weights of the different policy objectives, we do not assign a single weight to each objective. Instead, a multitude of different policy preferences are considered, following a policy frontier approach. For the sake of parsimony, we focus on the trade-offs between inflation and the Basel gap, which represent most of the conflicts found in the baseline analysis. More precisely, we study how the variances of inflation move when macroprudential rules

are optimized while the weight of the financial stability objective increases in relative terms in the policymakers' loss function. Similarly, we investigate how the variance of the credit gap changes when the policy rule is optimized with an increasing relative weight for inflation in the loss function. Details are provided in the online appendix F.

This policy frontier approach confirms that the baseline results still hold when the policy rules are optimized, for a multitude of policy preferences. We find that increasing the weight of credit gap stabilization in the loss function makes the variance of the Basel gap decrease, at the expense of higher volatility of inflation, for each configuration giving rise to a conflict between the objectives of inflation and credit gap stabilization in the baseline analysis. Similarly, increasing the relative preference for the stabilization of inflation makes prices more stable at the expense of higher volatility of the credit gap, under collateral, investment and bank capital shocks, in line with conflicts stemming from monetary policy.

7 Concluding remarks

Macroprudential policy has recently become a full-fledged instrument of economic policy, as demonstrated by the prompt relaxation of capital requirements in many countries in response to the COVID-19 crisis. However, the widespread use of macroprudential tools raises the question of their interaction with monetary policy.

This paper offers an original approach to assessing the precise conditions under which macroprudential and monetary policies may be conflicting. These conditions are evaluated based on different types of shocks and different policy instruments, including countercyclical capital buffers (CCyBs) and loan-to-value (LTV) limits. Conflicts are identified when monetary policy has adverse side effects for macroprudential objectives and *vice versa*.

We find that conflicts are fairly frequent, especially in the case of investment efficiency and bank capital shocks, due to their widespread impact on the economy. Among the policy instruments, the CCyB and monetary policy are found to generate conflicts in many cases. They both “get in all the cracks” by widely impacting the economy through the adjustment of retail rates, albeit with targets often moving in opposite directions. Hence they often work at cross-purposes. Nonetheless, a stronger reaction of monetary policy to the output gap should reduce the adverse side effects of monetary policy. In contrast, LTV caps, as more targeted instruments, cause few conflicts.

These results suggest that, from the perspective of negative spillover effects, LTV limits can be more easily implemented than countercyclical banks' capital buffers, which require smooth coordination with monetary policy. Furthermore, the latter could react more strongly to the output gap to mitigate the conflicts that it would otherwise cause.

More generally, our results open the way for a more formal analysis on the coordination of these policies and on the suitable institutional arrangements for the design of monetary and prudential regulation. Further research could also focus on extending the analytical framework by inserting an endogenous risk-taking channel as an additional source of financial-side vulnerability caused by monetary policy. Another extension could embed explicit financial crises with feedback to real-side effects to further assess the real-side impact of macroprudential tools. Finally, an additional research avenue may concern the existence of “internal conflicts”, referring to cases in which the interactions between the different macroprudential instruments may undermine the stabilization of credit.

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A Details on the model

Capital and final goods producers

Capital-producing firms act in a perfectly competitive market. They are owned by the entrepreneurs. They purchase last period's undepreciated capital $(1 - \delta)k_{t-1}$ from the entrepreneurs at a price Q_t^k and i_t units of final goods from retail firms at a price P_t . They combine them to produce new capital. The transformation of the final goods into capital is subject to quadratic adjustment costs. The new capital is then sold back to the entrepreneurs at the same price Q_t^k . Hence, capital producers maximize their expected discounted profits

$$\max_{\{k_t(j), i_t(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \left(q_t^k [k_t(j) - (1 - \delta)k_{t-1}(j)] - i_t(j) \right) \quad (\text{A1})$$

subject to eq. (8) in the text, where $q_t^k = Q_t^k/P_t$ is the real price of capital and $\Lambda_{0,t}^e$ the entrepreneurs' discount factor.

Final good producers are owned by patient households. They act in monopolistic competition, and their prices are sticky because of the existence of quadratic adjustment costs when prices are revised. They purchase the intermediate (wholesale) good from entrepreneurs in a competitive market and then slightly differentiate it at no additional cost. Each firm j chooses its price to maximize the expected discounted value of profits:

$$\max_{\{P_t(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[(P_t(j) - P_t^W) y_t(j) - \frac{\kappa_P}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - \pi_{t-1}^{\iota_p} \pi^{1-\iota_p} \right)^2 P_t y_t \right] \quad (\text{A2})$$

subject to the demand derived from consumers' maximization

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon^y} y_t \quad (\text{A3})$$

where κ_p denotes the cost of adjusting prices, $\iota_p \in [0, 1]$ is the degree of indexation to past inflation, ε^y is the demand price elasticity, P_t^W is the wholesale price and $\Lambda_{0,t}^P$ is the patient households' discount factor.

Employment agencies

Workers provide differentiated labour types sold by unions to perfectly competitive employment agencies, which assemble them in a CES aggregator with stochastic parameter ε_t^l and sell homogeneous labour to entrepreneurs. For each labour type m , there are two unions, one for patient households and one for impatient households. Each union sets nominal wages $W_t^i(m)$ for its members, with $i \in \{P, I\}$, by maximizing their utility subject to downward-sloping demand and to quadratic adjustment costs (parametrized by κ_w), with indexation ι_w to lagged inflation and $(1 - \iota_w)$ to steady state inflation (denoted π). Unions charge their members lump-sum fees to cover adjustment costs with equal split. Hence, they seek to maximize the following expression:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t^i \left\{ U_{c_t^i}(j, m) \left[\frac{W_t^i(m)}{P_t} l_t^i(j, m) - \frac{\kappa_w}{2} \left(\frac{W_t^i(m)}{W_{t-1}^i(m)} - \pi_{t-1}^{\iota_w} \pi^{1-\iota_w} \right)^2 \frac{W_t^i(m)}{P_t} \right] - \frac{l_t^i(j, m)^{1+\phi}}{1+\phi} \right\}, \quad (\text{A4})$$

subject to demand from employment agencies

$$l_t^i(i, m) = l_t^i(m) = \left(\frac{W_t^i(m)}{W_t^i} \right)^{-\varepsilon^l} l_t^i, \quad (\text{A5})$$

with ε^l being the elasticity of labour demand.

Banks' retail branches

Retail loan branch

The retail loan branch of the banking group j operates under monopolistic competition. It obtains wholesale loans $B_t^s(j)$, in real terms, at rates $R_t^{bs}(j)$, from the management branch. Allocations of wholesale funds for mortgage loans ($B_t^H(j)$) and corporate lending ($B_t^E(j)$) depend on the risk weights (ω_t^H and ω_t^E) for the capital adequacy ratio. Corresponding wholesale interest rates are given by Eq. (12). Retail loan branches resell these funds to households and entrepreneurs at lending rates $r_t^{bH}(j)$ and $r_t^{bE}(j)$, respectively, after differentiating them at no cost but facing quadratic adjustment costs for changing them. These costs are parametrized by κ_{bH} and κ_{bE} and are proportional to aggregate returns on loans. They are denoted $\mathcal{A}_{bs}(r_t^{bs}(j)) \equiv \frac{\kappa_{bs}}{2} (r_t^{bs}(j)/r_{t-1}^{bs}(j) - 1)^2 r_t^{bs} b_t^s$, for $s \in \{H, E\}$, with $r_t^{bs} = [\int_0^1 r_t^{bs}(j)^{1-\varepsilon^{bs}} dj]^{\frac{1}{1-\varepsilon^{bs}}}$ and with b_t^s representing aggregate loans in the economy. The objective of the retail loan branch j is to solve

$$\max_{\{r_t^{bH}(j), r_t^{bE}(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[\sum_{s=H,E} \left(r_t^{bs}(j) b_t^s(j) - \mathcal{A}_{bs}(r_t^{bs}(j)) \right) - \sum_{s=H,E} R_t^{bs}(j) B_t^s(j) \right], \quad (\text{A6})$$

subject to Dixit-Stiglitz loan demand curves $b_t^s(j) = (r_t^{bs}(j)/r_t^{bs})^{-\varepsilon^{bs}} b_t^s$. Units of loan contracts, bought by households and entrepreneurs, are a composite constant elasticity of substitution basket of differentiated financial products, with elasticity terms equal to $\varepsilon^{bH} > 1$ and $\varepsilon^{bE} > 1$, respectively. The first-order conditions give the dynamics of the lending rates r_t^{bs} with respect to both their past and expected values and to a markup ($\varepsilon^{bs}/(\varepsilon^{bs} - 1)$) over the wholesale lending rate, as given by Eq. (A39) in the online appendix.

Retail deposit branch.

The retail deposit branch of the banking group j , operating in a monopolistic competition context, collects deposits $d_t^P(j)$ from households at rates $r_t^d(j)$ and transfers quantity $D_t(j)$ to the management branch, which remunerates these funds at internal rate $R_t^d(j)$. Each deposit retail unit faces quadratic adjustment costs for changing its deposit rate over time. These adjustment costs, denoted as $\mathcal{A}_d(r_t^d(j))$, are parametrized by κ_d and are supposed to be proportional to the aggregate interest paid on deposits, such as $\mathcal{A}_d(r_t^d(j)) \equiv \frac{\kappa_d}{2} (r_t^d(j)/r_{t-1}^d(j) - 1)^2 r_t^d d_t$, where d_t represents aggregate deposits in the economy and $r_t^d = [\int_0^1 r_t^d(j)^{1-\varepsilon^d} dj]^{\frac{1}{1-\varepsilon^d}}$ is the deposit rate, with $\varepsilon^d < -1$ representing the elasticity of demand for deposits. Then, the objective of the retail deposit branch j is to solve

$$\max_{\{r_t^d(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[R_t^d(j) D_t(j) - r_t^d(j) d_t^P(j) - \mathcal{A}_d(r_t^d(j)) \right], \quad (\text{A7})$$

subject to a Dixit-Stiglitz deposit demand curve $d_t^P(j) = (r_t^d(j)/r_t^d)^{-\varepsilon^d} d_t$. The first-order condition of this programme defines the way the retail deposit branch optimally sets the retail deposit rate with respect to the adjustment costs, the policy rate and a markdown over the wholesale deposit rate, denoted $\varepsilon^d/(\varepsilon^d - 1)$, as indicated in Eq. (A38) in the online appendix.

Optimization program of the wholesale unit

After subtracting intra-group transactions, banking group profits are given by

$$\begin{aligned} \mathcal{P}_t^b(j) = & r_t^{bH}(j)b_t^H(j) + r_t^{bE}(j)b_t^E(j) - r_t^d(j)d_t^P(j) - \sum_{s=H,E} \mathcal{A}_{bs}(r_t^{bs}(j)) \\ & - \mathcal{A}_d(r_t^d(j)) - \mathcal{D}_t^v(K_t^b(j)) - \mathcal{D}_t^{lev}(K_t^b(j)). \end{aligned} \quad (\text{A8})$$

Considering the balance-sheet constraint $B_t(j) = D_t(j) + K_t^b(j)$ and after some algebra, this corresponds to the term to be optimized:

$$\max_{\{B_t(j), D_t(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[\sum_{s=H,E} R_t^{bs}(j) B_t^s(j) - R_t^d(j) D_t(j) - \mathcal{D}_t^v(K_t^b(j)) - \mathcal{D}_t^{lev}(K_t^b(j)) \right]. \quad (\text{A9})$$

The corresponding FOC are given by Eq. (12).

Market clearing and stochastic processes

The market clearing conditions for the final goods market are given by $y_t = c_t + q_t^k [k_t - (1 - \delta)k_{t-1}]$, with $c_t = c_t^P + c_t^I + c_t^E$. Equilibrium in the housing market is given by $\bar{h} = h_t^P(i) + h_t^I(i)$, where \bar{h} is the exogenous fixed housing supply. The monetary policy shocks is a white noise such as $\varepsilon_t^r \sim i.i.d. \mathcal{N}(0, \sigma_r^2)$. The other shocks follow an $AR(1)$ process such that $\log(\varepsilon_t^x) = (1 - \rho_x)\log(\varepsilon^x) + \rho^x \log(\varepsilon_{t-1}^x) + \xi_t^x$, with $x = \{m, eq, Kb\}$, where $\xi_t^x \sim i.i.d. \mathcal{N}(0, \sigma_x^2)$.

B Theoretical correlations under many different shocks

Table B1: Theoretical correlations between output, inflation and the credit gap under different shocks

Shock type	Correlations		
	Output Inflation	Output Basel gap	Inflation Basel gap
Household Collateral shock	–	–	–
Housing preference shock	–	–	–
Consumption pref. shock	–	–	–
CCyB shock	–	–	–
Bank capital shock	+	–	–
Productivity shock	+	–	–
Markup Deposits shock	+	–	–
Markup goods market shock	+	–	–
Markup labor market shock	+	–	–
Investment efficiency shock	–	–	+
Entrepreneurs Collateral shock	–	–	+
Markup Loans H shock	–	–	+
Markup Loans E shock	–	–	+
Monetary policy shock	+	+	+

Note: This table presents the signs of the theoretical correlations between pairs of policy targets, for all the shocks that are introduced in the model of Gerali et al. +/- refer to a positive / negative correlation. Shocks in bold type are those considered in the current analysis.

C Calibration of the structural parameters and shocks

Table C1: Calibration of the structural parameters and shocks

Parameter	Description	Value
β_P	Patient households' discount factor	0.9943
β_I	Impatient households' discount factor	0.975
β_E	Entrepreneurs' discount factor	0.975
ϕ	Inverse of the Frisch elasticity	0.5
ε^h	Steady state of housing in households' utility function	0.2
a^P, a^I, a^E	Degree of habit formation in consumption	0.856
α	Capital share in the production function	0.25
μ	Labour income share of patient households	0.8
ι_p	Indexation of prices to past inflation	0.16
ι_w	Indexation of nominal wages to past inflation	0.276
δ	Depreciation rate of physical capital	0.025
δ^b	Cost of managing the bank's capital position	0.084
κ_w	Cost of adjusting nominal wages	99.89
κ_i	Cost of adjusting investment	10.18
κ_P	Cost of adjusting good prices	28.65
κ_{car}	Cost of adjusting capital-asset ratio	50.0
κ_{lev}	Cost of adjusting leverage ratio	7.63
κ_{bE}	Cost of adjusting BLR to entrepreneurs	9.36
κ_{bH}	Cost of adjusting BLR to households	10.09
κ_d	Cost of adjusting deposit rate	3.50
$\varepsilon^l/(\varepsilon^l - 1)$	Steady state markup in the labour market	5.0
$\varepsilon^y/(\varepsilon^y - 1)$	Steady state markup in the goods market	6.0
$\varepsilon^{bE}/(\varepsilon^{bE} - 1)$	Steady state markup on BLR to entrepreneurs	1.154
$\varepsilon^{bH}/(\varepsilon^{bH} - 1)$	Steady state markup on BLR to households	1.154
$\varepsilon^d/(\varepsilon^d - 1)$	Steady state markdown on deposit rate	0.593
λ_{HP}	Smoothing parameter of HP filter	1600
ρ_m	Persistence of collateral shock	0.93
σ_m	Standard deviation of collateral shock	0.002
ρ_{qk}	Persistence of investment efficiency shock	0.547
σ_{qk}	Standard deviation of investment efficiency shock	0.013
ρ_{Kb}	Persistence of bank capital shock	0.81
σ_{Kb}	Standard deviation of bank capital shock	0.050
σ_r	Standard deviation of monetary policy shock	0.002

D Impulse response functions (w/ and w/o macroprudential rules)

Note: In the following plots, “H” and “E” refer to households and entrepreneurs, respectively. For instance, “H. Basel gap” and “E. Basel gap” refer to the mortgage and the corporate credit-to-GDP gaps, respectively. Horizontal axes represent quarters. The model “with macroprudential rules” embeds the CAR rule and the two LTV rules simultaneously.

Figure D1: Positive collateral shock

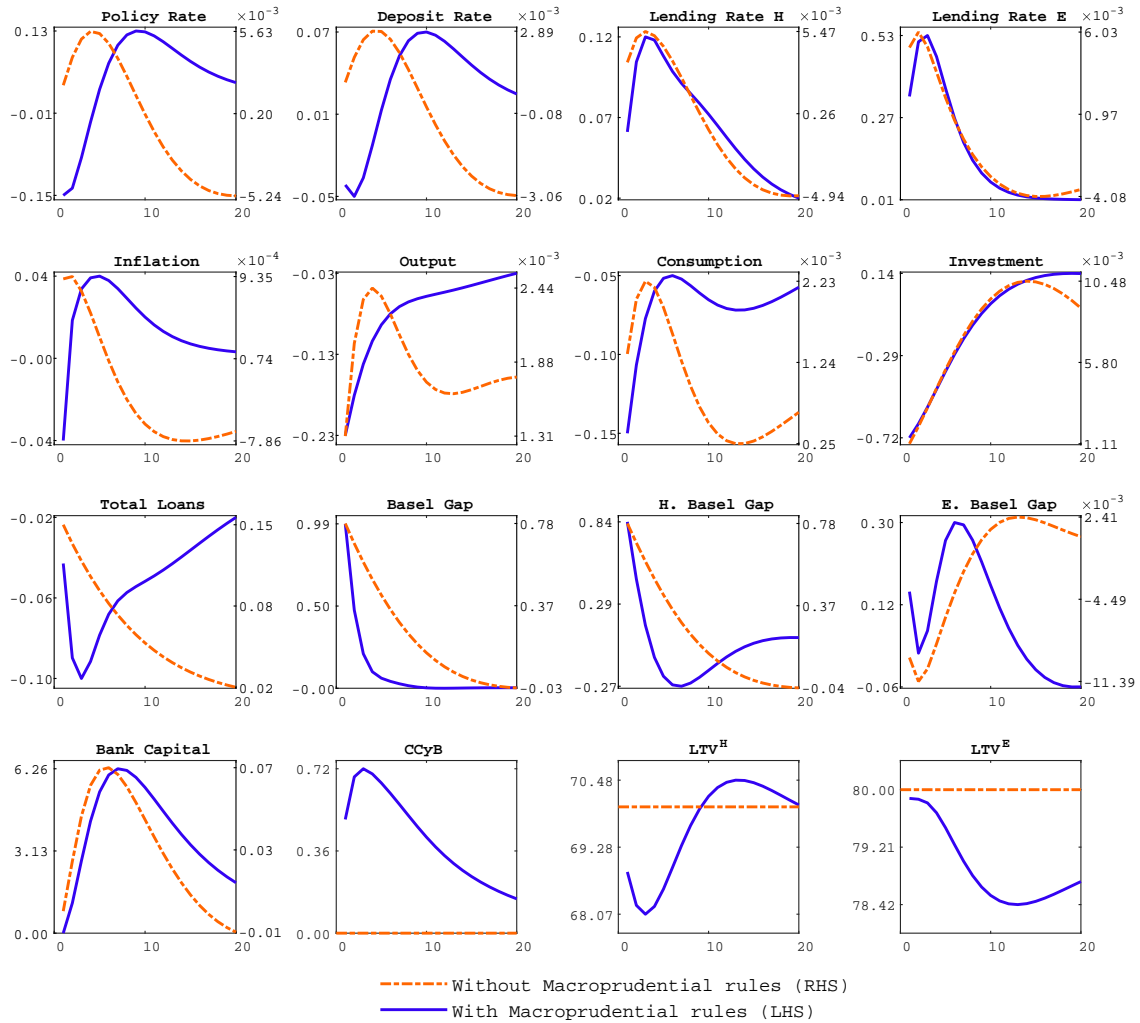


Figure D2: Negative investment efficiency shock

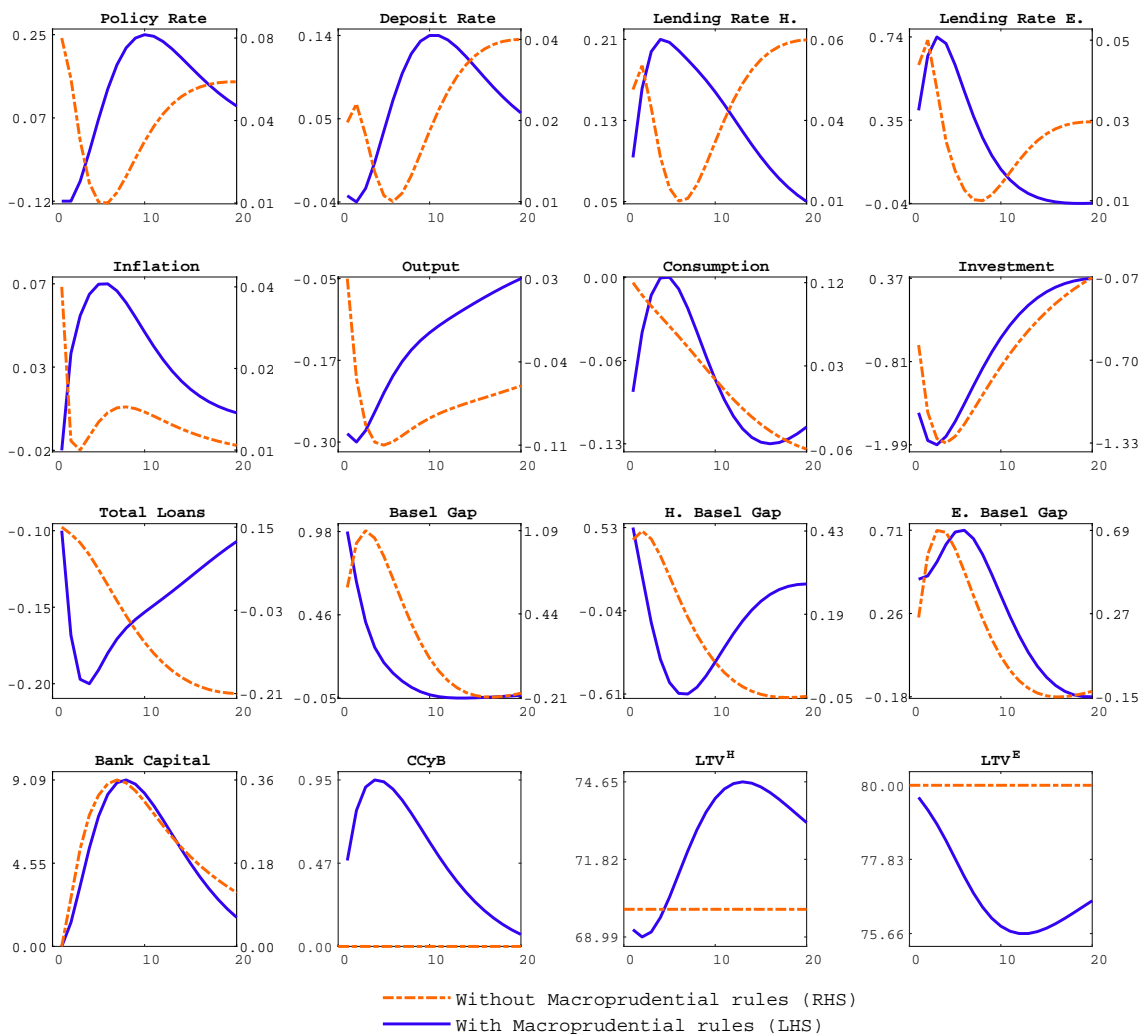


Figure D3: Negative bank capital shock

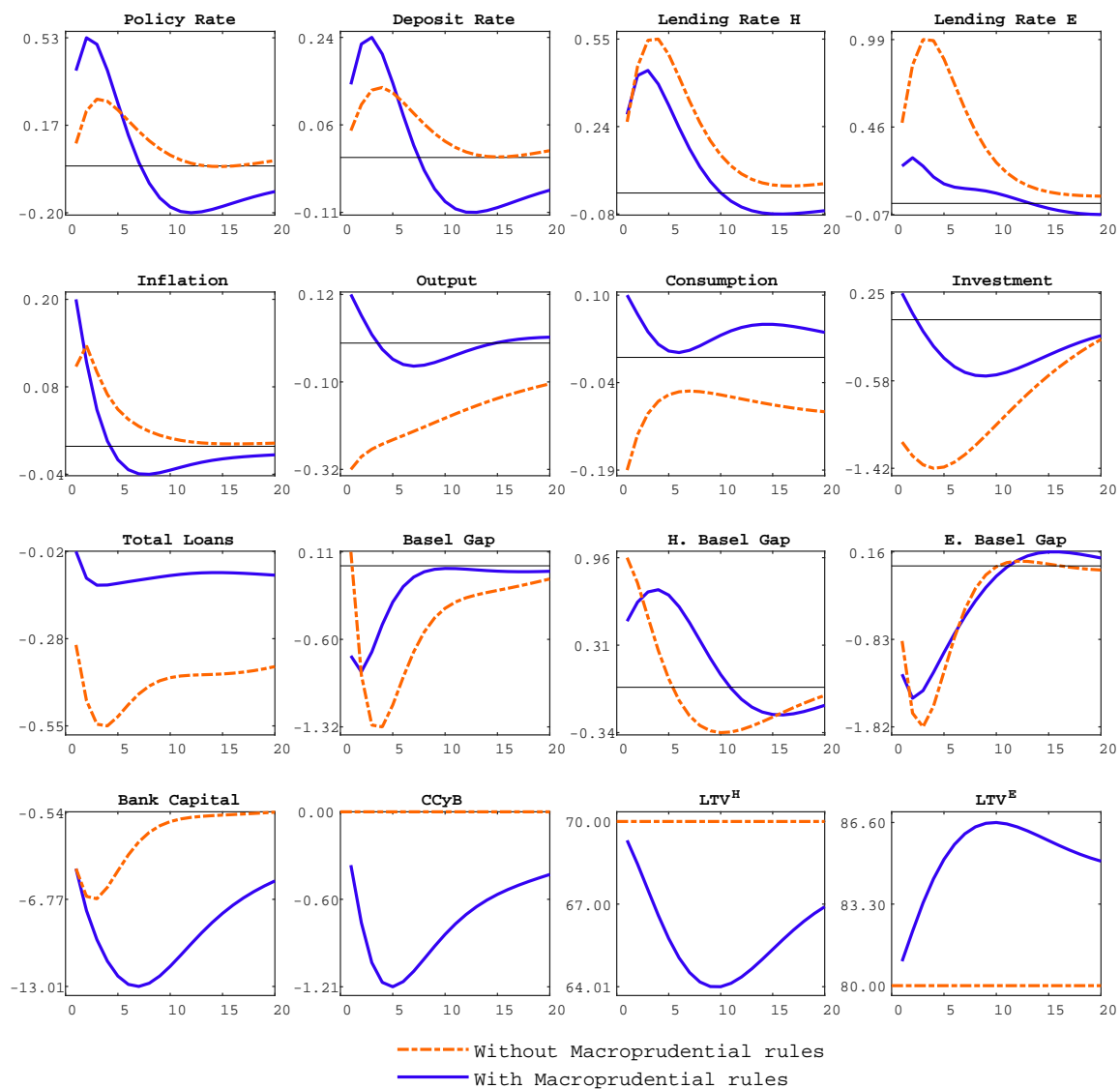


Figure D4: Positive monetary policy shock

