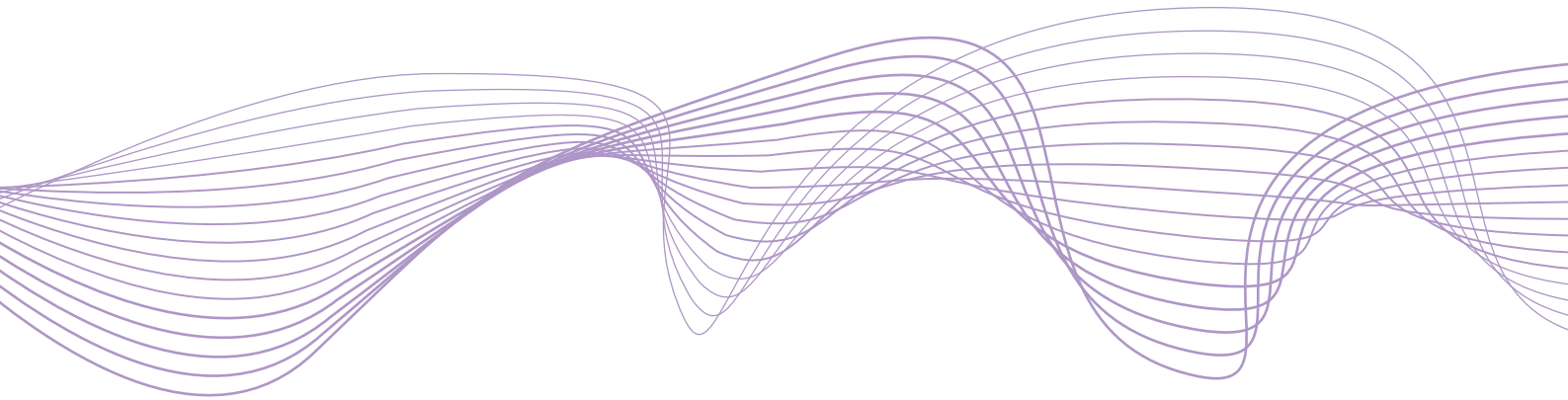


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Rethinking capital regulation:  
the case for a dividend  
prudential target

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## Abstract

*The paper investigates the effectiveness of dividend-based macroprudential rules in complementing capital requirements to promote bank soundness and sustained lending over the cycle. First, some evidence on bank dividends and earnings in the euro area is presented. When shocks hit their profits, banks adjust retained earnings to smooth dividends. This generates bank equity and credit supply volatility. Then, a DSGE model with key financial frictions and a banking sector is developed to assess the virtues of what shall be called dividend prudential targets. Welfare-maximizing dividend-based macroprudential rules are shown to have important properties: (i) they are effective in smoothing the financial and the business cycle by means of less volatile bank retained earnings, (ii) they induce welfare gains associated to a Basel III-type of capital regulation, (iii) they mainly operate through their cyclical component, ensuring that long-run dividend payouts remain unaffected, (iv) they are flexible enough so as to allow bank managers to optimally deviate from the target (conditional on the payment of a sanction), and (v) they are associated to a sanctions regime that acts as an insurance scheme for the real economy.*

Keywords: macroprudential regulation, capital requirements, dividend prudential target, financial stability, bank dividends

JEL classification: E44, E61, G21, G28, G35

# 1 Introduction

The recent financial crisis has highlighted the importance of counting with a comprehensive prudential regulatory framework that includes macroprudential tools to smooth the financial cycle and prevent the endogenous build-up of systemic risk (see, e.g., Galati and Moessner 2013, Constâncio 2017). Regulatory capital ratios remain a central element of such toolkit. Some of the key objectives financial regulators pursue with this policy instrument are to ensure soundness of banks and normal lending activities during economic downturns. However, the attainment of such objectives cannot be taken for granted since macroeconomic effects of meeting capital requirements heavily depend on the channel through which banks adjust their capital ratios.<sup>1</sup>

In order to increase its regulatory capital ratio, a bank can either raise capital (numerator) or decrease total risk-weighted assets (denominator). The denominator can be reduced either by shrinking total assets - in many cases via cutting back on lending - or by reducing their assets' risk weighted average (substitution of riskier assets for safer ones). The main caveat of the latter is that a risk shift of this kind may not necessarily contribute to sustained lending. For instance, the replacement of "risky" loans for public debt is an alternative way of restricting credit supply to the private sector.

Perhaps, one of the most powerful mechanisms to meet capital requirements while enhancing bank solvency and lending to the real economy is to directly raise capital. There are two main options in this regard: to issue new equity or to retain earnings. The issuance of new equity can be effective but it has a number of disadvantages that make it one of the least attractive strategies to raise capital on a regular basis: (i) it is costly, (ii) the desire of attracting new shareholders often pushes banks to increase their dividend payout ratios (retained earnings decreases), and (iii) it is the least attractive option for existing bank shareholders as a new share issue tends to reduce the market value of the existing shares.

Alternatively, the bank can opt to retain more earnings. Retained earnings represent the core component of high quality regulatory capital and a source of regular capital accumulation at a low direct cost. The bank can target higher retained earnings either by boosting total profits or by reducing its dividend payout ratio. The direct way of increasing profits is by enlarging the lending spread. Yet, competition in lending markets can even deter big banks from choosing this option. Beyond the fact that non bank lending has constantly gained weight since the outbreak of the recent crisis, small banks themselves can improve their market share (against big banks) by compressing their margins.

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<sup>1</sup>According to the evidence, bankers internally set their own target capital ratio. This ratio usually includes a buffer above the regulatory capital requirement. To the extent that such buffer is directly related to the capital requirement, I indistinctly use expressions "meeting capital requirements " and "adjusting capital ratios" to make reference to the action by which bankers adjust their regulatory capital ratio towards their internal target.

Regarding the alternative of cutting back dividends, the challenge is that markets (shareholders) immediately react to dividend announcements and penalize lower-than-expected dividend payments. Nevertheless, in this case there is a strong, economic theory-based reason that may justify public intervention. According to the evidence, large, established corporations (including banks) distribute a significant percentage of their profits in the form of dividends and they tend to smooth them over the cycle. There is a vast theoretical and empirical literature focused on the analysis of the various market frictions that may be behind this pattern. See Lintner (1956), Miller and Rock (1985), Dewenter and Warther (1998), La Porta et al. (2000), Allen and Michaely (2003), DeAngelo et al. (2009), and Leary and Michaely (2011), among others. There is, however, little agreement on why corporations really smooth dividends and what determines their propensity to smooth.

The joint consideration of several recent empirical studies points to the existence of a potential link between the dividend policies of euro area banks and the adjustment mechanisms through which they improved their capital ratios in the aftermath of the Great Recession. Based on the statement that retained earnings is the most important source of banks' own funds, Shin (2016) documents on the accumulated dividends and retained earnings during 2007-2014 for a sample of 90 euro area banks, to conclude that for certain eurozone countries, *"retained earnings would have been more than double what it was at the end of 2014, had profits been ploughed back into the bank."*

In addition, Cohen and Scatigna (2016) show that for the period 2009-2013 the euro area banking sector was boosting regulatory capital ratios, foremost via asset shrinking, while virtually the rest of the world was doing so, primarily by means of capital increases. This evidence is aligned with the main findings in Gropp et al. (2018). Taking the EBA 2011 capital exercise as a quasi natural experiment, these authors show that European banks which had to raise their core tier 1 capital ratios in response to the mentioned exercise did it by reducing their levels of risk-weighted assets rather than by increasing their levels of capital. More precisely, they engaged in asset shrinking rather than in risk reduction. A reduction in total assets that has been mainly attributed to a reduction in outstanding customer loans, with effects on the real economy.

The objective of this paper is to evaluate the effectiveness of dividend-based prudential regulation for banks in complementing the existing capital regulation in its aim of improving bank soundness, financial stability, and social welfare.<sup>2</sup>

The proposal for regulating bank dividends as a complement of capital requirements is not a new one. As argued in Acharya et al. (2012), *"The erosion of common equity was exacerbated by*

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<sup>2</sup>Basel III regulation states that credit institutions face no restrictions on their dividend policies provided that they comply with the minimum capital requirement plus the conservation buffer (10.5% of risk-weighted assets). Existing regulation says little about the adjustment mechanisms through which banks should meet their capital requirements.

*large scale payments of dividends, in spite of widely anticipated credit losses. Dividend payments represent a transfer from creditors (and potentially taxpayers) to equity holders in violation of the priority of debt over equity..Thus, an early imposition of regulatory sanctions against the paying of dividends (for instance, as part of an increasing “ladder of sanctions” that are based on market or common-equity based notions of bank leverage) may have an important place in the agenda for reform of the regulatory system”.*<sup>3</sup> Moreover, Goodhart et al. (2010) follow a two-period modeling approach to assess the impact of imposing dividend restrictions on the functioning of the interbank market. Acharya et al. (2017) provide theoretical rationale for the use of dividend restrictions for banks. Similarly, Admati et al. (2013) advocate dividend restrictions and capital conservation in bad times.

To the best of my knowledge, there hasn’t been developed any work in which a DSGE modeling approach is adopted to assess the relevance of bank dividend regulation as a macroprudential tool in a world of capital requirements. Existing theoretical work on bank dividend-based macroprudential regulation is limited and usually tends to focus on the particular case in which regulated institutions do not comply with capital legislation, disregarding the potential benefits of regulating bank payout policies, even when financial institutions meet their capital requirements.

On these grounds, and based on the available evidence, this paper attempts to contribute to fill this gap in the literature by developing a financial business cycle model which incorporates the following key features: (i) bank capital accumulation out of retained earnings, (ii) endogenous bank dividend policies, and (iii) a set of financial frictions that makes bankers to optimally adjust capital ratios through the retained earnings and credit supply channel in order to smooth dividends. Such imperfections impede aggregate financial and economic fluctuations to be optimal from a social welfare point of view.

Absent a broad consensus on this front, I opt to remain agnostic about the underlying causes behind dividend smoothing and only attempt to reproduce this pattern in a standard but simple manner. In particular, I allow for two mechanisms through which bank dividend smoothing can potentially take place in the model: (i) bankers’ preferences (which are represented by a CES utility function), and equity payout adjustment costs, in the spirit of Jermann and Quadrini (2012). These are, probably, two of the most widely followed approaches to generate a pattern of dividend smoothing in a simple DSGE model (see, e.g., Jermann and Quadrini 2012, Iacoviello 2015, and Begenau 2019).<sup>4</sup>

The first mechanism is consistent with a strand of literature arguing dividend smoothing relates

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<sup>3</sup>These authors carry out an empirical analysis based on U.S. banking data for the period 2007-2009 to draw some general conclusions and give specific recommendations on capital regulation.

<sup>4</sup>In this regard, it is relevant to highlight the aim of this model is not to carefully microfound dividend smoothing but rather to reproduce this pattern at an aggregate level, in order to focus the analysis on the effects of dividend-based macroprudential regulation.

to managers' preferences (see, e.g., Fudenberg and Tirole 1995 and Wu 2017). The second one is aligned with recent evidence suggesting payout policies based on dividend smoothing strategies are costly to corporations (Brav et al. 2005). Whether the pattern of dividend smoothing is generated by the banker's preferences or by the dividend adjustment cost function heavily depends on the parameterization of the two. As it will be discussed further, due to empirical and theoretical reasons, the model has been calibrated such that dividend smoothing is induced by bankers' preferences, implying the role played by the dividend adjustment cost function in this model is mostly limited to the specification and transmission of the proposed prudential regulation (and that its corresponding coefficient can be basically interpreted as a policy parameter).

In the same way Angelini, Neri and Panetta (2014) specify a target for dynamic capital requirements, the model incorporates a dynamic regulatory target for bank dividends. The main difference between their approach and the one followed in this paper is that, in this case, the extra cost bankers can incur when deviating from what shall be called the "dividend prudential target" (henceforth "DPT") is not taken as a deadweightloss. Rather, the paper assumes such cost takes the form of a penalty payment or sanction that is collected by the prudential authority and directly transferred as a net subsidy to the non financial sector of the economy. As it will be shown, under certain conditions this sanctions regime can be interpreted as an insurance scheme for the real economy.

The rest of the model builds on a number of recent contributions to the macro-finance literature which have been essential to shed light on the macroeconomic implications of financial interactions. The main role of the banking sector in this model is to allow for resource transfers between savers and borrowers. In the spirit of Bernanke et al. (1999), the presence of certain frictions enables financial intermediation activities to endogenously propagate and amplify shocks to the macroeconomy. As in Gertler and Karadi (2011) and Gertler and Kiyotaki (2010), bankers face a balance sheet constraint when obtaining deposits. In the tradition of Kiyotaki and Moore (1997), borrowers are constrained in their capacity to borrow by the value of their real estate collateral. Based on Iacoviello (2015), financial intermediaries face a similar type of borrowing constraint which can be interpreted as a capital adequacy restriction.<sup>5</sup> This assumption is important in order to focus the attention on the effects of a possibility not considered in the Basel III Accord. To regulate bank dividend policies even when credit institutions comply with capital requirements. The general structure of the model has its similarities to Gerali et al. (2010).

In a first stage, a stylized version of the model is presented to clearly identify the transmission

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<sup>5</sup>This capital adequacy constraint can be interpreted as the overall regulatory capital ratio bankers target internally. According to the evidence, such target ratio typically includes a buffer bankers maintain above the minimum capital requirement imposed by the financial regulator. Some of the factors that determine such buffer are profitability, risk, size and loan loss provisions.

channel through which the proposed policy rule complements capital ratios in the attainment of their goals. A quantitative exercise is carried out to show that simple dividend prudential targets which react to deviations of the credit-to-GDP gap call for procyclical, relatively more volatile bank dividends in order to smooth the financial cycle.

Then, the model is extended as in Iacoviello (2005). Incorporating an additional type of borrower (impatient households), physical capital and various types of exogenous shocks helps to improve the dynamics of the model and its matching to quarterly euro area data. As in Clerc et al. (2015), households own all existing financial and non-financial corporations in the economy. That allows me to carry out a sensible welfare analysis that restricts to households without neglecting any consumption capacity generated in the economy. Welfare-maximizing dividend prudential targets are shown to have important properties: (i) they are effective in smoothing financial and business cycles by means of less volatile bank retained earnings, (ii) they induce welfare gains associated to a Basel III-type of capital regulation<sup>6</sup>, (iii) they mainly operate through their cyclical component, ensuring that long-run dividend payouts remain unaffected, (iv) they are flexible enough so as to allow bank managers to optimally deviate from the target (conditional on the payment of a sanction), and (v) they are associated to a sanctions regime that acts as an insurance scheme for the real economy.

The paper is organized as follows. Section 2 presents empirical evidence on bank dividends and earnings in the euro area. Section 3 describes the basic model and identifies the transmission mechanism through which a dividend prudential target improves bank soundness and financial stability. Section 4 presents the extended model to improve the matching of the model to the data. Section 5 develops a quantitative exercise to assess the welfare effects of the proposed policy and its interactions with regulatory capital ratios. Section 6 concludes.

## 2 Patterns of Bank Dividends in the Euro Area

Figure 1 describes some of the key patterns of euro area bank dividends and their link with equity developments. Plotted financial data is at quarterly frequency and has been seasonally adjusted by means of the Tramo/Seats method. Financial data is from the Euro Stoxx Banks Index, SX7E.<sup>7</sup>

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<sup>6</sup>Countercyclical dividend prudential targets complement Basel III capital regulation through two main channels: (i) They tend to compensate the negative welfare effects induced by hikes in the regulatory capital ratios (through a more restrictive and relatively more volatile credit supply), and (ii) they reinforce the effectiveness of the CCyB in smoothing the business and the financial cycle.

<sup>7</sup>The Euro Stoxx Banks Index, SX7E, is a capitalization-weighted index. The largest stocks in the EMU banking sector are selected to weigh in the index according to their free-float market capitalization. As of October 31, 2018, the top ten components of the index (and their corresponding weights) were Banco Santander (16.42%), BNP Paribas (12.90%), ING Group (9.89%), BBVA (7.90%), Intesa Sanpaolo (7.73%), Societe Generale Group (6.36%), Unicredit (5.81%), Deutsche Bank (4.01%), KBC Group (3.87%), and Credit Agricole (3.41%).

Given the purpose of the paper, such composite index has been selected as a representative group of the euro area banking system for several reasons. First, it captures relatively well the performance of the sector since it is composed of large, listed banks that are leaders in their industry in terms of market capitalization. Second, given the size and interconnectedness of its members, it is a fairly good sample of banks to carry out systemic risk analysis. Third, the signalling power of dividends is more evident for the case of large, listed companies. Fourth, the constructed series are from data that is available and updated by Bloomberg.

Figure 1(a) plots the euro area annual GDP growth rate (secondary y-axis) and the dividend payout ratio of the SX7E for the period 2002:I-2018:II. The dividend payout ratio is defined as the total net dividend payout (including all cash type of dividends and excluding returns of capital and in-specie dividends) as a percentage of net profits. The payout ratio is notably countercyclical and it becomes more volatile in times of severe financial stress and economic downturn (2009 and 2012). According to the data reported by Bloomberg, in 2009:II, distributed earnings represented about 82.5% of net profits while they exceeded 100% of total earnings in 2012:II and 2012:III.

Figure 1(b) sheds light on the main underlying drivers of such pattern. Especially from 2009:I onwards, bank managers opted to smooth dividends over the cycle, paying high and stable amounts of dividends in cash even if net income for the period was negative. Overall, both variables are procyclical, while earnings are relatively more volatile than dividends. Earnings (net profits) have been represented according to two different measures of adjusted net income. However, both of them are based on the definition of operating income after provisions.<sup>8</sup> Due to certain events and regulatory changes, loan-loss provisioning increased in the aftermath of the financial crisis. Such provisions are crucial to understand the aggregate net losses incurred in certain quarters between 2011 and 2014.<sup>9</sup> Note that the spike of the dividend payout ratio in 2012:III relates to the July 2012 financial turmoil. Relying on the signalling role attributed to dividend policies, bankers maintained dividend payouts roughly stable despite the severe fall in earnings.<sup>10</sup>

Such a dividend policy has tangible implications for the composition and performance of bank

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<sup>8</sup>See Appendix A for details on data construction.

<sup>9</sup>Due to auditing purposes, banks tend to record an important part of their annual loss provisions in the fourth quarter. That becomes more obvious when looking at raw rather than seasonally-adjusted data on net income.

<sup>10</sup>The series presented in figure 1(b) may not necessarily coincide with the time series on the dividend payout ratio plotted in figure 1(a). Due to data availability, the former have been constructed as a simple sum of the SX7E members whereas the latter is a capitalization-weighted sum of the same group of banks. In addition, quarterly aggregate data on payout ratios should be taken with caution for at least two reasons: (i) For each quarter, the index can only incorporate information on members whose net profits for the period are strictly positive. Otherwise the payout ratio cannot be computed. (ii) The adjustments made to raw data on net income (denominator of the payout ratio) often vary across analysts. These adjustments can be quantitatively important, especially when considering a time series that accounts for a period of severe financial crisis and deep regulatory changes (in loan-loss provisioning rules, etc).



equity over the cycle and for the available adjustment mechanisms to meet the target capital ratio. Figure 1(c) plots total equity and retained earnings of the SX7E for the same period.<sup>11</sup> Not surprisingly, both aggregates are procyclical and highly correlated. Nonetheless, retained earnings are relatively more volatile, especially during economic downturns. Given that retained earnings is a core component of total equity, these patterns can be interpreted as suggestive evidence of two important findings. First, the adjustment in the face of shocks that affect banks' net profits is mainly borne by retained earnings (i.e., dividend smoothing). Second, retained earnings are an important driver of bank equity (and, hence, credit supply) falls during economic recessions.

All in all, these patterns suggest that bank managers assign a prominent signaling role to dividends. This becomes particularly clear in periods of financial stress. Consequently, retained earnings have to adjust severely. This evidence deserves especial attention from the policymaker. To the extent that issuing new equity in times of market stress and economic downturn can be particularly costly, this art of dividend policies may be crucial to understand the preference of euro area banks for meeting capital requirements through asset shrinking.

### 3 The basic model

Consider three types of agents who interact in a real, closed, decentralized and time-discrete economy in which all markets are competitive. Households work, consume, accumulate housing and invest their savings in one-period bank deposits. Entrepreneurs demand real estate capital and labor to produce an homogeneous final good. Due to a discrepancy in their discount factors, in the aggregate households are net savers whereas entrepreneurs are net borrowers. There are financial flows in equilibrium. Bankers intermediate financial resources by borrowing from households and lending to entrepreneurs. They devote the resulting net profit to do both; pay dividends (bankers' consumption) and meet the capital requirement by retaining earnings. For each type of agent, there is a continuum of individuals in the  $[0, 1]$  interval.

In the spirit of Iacoviello (2005), entrepreneurs and bankers are assumed to face borrowing constraints that are binding in a neighborhood of the steady state. Consequently, the first best is unattainable in equilibrium. Moreover, the presence of credit and equity payout adjustment costs potentially generates additional inefficiencies over the cycle. Such financial imperfections play two important roles: (i) they amplify the effects of exogenous shocks through the financial sector, and (ii) they open up the possibility of a welfare-improving public intervention.

The aim of this section is to identify the transmission mechanism through which the considered

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<sup>11</sup>As made available by Bloomberg, each of these time series is presented as the capitalization weighed sum of the SX7E members after having normalized individual data by the number of shares outstanding.

policy operates. In doing so, the paper evaluates its effectiveness in favouring financial stability by smoothing the credit cycle.

## 3.1 Main Features

### 3.1.1 Households (net savers)

Let  $C_{h,t}$ ,  $H_{h,t}$  and  $N_{h,t}$  represent consumption, housing demand and hours worked by households in period  $t$ . The representative household seeks to maximize the objective function

$$E_0 \sum_{t=0}^{\infty} \beta_h^t \left[ \log C_{h,t} + j \log H_{h,t} - \frac{N_{h,t}^{1+\phi}}{(1+\phi)} \right]$$

subject to the sequence of budget constraints

$$C_{h,t} + D_t + q_t(H_{h,t} - H_{h,t-1}) = R_{h,t-1}D_{t-1} + W_{h,t}N_{h,t}$$

where  $D_t$  denotes the stock of deposits,  $R_{h,t}$  is the gross interest rate on deposits,  $q_t$  is the price of housing and  $W_{h,t}$  the wage rate. Housing does not depreciate.  $\beta_h \in (0, 1)$  is the households' subjective discount factor,  $j$  is the preference parameter for housing services and  $\phi$  stands for the inverse of the Frisch elasticity. Each period, the representative household allocates its resources in terms of wage earnings, properties in the housing market and gross returns on total deposits between final consumption and investment in deposits and housing. The standard intertemporal and intratemporal optimality conditions can be derived from the first order conditions of the problem.

$$\frac{1}{C_{h,t}} = \beta_h R_{h,t} E_t \left( \frac{1}{C_{h,t+1}} \right) \quad (1)$$

$$\frac{q_t}{C_{h,t}} = \frac{j}{H_{h,t}} + \beta_h E_t \left( \frac{q_{t+1}}{C_{h,t+1}} \right) \quad (2)$$

$$\frac{W_{h,t}}{C_{h,t}} = N_{h,t}^\phi \quad (3)$$

Expression (1) is the Euler equation for consumption, which in this model determines the equilibrium interest rate on deposits. Equation (2) refers to the optimality condition for intertemporal substitution between consumption and housing demand. Expression (3) is the labor supply

schedule, relating real wages to the marginal rate of substitution between consumption and hours worked.

### 3.1.2 Entrepreneurs (net borrowers)

The representative entrepreneur chooses the trajectories of consumption  $C_{e,t}$ , housing  $H_{e,t}$ , demand for labor  $N_{h,t}$  and bank loans  $B_t$  that maximize

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \log C_{e,t}$$

subject to the sequence of budget constraints

$$C_{e,t} + R_{e,t}B_{t-1} + q_t(H_{e,t} - H_{e,t-1}) + W_{h,t}N_{h,t} + \Phi_e(B_t) = Y_t + B_t$$

where  $B_t$  stands for bank loans,  $R_{e,t}$  is the gross interest rate on loans, and  $\Phi_e(B_t) = \frac{\phi_e}{2} \frac{(B_t - B_{t-1})^2}{B^{ss}}$  is a quadratic loan portfolio adjustment cost, assumed to be external to the entrepreneur as in Iacoviello (2015). This cost discourages the entrepreneur from changing their credit balances too quickly, thereby contributing to match the empirical fact that bank credit varies slowly over time.  $Y_t$  is final output.  $B^{ss}$  is the steady-state value of  $B_t$  and  $\phi_e$  is the loans adjustment cost parameter.  $\beta_e \in (0, 1)$  is the subjective discount factor of the entrepreneur, which is assumed to be strictly lower than  $\beta_h$ , implying that, in equilibrium, households are net savers and entrepreneurs are net borrowers. Each period, the representative entrepreneur devotes her resources in terms of produced final output and loans to consume, repay its debt, remunerate productive factors and adjust credit demand.

The homogeneous final good is produced by using a Cobb-Douglas technology that combines labor and commercial real estate as follows:<sup>12</sup>

$$Y_t = H_{e,t-1}^v N_{h,t}^{1-v} \quad (4)$$

In addition, entrepreneurs are subject to

$$B_t \leq m_t^H E_t \left( \frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_{h,t} N_{h,t} \quad (5)$$

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<sup>12</sup>The specification of a production function in which real estate enters as an input has become common practice in the macro-finance literature. See, e.g., Iacoviello (2005 and 2015), Andrés and Arce (2012) and Andrés et al. (2013).

Expression (5) dictates that the borrowing capacity of entrepreneurs is tied to the value of their collateral. In particular, they cannot borrow more than a possibly time-varying fraction  $m_t^H$  of the expected value of their real estate stock. More precisely,  $m_t^H = m^H \varepsilon_t^{mh}$  is the exogenously time-varying loan-to-value ratio, where  $m^H \in [0, 1]$  and  $\varepsilon_t^{mh}$  follows a zero-mean AR(1) process with autorregressive coefficient equal to  $\rho_{mh}$  and i.i.d innovations  $e_{mh,t}$  that are normally distributed and have a standard deviation equal to  $\sigma_{mh}$ . Moreover, the borrowing constraint indicates that a fraction  $m^N \in [0, 1]$  of the wage bill must be paid in advance, as in Neymeyer and Perri (2005).<sup>13</sup>

As in Iacoviello (2015), entrepreneurs are assumed to discount the future more heavily than households and bankers. Formally,  $\beta_e = \frac{1}{\gamma \frac{1}{\beta_h} + (1 - \gamma) \frac{1}{\beta_b}}$ , an assumption that ensures the borrowing constraint is binding in a neighborhood of the steady state.<sup>14</sup>

The optimality conditions for housing and labor demand can be obtained from the first order conditions

$$\frac{1}{C_{e,t}} \left[ q_t - \left( 1 - \frac{\partial \Phi_e(B_t)}{\partial B_t} \right) m_t^H E_t \left( \frac{q_{t+1}}{R_{e,t+1}} \right) \right] = \beta_e E_t \left\{ \frac{1}{C_{e,t+1}} \left[ q_{t+1} (1 - m_t^H) + v \left( \frac{Y_{t+1}}{H_{e,t}} \right) \right] \right\} \quad (6)$$

$$\frac{1}{C_{e,t}} \left[ W_{h,t} + m^N W_{h,t} \left( 1 - \frac{\partial \Phi_e(B_t)}{\partial B_t} \right) - (1 - v) \frac{Y_t}{N_{h,t}} \right] = \beta_e E_t \left[ \frac{1}{C_{e,t+1}} m^N W_{h,t} R_{e,t} \right] \quad (7)$$

Equations (6) and (7) inform about the optimal intertemporal substitution schemes between consumption and demand of the corresponding productive factor. The way  $m_t^H$  and  $m^N$  enter in each of the optimality conditions shows that the collateral constraint introduces a wedge between the marginal productivity of the input and its price. Whereas credit adjustment costs only distort entrepreneurs' decisions in the transition dynamics, the presence of a borrowing constraint of the type (5) does not only generate inefficiencies in the transition but also in the steady state itself. To have a clear account of this phenomenon, the steady state expressions of (6) and (7) are presented

$$q = \frac{v}{\eta} \left( \frac{Y}{H_e} \right)$$

<sup>13</sup>Whitout loss of generality, this assumption is made for quantitative analysis-related reasons. It helps in shaping the steady state levels and transition dynamics of aggregate financial variables, particularly in a reduced form model of this kind.

<sup>14</sup>As it will be shown later,  $\beta_b$  is the discount factor of bankers and  $\gamma \in [0, 1]$  refers to their borrowing capacity expressed in terms of banks' total assets.

$$W_h = \frac{(1-v) Y}{\psi N_h}$$

where  $\eta = \frac{1}{\beta_e} \left[ 1 - \frac{m^H}{R_e} - \beta_e(1 - m^H) \right]$ , and  $\psi = \{1 + m^N [1 - \beta_e R_e]\}$ . It could be shown that, given the considered lower and upper bounds for  $m^H$  and  $m^N$  and the range of values typically proposed in the literature for the discount factors of borrowers and bankers, the following inequalities always hold in the steady state of this economy:  $\eta < 1$  and,  $\psi > 1$ . Compared to a frictionless economy, in the long-run equilibrium the commercial real estate-to-labor ratio is inefficiently low.

### 3.1.3 Bankers

Let  $d_{b,t}$  represent bank dividends (which are fully devoted to final consumption by bankers) in period  $t$ ;  $\sigma > 0$  be the elasticity of intertemporal substitution (EIS), and  $\beta_b < \beta_h$ . The representative banker seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_b^t \frac{1}{(1 - \frac{1}{\sigma})} d_{b,t}^{(1 - \frac{1}{\sigma})} \quad (8)$$

subject to

$$B_t = K_{b,t} + D_t \quad (9)$$

$$d_{b,t} + K_{b,t} - (1 - \delta)K_{b,t-1} = r_{e,t}B_{t-1} - r_{h,t-1}D_{t-1} - \Phi_b(B_t) - \varphi(d_{b,t}) \quad (10)$$

$$D_t \leq \gamma B_t \quad (11)$$

Where equations (9), (10) and (11) denote the balance sheet identity, the sequence of cash flow restrictions, and the borrowing constraint of the banker, respectively.

According to (9), bank assets are financed by the sum of bank equity  $K_{b,t}$  (also referred to as bank capital) and debt. There is only one type of bank assets; one-period loans which are extended to entrepreneurs. Bank debt is entirely composed of funds borrowed by households in the form of homogeneous one-period deposits. The model assumes full inside equity financing, in the sense that bank equity is solely accumulated out of retained earnings. Formally, the law of motion for bank capital is similar to that of Gerali et al. (2010)

$$K_{b,t} = J_{b,t} - d_{b,t} + (1 - \delta)K_{b,t-1} \quad (12)$$

where  $J_{b,t}$  stands for bank net profits and  $\delta \in [0, 1]$  denotes the fraction of own resources the banker can no longer accumulate as bank capital in period  $t$  due to exogenous factors. Rearranging in expression (12), bank net profits can be decomposed into three parts:

$$J_{b,t} = \underbrace{\underbrace{(K_{b,t} - K_{b,t-1})}_{\text{reinvested profits}} + \underbrace{\delta K_{b,t-1}}_{\text{eroded equity}}}_{\text{retained earnings}} + \underbrace{d_{b,t}}_{\text{distributed earnings}} \quad (13)$$

where the term  $(K_{b,t} - K_{b,t-1})$  refers to the part of profits made in period  $t$  which are reinvested in the financial intermediation business, and  $\delta K_{b,t-1}$  is the fraction of bank own resources which, due to exogenous factors, cannot be further accumulated as bank capital into the next period. The term  $\delta K_{b,t-1}$  can be interpreted in several manners: (i) own resources the banker devotes to manage bank capital and to play its role as financial intermediary, or (ii) equity that erodes due to a variety of factors which are not explicitly accounted for in the model and which may relate to specific characteristics of capital such as its quality or its value.

The definition of bank equity as a stock variable that accumulates over time out of retained earnings is a crucial assumption due to empirical factors. First, an important proportion of total bank equity is accumulated out of retained earnings in practice (see figure 1c).<sup>15</sup> Second, equation (12) allows to map the model to first and second moments of data on bank dividends and earnings (see section 5).

Equation (10) is a flow of funds constraint which states that in each period the banker has to distribute net profits  $J_{b,t}$  between dividend payouts  $d_{b,t}$  and retained earnings. In the basic model, bank net profits are defined as the difference between net interest income and the corresponding credit and equity payout adjustment costs.<sup>16</sup>  $r_{e,t}$  and  $r_{h,t}$  denote the net interest rates on loans and deposits, respectively. As in Jermann and Quadrini (2012), the model assumes an equity payout adjustment cost of the type

$$\varphi(d_{b,t}) = \frac{\kappa}{2} (d_{b,t} - d_b^{ss})^2 \quad (14)$$

where  $\kappa \geq 0$  is the payout adjustment cost parameter, and  $d_b^{ss}$  the long-run payout target

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<sup>15</sup>In fact, it is the availability of (cumulative) retained earnings what allows bankers to pay dividends even when earnings for the period are non-positive.

<sup>16</sup>As in the case of the entrepreneur,  $\Phi_b(B_t) = \frac{\phi_b}{2} \frac{(B_t - B_{t-1})^2}{B^{ss}}$  is a quadratic loan portfolio adjustment cost and is assumed to be external to the banker.  $\phi_b \geq 0$  is the credit adjustment cost parameter.

(steady state). Given the preferences of the representative banker (i.e., represented by a CES utility function), there are two standard cases which can be labelled as representative of the two main alternative ways of accounting for the empirical regularity of dividend smoothing, under this set-up. When  $\lim_{\sigma \rightarrow \infty} u(d_{b,t}) = d_{b,t}$  and  $\kappa > 0$ , the modeling device represented by expression (14) generates a pattern of dividend smoothing.<sup>17</sup> Lintner (1956) found that managers have a dividend payout target and a fixed rate at which dividends should converge towards that target. While remaining agnostic about the underlying factors of dividend smoothing, assuming  $\varphi(d_{b,t})$  allows to capture the main macroeconomic implications of such phenomenon in a simple manner. At the individual level, bank managers face costs from deviating from a pre-determined payout target.<sup>18</sup> At the social level, it generates inefficiencies over the cycle.

By way of contrast, when  $\lim_{\sigma \rightarrow 1} u(d_{b,t}) = \log d_{b,t}$ , bankers' preferences already account for the empirical fact of dividend smoothing and the main role played by function (14) basically limits to allow for the proposed dividend-based regulatory scheme.<sup>19</sup> <sup>20</sup> Importantly, given the aim and scope of this paper, the calibration of the model presented in sections 3 and 5 of this paper falls within this general case.<sup>21</sup>

Expression (11) stipulates that bankers are constrained in their ability to issue liabilities. For a given period  $t$ , deposits cannot exceed a proportion  $\gamma \in [0, 1]$  of total assets. Given this expression is binding in a neighborhood of the steady state,  $(1 - \gamma)$  can be interpreted as the target capital ratio internally set by bankers.

The optimality condition for this maximization problem can be obtained after having rearranged and substituted in its three first order conditions.

$$\frac{(1 - \gamma) + \frac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t} - d_b^{ss})]} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma(R_{h,t} - \delta)}{d_{b,t+1}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t+1} - d_b^{ss})]} \right\} \quad (15)$$

Expression (15) stands for the optimality condition for intertemporal substitution between the

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<sup>17</sup>see, e.g., Jermann and Quadrini (2012), for a simple DSGE model with a financial friction, and Begenau (2019) for a DSGE model with a banking sector and capital requirements. See Brav et al. (2005) for some recent evidence suggesting payout policies based on dividend smoothing strategies are costly to corporations.

<sup>18</sup>An important empirical fact is that markets react negatively (positively) to announcements of dividend decreases (increases). See Allen and Michaely (2003).

<sup>19</sup>See, e.g., Iacoviello (2015), for a DSGE model in which bankers' preferences are modeled in this fashion. See, e.g., Fudenberg and Tirole (1995) and Wu (2017), for theoretical and empirical studies suggesting dividend smoothing relates to managers' preferences.

<sup>20</sup>The social costs of dividend smoothing can potentially take two forms in this model. First, the direct cost in terms of the resources devoted by bankers to deviate from the dividend target, which in the aggregate may be non-negligible (this type of inefficiency only emerges when  $\sigma$  is sufficiently small and  $\kappa > 0$ ). Second, the implicit social welfare cost in terms of increased volatility in financial aggregates (loans, deposits, etc) induced by forcing retained earnings to act as the main adjustment variable in the face of shocks that hit bank profits.

<sup>21</sup>See section 5 for a detailed discussion on the reasons underlying this approach.

part of net income devoted to the dividend payout policy (denominator) and that dedicated to the financial intermediation activity (numerator). The engine of the intertemporal activity of bankers is earnings retention. Importantly, bankers endogenously manage the size of their balance sheet and set the growth path of future expected profits (and, thus, of expected dividends) by controlling for retained earnings.

From the perspective of the banker as a consumer, expression (15) can be interpreted as the standard Euler equation for intertemporal substitution of consumption.<sup>22</sup> The term  $\frac{1}{d_{b,t}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t} - d_b^{ss})]}$  refers to the marginal utility of resources devoted to consumption in period  $t$ .<sup>23</sup> The terms in the numerator of each side of the equation account for all the different components involved in the expected gross return on marginal savings (via earnings retention) in period  $t$ . Recall from equations (9) and (11) that increasing equity by  $(1 - \gamma)$  units, automatically implies the borrowing of additional  $\gamma$  units of debt and the extension of an extra unit of loans. The latter implies paying a marginal cost for having adjusted the loan portfolio of  $\frac{\partial \Phi_b(B_t)}{\partial B_t}$  in period  $t$ . Then, it follows that  $(R_{e,t+1} - \delta)$  is the marginal revenue of lending,  $\gamma(R_{h,t} - \delta)$  the marginal cost of issuing debt, and  $(1 - \gamma)$  the marginal opportunity cost of equity (in terms of foregone marginal utility of dividends). In the optimum the banker is indifferent between devoting an extra unit of profits to paying dividends today and postponing such payment to the next period.

From the lens of the banker as a manager, it is optimal to invest (via earnings retention) up to the point in which the marginal cost of retaining an additional unit of net profits equalizes the marginal revenue of such investment. Expressed in terms of the opportunity cost (foregone marginal utility of dividends), the right-hand side of expression (15) informs about the discounted marginal gross lending spread the banker expects to obtain tomorrow as a consequence of having invested  $(1 - \gamma)$  units of retained earnings today.<sup>24</sup>

Given the interest rate on deposits, expression (15) determines the equilibrium interest rate on loans. Hence, the assumption by which  $\beta_b < \beta_h$  ensures that in the steady state,  $(R_{e,t+1} - \delta) - \gamma(R_{h,t} - \delta) > 0$ .

Equation (15) synthesizes the information of a powerful mechanism for transmission and amplification of shocks that hit bank profits. Absent the possibility of raising capital by issuing new equity (equation 12), the strong preference for dividend smoothing implicit in expressions (8) and (14) implies that the bulk of the adjustment to shocks that hit profits is going to be made via retained earnings. Due to the strong link between equity, loans and deposits (equations 9 and 11),

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<sup>22</sup>Recall that in the basic model bankers are both, owners and managers of the bank. As owners, in each period they receive a dividend payout which is fully devoted to final consumption within the same period.

<sup>23</sup>Which include the dividend payment and the equity payout adjustment cost.

<sup>24</sup>Again, by equations (9) and (11), such decision automatically involves borrowing additional  $\gamma$  units of deposits and lending an extra unit of assets.



such fluctuations in retained earnings are going to have an impact on the welfare of savers and borrowers through volatile deposits and loans, respectively.

### 3.1.4 Macroprudential Authority

In the baseline scenario, the only policy instrument the prudential authority has at hand is the constant capital requirement implied by equation (11). The regulator is assumed to have full control over the capital adequacy parameter  $\gamma$  from equation (11).

Consider an alternative policy scenario in which the capital requirement  $\gamma$  is complemented by a simple prudential rule on bank dividends

$$d_t^* = \rho_d + \rho_\chi \left( \frac{x_t}{x^{ss}} - 1 \right) \quad (16)$$

where  $d_t^*$  is what shall be called the dividend prudential target. This rule comprises a microprudential component,  $\rho_d$ , which is the equity payout targeted by the prudential authority in the absence of financial fluctuations, and a macroprudential component,  $\rho_\chi \left( \frac{x_t}{x^{ss}} - 1 \right)$ , that adjusts to tame the financial cycle.  $x_t$  is an aggregate the prudential authority closely monitors to detect potential signs of systemic risk and financial instability (e.g., the credit-to-output ratio), and  $x^{ss}$  its steady state value. Thus,  $\rho_\chi$  is the policy parameter that measures the degree of responsiveness of  $d_t^*$  to deviations of  $x_t$  from its steady state level (e.g., reaction to the so called credit-to-output gap).

As in Angelini, Neri and Panetta (2014), the macroprudential policy rule enters in the corresponding equity adjustment cost function (equation 14) as follows

$$\varphi^*(d_{b,t}^a) = \frac{\kappa}{2} (d_{b,t}^a - d_t^*)^2 \quad (17)$$

where  $d_{b,t}^a$  refers to the bank dividend payout in the alternative policy scenario. In period  $t$ , the following inequalities may hold:  $d_{b,t} \neq d_{b,t}^a$  and  $d_b^{ss} \neq d_t^*$ , implying  $\varphi(d_{b,t}) \neq \varphi^*(d_{b,t}^a)$ . Given that such adjustment cost differential would be triggered by policy intervention, the corresponding resources shouldn't be considered as a deadweight loss, but rather as a penalty bankers must pay to the public authority for having deviated from  $d_t^*$ . In the model, such public resources are transferred within the same period to the non financial sector of the economy. The net subsidy under consideration can be defined as follows

$$T_t = \frac{\kappa}{2} \left[ (d_{b,t}^a - d_t^*)^2 - (d_{b,t} - d_b^{ss})^2 \right] \quad (18)$$

As it will become more evident in the quantitative exercise, the net subsidy (18) can be positive or negative over the cycle and its size is proportional to the deviation of the representative banker,  $d_{b,t}^a$ , from the dividend prudential target,  $d_t^*$ .

Importantly, the transmission of macroprudential dividend regulation in this model mainly takes place through the optimality condition of the representative banker, which now reads

$$\frac{(1 - \gamma) + \frac{\partial \Phi_b(B_t)}{\partial B_t}}{(d_{b,t})^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t} - d_t^*)]} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma(R_{h,t} - \delta)}{(d_{b,t+1})^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t+1} - d_{t+1}^*)]} \right\} \quad (19)$$

Absent a dynamic dividend target, the banker finds optimal to react to exogenous shocks mostly by readjusting the variables that take part in the financial intermediation activity (numerator on each side of equation 15).<sup>25</sup> Under a dividend prudential target within the class (16), the regulator aims at discouraging bankers from making the adjustments via credit supply by means of more responsive bank dividends (denominator on each side of equation 19).

Without prejudice of the merit alternative specifications of dividend regulation may have, the regulatory scheme comprised of equations (16), (17), and (18) has been selected due to its properties, which will be commented upon in the quantitative exercise of this section.<sup>26</sup>

Dividend prudential targets are aimed at mitigating the potential negative macroeconomic effects of adjusting regulatory capital ratios and at enhancing the effectiveness of capital regulation as a macroprudential tool. Thus, it is reasonable to consider an additional policy scenario to assess the functioning of dynamic capital requirements in this model. In order to do so, the debt-to-assets ratio,  $\gamma$ , is augmented with a cyclical component

$$\gamma_t = \gamma + \gamma_x \left( \frac{x_t}{x^{ss}} - 1 \right) \quad (20)$$

where  $\gamma_x$  is the macroprudential policy parameter associated to the regulatory capital ratio implied by equation (20),  $(1 - \gamma_t)$ .  $x_t$  is the same macroeconomic indicator chosen for policy rule (16). Note that equations (11) and (15) are directly affected by this new policy environment.

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<sup>25</sup>In equations (17) and (18), variables under the alternative policy scenario have been denoted with superscript "a" to make clear that the following inequality may hold;  $d_{b,t} \neq d_{b,t}^a$ , for  $t = 0, 1, 2, \dots$ . For simplicity, such superscript has been omitted in other equations in which it would be applicable, such as expression (19).

<sup>26</sup>Alternatively, a regulatory scheme on bank dividends could be based either on distributed earnings taxation or on a linear restriction on dividend payouts (generally defined as an upper bound for dividend payments in terms of net profits).

### 3.1.5 Aggregation and market clearing

In equilibrium, all markets clear. In the case of the final goods market, the aggregate resource constraint dictates that the income generated in the production process is fully expended in the form of final private consumption, and banking expenditure devoted to adjust key financial aggregates and to manage the capital position of the bank,  $\delta K_{b,t-1}$  (also interpretable as eroded equity).<sup>27</sup>

$$Y_t = C_t + \delta K_{b,t-1} + \varphi(d_{b,t}) + \phi_b(B_t) + \phi_e(B_t) \quad (21)$$

where  $C_t$  denotes the aggregate consumption of the three agent types. Formally,  $C_t = C_{h,t} + C_{e,t} + d_{b,t}$ . Similarly, aggregate demand for housing equalizes supply. Housing supply is specified as a fixed endowment that is normalized to unity.

$$\bar{H} = H_{h,t} + H_{e,t}$$

## 3.2 Quantitative Exercise

Do dividend prudential targets contribute to financial stability by smoothing the financial cycle? To gain some insights into this matter, this paper analyzes the economy's response to a financial shock under alternative policy scenarios. In particular, the aim of this section is twofold. First, to clearly identify the transmission mechanism through which the proposed policy rule works. Second, to quantitatively assess the potential of dividend prudential targets to tame the credit cycle in the face of collateral shocks.

In order to do so, the paper follows Angelini, Neri and Panetta (2014), who assume the macroprudential authority seeks to minimize an ad hoc loss function with respect to the parameters of the policy rule. In following that approach, there is no attempt in presenting such an objective function as a welfare criterion, but rather as a measure of the potential the proposed policy rule has to prevent the build-up of macro-financial imbalances.

A utility-based welfare analysis will be carried out in section 5 for the extended model.

### 3.2.1 Calibration

The calibration is largely based on Gerali et al. (2010) and Iacoviello (2015). The households' discount factor is set to 0.9943, implying a steady-state interest rate on deposits slightly above 2

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<sup>27</sup>This specification of the resource constraint guarantees that the final goods market clears. The moments of the distribution function of final output,  $Y_t$ , as defined in expression (4) are identical to those of the same variable as defined in identity (21). The omission of any of the terms in the latter, including  $\delta K_{b,t-1}$ , would likely yield an excess supply in the mentioned market. See the technical appendix of Gerali et al. (2010) for a model in which bank capital evolves according to a similar law of motion as equation (12) and markets clearing requires  $\delta K_{b,t-1}$  to be interpreted as final expenditure and included in the resource constraint.

percent (2.3%). The discount factor of the entrepreneur is fixed to 0.94, within the range typically suggested in the literature for constrained consumers. The banker's discount factor,  $\beta_b$ , is chosen to ensure that the steady-state annualized lending rate to the private sector is roughly 5.6 percent, implying an annualized lending spread of 3.4%.

As in Iacoviello (2015), the weight of housing in the household's utility function is set to 0.075, the elasticity of production with respect to commercial housing,  $v$ , at 0.05, the loan portfolio adjustment cost parameter of entrepreneurs and bankers to 0.25, and the leverage parameter for the bank to 0.9. The latter implies a capital-asset ratio of 0.1, implying a positive capital buffer (over the minimum capital requirement of 0.08), as the evidence suggests. As in Jermann and Quadrini (2012), the dividend adjustment cost parameter,  $\kappa$ , is fixed to 0.426.

The loan-to-value ratio on housing,  $m_H$ , the intertemporal elasticity of substitution for consumption of bankers,  $\sigma$ , and the inverse of the Frisch elasticity of labor,  $\phi$ , are set to standard values of 0.7, 1, and 1.5, respectively.

The bank capital depreciation rate is calibrated at 0.034 so as to ensure the steady state dividend payout ratio is in the vicinity of 0.6, as the evidence for the SX7E index suggests.  $m_N$  is fixed to 0.5, implying a loan-to-output ratio of 1.9, as in the model estimated for the euro area in Gerali et al. (2010). The autocorrelation coefficient and the standard deviation associated to the housing collateral shock are obtained from the structural estimation of the same paper.

### 3.2.2 The Transmission Mechanism of Dividend Prudential Targets

Figure 2 plots the response of some key banking and financial aggregates to a unitary negative collateral shock.<sup>28</sup> Impulse responses are defined in terms of percentage deviations from the steady state and the solid line refers to the baseline scenario. The shock triggers a credit crunch that negatively affects bank net profits. In line with the evidence shown in section 2, dividends and retained earnings fall during the bust (i.e., they are procyclical), being the former relatively less volatile than the latter. The dividend payout ratio is notably countercyclical since the adjustment is mainly borne by retained earnings.

The starred and dotted lines correspond to an economy in which the macroprudential authority solves the following problem with respect to the policy parameters of the dividend prudential target and the dynamic capital requirements, respectively

$$\arg \min_{\Theta} L^{mp} = \kappa_z \sigma_z^2 \quad \kappa_z > 0 \quad (22)$$

where  $\Theta$  refers to the vector of policy parameters with respect to which the policymaker solves

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<sup>28</sup>See Andrés et al. (2013) and Iacoviello (2015) for a detailed description and presentation of the macroeconomic effects of housing collateral shocks faced by entrepreneurs in similar set-ups of the economy. Section 5 of this paper discusses the main macroeconomic effects of the proposed prudential instrument to a variety of shocks.

the optimization problem and  $\sigma_z^2$  is the asymptotic variance of a macroeconomic indicator of the choice of the regulator. Due to its relevance in macroprudential policy decision-making,  $z_t$  has been chosen to be the loans-to-output gap. Based in the literature, the preference parameter  $\kappa_z$  is fixed to 1. In order to identify the optimal simple rule within the class (16) that solves (22), it has been searched over a multidimensional grid of parameter values, which can be defined as follows.  $\rho_d \in \{0 - 1\}$ ,  $\rho_x \in \{(-150) - 150\}$ . The choice of the search grid deserves a thorough explanation. First,  $\rho_d$  refers to the dividend payout targeted by the prudential authority in the steady state. Taking that into account and normalizing the values for  $\rho_d$  by expressing them in terms of steady state bank profits, it is reasonable to assume that its optimized value will lie somewhere between 0 and 1 (0 refers to the case in which all profits are retained and 1 to that in which steady state profits are fully distributed). Second, a wide grid of values for  $\rho_x$  has been chosen for several reasons. Firstly, the dynamics of this policy rule is largely unknown. Secondly, the combination of two potential drivers for dividend smoothing (log utility of bankers and equity adjustment costs) and a somewhat low baseline value for structural parameter  $\kappa$ , suggests the rule will have to be considerably responsive for bankers to optimally deviate from their long-run target.

There has been searched within the baseline calibration model. The values that correspond to the optimized policy rule are the following:  $\rho_d = 0.56$ ,  $\rho_x = 67.84$ . The optimal simple rule within the class (16) that solves (22) under full commitment calls for a countercyclical (i.e.,  $\rho_x > 0$ ) and highly responsive dividend prudential target and a steady state dividend payout slightly lower than the one targeted by bankers absent any dividend regulation.<sup>29</sup>

As figure 2 makes clear, such rule calls for highly procyclical, relatively more volatile bank dividends. Importantly, now bank dividends adjust more gradually towards its steady state level. The influence credit adjustment costs have on the prudential tool through the credit-to-output ratio account for this effect. As a result of this, retained earnings and bank capital are less volatile than in the baseline scenario. As retained earnings, dividends are now a key adjustment variable as well. Thus, the hike in the dividend payout ratio becomes less pronounced during the bust phase. Given the linear relationship between equity and loans implied by equations (9) and (11), the policy is effective in taming the credit cycle.

For the sake of comparison between the workings of prudential policy rules (16) and (20), consider a third scenario in which the macroprudential authority solves (22), but this time with respect to the parameters of policy rule (20),  $\gamma$  and  $\gamma_x$  (dotted line). The selected grid of parameter values can be defined in the following manner.  $\gamma \in \{0.85 - 0.92\}$ ,  $\gamma_x \in \{(-1) - 1\}$ . The grid for  $\gamma$  implies a sensible range of values for the capital ratio between the minimum capital requirement (i.e., 0.08) and a regulatory capital ratio of 0.15. The grid for  $\gamma_x$  is based upon the Basel III Accord and has been chosen to assess whether the optimized capital buffer in this model is countercyclical

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<sup>29</sup>Recall that the baseline calibration implies a dividend payout ratio of roughly 0.6.

(i.e.,  $\gamma_x < 0$ ) or not. The optimized policy rule within the class (16) that solves (22) under full commitment corresponds to:  $\gamma = 0.895$ ,  $\gamma_x = -0.380$ .<sup>30</sup> As shown in figure 3, this policy (dotted line) smooths credit supply and the loans-to-output gap.<sup>31</sup>

However, the mechanisms triggered by each of the two macroprudential rules under examination are different. Under an optimized dynamic capital requirement, bankers have to meet a lower target capital ratio. Hence, the adjustment in retained earnings to smooth dividends is even more pronounced than in the baseline scenario. Loans volatility is reduced by the relative substitution of equity for debt induced by the countercyclical capital buffer (CCyB).<sup>32</sup> In contrast, the credit smoothing attained through the optimized dividend prudential target builds on less volatile retained earnings and bank equity.

Table 1 summarizes the results of the solution to problem (22), for a variety of arguments for the loss function,  $\sigma_z^2$ . Part (i) of the table presents the prudential losses for a variety of loss functions, under the baseline scenario. Part (ii) reports the results of the solution to the mentioned problem when optimizing with respect to  $\rho_d$  and  $\rho_x$ . Part (iii) presents the results of the solution to the same problem but only when having optimized with respect to  $\rho_x$ . Several conclusions are worth mentioning. First, the kind of dividend-based macroprudential rule that promotes financial stability is robust across macroeconomic indicators,  $z_t$ . The optimized rule within the class (16) that smooths the financial cycle is countercyclical and notably responsive.<sup>33</sup> Second, dividend prudential targets aimed at promoting financial stability mainly operate through their cyclical component.<sup>34</sup>

The quantitative exercise helps to identify several properties of the optimized dividend prudential target. (i) It is effective in smoothing the credit cycle by means of a countercyclical, highly responsive dividend prudential target that ensures the main burden of the adjustment is no longer borne by retained earnings. (ii) It is flexible in the sense that it allows bankers to optimally deviate from the target.<sup>35</sup> As noted in figure 3, bankers optimally choose dividends to be considerably less volatile than the dividend prudential target. (iii) It is associated to a sanctions regime that

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<sup>30</sup>In order to ensure that I have found a global minimum in each of the two optimization problems, I have selected different tuples of initial conditions. Optimized parameter values remain the same regardless of the initial guess.

<sup>31</sup>Given the objective of the prudential authority (i.e., to solve (22)), the optimized rule within the class (20) mainly operates through its cyclical component,  $\gamma_x$ .

<sup>32</sup>Note that in this model, during the bust phase, the action of the CCyB by which the target capital ratio descends, automatically implies an increase in the leverage ratio.

<sup>33</sup>Interestingly, when optimizing only with respect to  $\rho_x$ , the parameter value that solves problem (22) coincides for most of the considered macroeconomic indicators,  $z_t$ , ( $\rho_x = 54.96$ ).

<sup>34</sup>Note that the differences in terms of macroprudential losses between solving the optimization problem with respect to  $\rho_d$  and  $\rho_x$ , and solving it only with respect to  $\rho_x$  are small.

<sup>35</sup>In the model, this property is important to ensure that a balance between the social benefits from credit smoothing and the cost for bankers of higher dividend volatility is optimally stricken. In practice, this kind of flexibility could be decisive in order for the regulatory scheme to be implementable. Allowing for deviations permits bankers to manage additional risks which are not considered in this model (e.g., the risk of a severe fall in the equity price in response to a regulatory induced cut in dividends).

acts as an insurance scheme for the real economy.<sup>36</sup> (iv) It mainly operates through its cyclical component, allowing for tangible effects without having to affect long-run dividend payouts.<sup>37</sup> (v) As shown in figure 3, it is more effective than a standalone optimized capital rule of the type (20) in smoothing the credit cycle (measured by the asymptotic variance of the credit gap and the credit-to-output gap), as well as in promoting bank soundness (proxied by the asymptotic variance of bank equity).

## 4 Extended Model

In order to improve the dynamics of the model and its mapping to the data, the model is extended in three main directions. First, a second type of household with a lower subjective discount factor is incorporated into the model. Thus, two types of households coexist, one being net savers (patient households) and the other one being net borrowers (impatient households). In equilibrium bank loans are now extended to credit constrained households and entrepreneurs. Second, the model allows for physical variable capital. Capital-good-producers sell their output to entrepreneurs, who use it as an input in the productive process. Third, additional shocks are considered to allow for a more comprehensive analysis of dividend prudential targets.

Importantly, in this version of the model households are the owners of all existing firms: final-good-producing firms (entrepreneurs), banks and capital-good-producing firms. As in Clerc et al. (2015) and Mendicino et al. (2018), this approach permits to restrict the welfare analysis to households without neglecting any consumption capacity generated in the economy.

The specification of preferences has also been revised for all types of agents: (i) Households in the extended model are assumed to have GHH preferences (see Greenwood et al. 1988). This type of preferences has been extensively used in the business cycle literature as a useful device to match several empirical regularities. Their main difference when compared to log preferences, as assumed in the basic model, is that consumption and leisure are non-separable and wealth effects on labor supply are arbitrarily close to zero.<sup>38</sup> (ii) By generalizing log utility functions of entrepreneurs and

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<sup>36</sup>As noted in figure 2, the net subsidy (equation 18) associated to the optimized dividend prudential target is countercyclical. That is to say, their recipients (households and/or entrepreneurs) benefit from a positive payment when the marginal utility of their consumption is relatively high.

<sup>37</sup>This result has important implications. Optimizing (regulating) only with respect to the cyclical component of the dividend-based rule ensures that in the steady state: (i) the dividend payout and the welfare of bankers are not negatively affected, and (ii) equations (17) and (18) are equal to zero.

<sup>38</sup>See Jaimovich and Rebelo (2009) for a generalization of GHH preferences and Galí (2011) for a similar specification of individual preferences that permits to control for the size of wealth effects. Schmitt-Grohé and Uribe (2012) present evidence suggesting that wealth effects on labor supply are practically zero. As in this paper, GHH preferences have been formulated by other authors when evaluating macroprudential policies, in order to prevent a counterfactual increase in labor supply during crises (see, e.g., Bianchi and Mendoza 2018).

bankers to CES utility functions, corresponding elasticities of intertemporal substitution can be calibrated to match the second moments of dividends.

This section only discusses the main changes the extended model incorporates, with respect to the basic version under the baseline scenario. The full set of equilibrium equations that includes the policy block, can be found in Appendix B.

## 4.1 Overview of the Model

### 4.1.1 Households

Impatient households discount the future more heavily than patient ones, implying  $\beta_i < \beta_p$ . In the extended model the representative household maximizes

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t \left[ \frac{1}{1 - \sigma_h} \left( C_{\varkappa,t} - \frac{N_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} + \varepsilon_t^h j \log H_{\varkappa,t} \right] \quad (23)$$

where  $\varkappa = p, i$  denotes the type of household the problem refers to.  $\sigma_h$  stands for the risk aversion parameter of households and  $\varepsilon_t^h$  is an exogenous preference shock for housing demand. Shocks in the extended model have the same properties as the one presented in the basic version.

**Patient households (net savers)** In the case of patient households, the maximization of (23) is restricted to the sequence of budget constraints

$$C_{p,t} + D_t + q_t(H_{p,t} - H_{p,t-1}) = R_{d,t-1}D_{t-1} + W_t N_{p,t} + \omega_b d_{b,t} + \chi T_t + \omega_e d_{e,t} \quad (24)$$

where  $d_{e,t}$  refers to earnings distributed by entrepreneurs.  $\omega_b$  is the fraction of banks owned by patient households and  $\omega_e$  the proportion of entrepreneurial firms owned by the same agent type.  $\chi$  is the fraction of net subsidy they receive from the prudential authority, which is considered to be equal to the stake of banks they own (i.e.,  $\chi = \omega_b$ ). That is, the degree of "insurance" received by households is assumed to be proportional to their exposure to the increased bank dividend volatility triggered by the dividend prudential target. This is relevant for the alternative policy scenario, in which the following inequality may hold,  $T_t \neq 0$ .

**Impatient households (net borrowers)** As a net borrower, the representative impatient household is restricted not only by a sequence of budget constraints but also by a borrowing limit.



$$\begin{aligned}
C_{i,t} + R_{i,t-1}B_{i,t-1} + q_t(H_{i,t} - H_{i,t-1}) + \Phi_i(B_{i,t}) \\
= B_{i,t} + W_t N_{i,t} + (1 - \omega_b)d_{b,t} + (1 - \chi)T_t + (1 - \omega_e)d_{e,t}
\end{aligned} \tag{25}$$

$$B_{i,t} \leq m_{i,t}^H E_t \left[ \frac{q_{t+1}}{R_{i,t}} H_{i,t} \right] \tag{26}$$

Each period, impatient households devote their available resources in terms of wage earnings, loans, distributed earnings, and the corresponding net subsidy; to consume, repay their debt, demand housing real estate and adjust their loan portfolio. As it was the case for entrepreneurs in the basic model, the borrowing capacity of impatient households is tied to the expected value of their housing property. Such collateral is hit by an exogenous shock,  $m_{i,t}^H$ .

#### 4.1.2 Entrepreneurs

Let  $\Lambda_{0,t}^e = \left[ \omega_e \beta_p \frac{\lambda_{t+1}^p}{\lambda_t^p} + (1 - \omega_e) \beta_i \frac{\lambda_{t+1}^i}{\lambda_t^i} \right]$  be the stochastic discount factor of entrepreneurs (managers), with  $\lambda_t^p$  and  $\lambda_t^i$  being the Lagrange multipliers of the patient and impatient households' optimization problems, respectively. Then, the representative entrepreneur maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \frac{1}{(1 - \frac{1}{\sigma})} d_{e,t}^{(1 - \frac{1}{\sigma})} \tag{27}$$

subject to the sequence of budget constraints, the available technology and the corresponding borrowing limit

$$d_{e,t} + R_{b,t}B_{e,t-1} + q_t^k [K_{e,t} - (1 - \delta_t^k)K_{e,t-1}] + q_t(H_{e,t} - H_{e,t-1}) + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t} \tag{28}$$

$$Y_t = A_t (u_t k_{e,t-1})^\alpha H_{e,t-1}^\eta N_t^{(1 - \alpha - \eta)} \tag{29}$$

$$B_t \leq m_{e,t}^H E_t \left( \frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_{h,t} N_{h,t} \tag{30}$$

Note the three differences of this optimization problem compared to the one presented in the

previous section. First, Owners and managers of final-good-producing firms are no longer the same agent. Second, entrepreneurs also face a technology shock,  $A_t$ . Third, in order to produce final goods, the available technology does not only combine labor and commercial real estate but also variable physical capital. As in Schmitt-Grohé and Uribe (2012), the depreciation rate of physical capital is an increasing and convex function of the rate of capacity utilization. In particular:

$$\delta_t^k(u_t) = \delta_0^k + \delta_1^k(u_t - 1)^2 + \frac{\delta_2^k}{2}(u_t - 1)^2 \quad (31)$$

### 4.1.3 Bankers

Similarly,  $\Lambda_{0,t}^b = \left[ \omega_b \beta_p \frac{\lambda_{t+1}^p}{\lambda_t^p} + (1 - \omega_b) \beta_i \frac{\lambda_{t+1}^i}{\lambda_t^i} \right]$  stands for the stochastic discount factor of bankers. Bank managers seek to maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^b \frac{1}{(1 - \frac{1}{\sigma})} d_{b,t}^{(1 - \frac{1}{\sigma})} \quad (32)$$

subject to a balance sheet identity, a sequence of cash flows restrictions, and a borrowing constraint, respectively

$$B_{it} + B_{e,t} = K_t + D_t \quad (33)$$

$$d_{b,t} + K_{b,t} - (1 - \delta_t)K_{b,t-1} = r_{e,t}B_{e,t-1} + r_{i,t-1}B_{i,t-1} - r_{d,t-1}D_{t-1} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - \varphi(d_{b,t}) \quad (34)$$

$$D_t = \gamma_i B_{i,t} + \gamma_e B_{e,t} \quad (35)$$

As for the case of entrepreneurs, in the extended model there is a separation between ownership and management of banks. The loan portfolio is composed of two types of assets,  $B_{i,t}$  and  $B_{e,t}$ , which may differ in two aspects: (i) their associated capital requirements,  $\gamma_i$  and  $\gamma_e$ , and (ii) their respective adjustment cost parameter.  $\delta_t = \delta \varepsilon_t^{kb}$  denotes a possibly time-varying erosion rate of bank equity, where  $\delta \in [0, 1]$  and  $\varepsilon_t^{kb}$  is an exogenous shock.<sup>39</sup> As it will be discussed in section

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<sup>39</sup>  $\varepsilon_t^{kb}$  is a bank capital shock similar to the one considered in Gerali et al. (2010). However, in this paper I assume that  $\varepsilon_t^{kb}$  hits eroded bank equity,  $\delta_t K_{b,t-1}$ , rather than uneroded bank capital,  $(1 - \delta_t)K_{b,t-1}$ . Since the term  $\delta_t K_{b,t-1}$  enters in the resource constraint, this is an important consideration in order to ensure that all statistical moments of output as defined in equation (29) are identical to those of the same variable as defined in identity (40) and, thus to guarantee that the model is "properly closed".

5, combined with that of the preference parameter  $\sigma$ , the calibration of the size of this shock is important to match the empirical relative volatilities of bank earnings and dividends.

Importantly, the solution to this optimization problem yields two optimality conditions analogous to expression (15), one for each asset class.

#### 4.1.4 Capital goods producers

At the beginning of each period, capital producers demand an amount  $I_t$  of final good from entrepreneurs, which combined with the available stock of capital, allows them to produce new capital goods. Capital producers choose the trajectory of net investment in variable capital,  $I_t$ , that maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e (q_{k,t} \Delta x_t - I_t) \quad (36)$$

subject to

$$x_t = x_{t-1} + I_t \left[ 1 - \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \quad (37)$$

where  $\Delta x_t = K_{e,t} - (1 - \delta_t^k) K_{e,t-1}$  is the flow output.  $S \left( \frac{I_t}{I_{t-1}} \right) = \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2$  is an investment adjustment cost function, whose formulation has become standard in the literature (see, e.g., Christiano et al. 2005 and Schmitt-Grohe and Uribe 2012) due to empirical reasons. The maximization of (36) permits to derive a market price for capital,  $q_{k,t}$

$$1 = q_{k,t} \left[ 1 - \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 - \psi_I \left( \frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} \right] + E_t \left[ \Lambda_{0,t}^e q_{k,t+1} \psi_I \left( \frac{I_{t+1}}{I_t} - 1 \right) \left( \frac{I_{t+1}}{I_t} \right)^2 \right] \quad (38)$$

The usual law of motion for physical capital holds

$$K_{e,t} = (1 - \delta_t^k) K_{e,t-1} + I_t \left[ 1 - \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \quad (39)$$

### 4.1.5 Aggregation and market clearing

By the Walras' law, all markets clear . The aggregate resource constraint of the economy represents the equilibrium condition for the final goods market.

$$Y_t = C_{p,t} + C_{i,t} + q_t^k I_t + \delta_t K_{b,t-1} + Adj_t \quad (40)$$

where the term  $Adj_t$  corresponds to the sum of all resources dedicated in the economy to adjust loans and bank dividends in period  $t$ . Similarly, in equilibrium labor demand equals total labor supply,

$$N_t = N_{p,t} + N_{i,t} \quad (41)$$

Even if loans to impatient households and to entrepreneurs may be related to some external differences, they are homogeneous across agents. Thus, in equilibrium

$$B_t = B_{i,t} + B_{e,t} \quad (42)$$

In equilibrium, the housing market clears

$$\bar{H} = H_{p,t} + H_{i,t} + H_{e,t} \quad (43)$$

## 5 Quantitative Analysis

### 5.1 Calibration

I follow a three-stage strategy in order to calibrate the model to quarterly euro area data for the period 2002:I-2018:II. <sup>40</sup>In a first step, I pre-set some parameter values that have become standard in the business cycle literature (table 2A). Then, I calibrate a second group of parameters by using key steady state ratios and first moments of the data (table 2B). Lastly, I simulate the model to calibrate a third group of parameters so as to match certain second moments of the data (table 2C).

First, several parameters are set following convention. Some of them are standard in the literature. Some others are based on papers in the field of macro-finance. The inverse of the Frisch elasticity of labor is set to a value of 1, whereas the risk aversion parameter of household

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<sup>40</sup>All time series expressed in Euros are seasonally adjusted and deflated. With regards to second moments matching, the log value of deflated time series has been linearly detrended before computing standard deviation targets. All details on data description and construction are available in Appendix A.

preferences is fixed to a standard value of 2. Loan-to-value ratios on housing (for both, households and entrepreneurs) are set equal to 0.7. These values are based on data of the big four euro area economies and coincide with those presented in Gerali et al. (2010), and Quint and Rabanal (2014), among others. Regarding the dynamic depreciation rate of physical capital  $\delta_t^k$ ;  $\delta_0^k$  is fixed to a standard value of 0.025 while, following convention,  $\delta_1^k$  and  $\delta_2^k$  are defined as specific fractions of the steady state interest rate on physical capital. As in Jermann and Quadrini (2012), the equity payout cost parameter  $\kappa$  is set to 0.426. The adjustment cost parameter value for corporate loans coincides with that obtained in the structural estimation by Iacoviello (2015).

Second, another group of parameters is calibrated by using steady state targets. The patient households' discount factor,  $\beta_p = 0.9943$ , is chosen such that the annual interest rate equals 2.3%. The impatient households' discount factor is set to 0.95, in order to generate an annualized bank spread of 3.4%.<sup>41</sup> Household weights on housing utility,  $j_p$  and  $j_i$ , have been calibrated to match the savers-to borrowers housing ratio and the household loans-to-GDP ratio, respectively. Patient households are assumed to own all the entrepreneurial and capital-producing firms of the economy,  $\omega_e = 1$ , while impatient households own all the banks,  $\omega_p = 0$ . This assumption is based on the following reasons. (i) They are chosen to match a corporate loans-to-GDP ratio of 175.3% and a weight of corporate loans on total credit of 0.451, respectively. (ii) It permits to limit the welfare analysis to two types of agents (henceforth referred to as savers and borrowers) while fully separating by agent types the two key sources of business cycle costs triggered by optimized dividend prudential targets.<sup>42</sup> <sup>43</sup> <sup>44</sup> The shares in final-good-production of physical capital  $\alpha$  and commercial real estate  $\eta$  are set to match an investment-to-GDP ratio of 21.19% and an aggregate real estate wealth-to-annual output of 280.2%, respectively.

With regards to bank parameters, it shall be proceeded as follows. The depreciation rate of bank capital  $\delta$  is set to 0.041, which is consistent with a payout ratio of 0.563, in line with the

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<sup>41</sup>In order to compute the annualized bank spread,  $(r_b^{ss} - r_d^{ss})$ ,  $r_b^{ss}$  has been defined as the average of the steady state rates on household and corporate loans, each of them weighted by the proportion of total loans it represents. Steady state interest rates are the only targets that have not been obtained from updated euro area data but from the constructed series in Gerali et al. (2010).

<sup>42</sup>As it will be discussed in the welfare analysis that follows, two negative welfare effects induced by dividend-based rules have to be weighted with the positive effects derived from financial smoothing. On the one hand, bank owners suffer from an increased volatility in bank dividends. On the other hand, entrepreneurial-firm owners face a "loan portfolio readjustment effect" by which supply for corporate loans tends to be partially substituted for household loans due to the higher capital requirement they are associated to.

<sup>43</sup>Importantly, the assumption by which borrowers are allowed to own part of the entrepreneurial firms and banks in the model rests on empirical evidence confirming that a fraction of the households holding shares are indebted.

<sup>44</sup>In addition, the proposed set up does not allow for savers to own all entrepreneurial firms and banks. Were they owners of all banks, the relationship between  $\beta_p$  and  $\Lambda_{0,t}^b$  would be such that there would not be positive financial flows in equilibrium. Alternative set ups have been proposed in the literature to allow savers to be owners of all firms in the economy (see, e.g., Gertler and Kiyotaki 2010, Gertler and Karadi 2011, and Clerc et al. 2015). However, in order for these approaches to be applicable, these authors have to make assumptions implying that dividend payout ratios are constant and (usually) very low. A result that is sharply at odds with reality and which does not permit to carry out the type of analysis proposed in this paper.

evidence of the SX7E banks' index presented in section 2. Note that after having rearranged in the steady state expression of equation (12)

$$\frac{d_b}{J_b} = 1 - \frac{\delta K_b}{J_b}$$

from which the influence parameter  $\delta$  has on the steady state payout ratio becomes evident. The calibrated values of the complementaries of capital requirements on household loans  $\gamma_i$  and corporate loans  $\gamma_e$  are obtained by solving a system of two linear equations

$$0.895 = \gamma_i \frac{B_i}{B} + \gamma_e \frac{B_e}{B} \quad (44)$$

$$(1 - \gamma_e) = 2.1176(1 - \gamma_i) \quad (45)$$

Equation (44) is the result of equating the steady state leverage ratio to 0.895 after having normalized expression (35) to total loans. Its interpretation is straightforward. The equilibrium capital requirement is a weighted average of the two sectorial capital requirements,  $(1 - \gamma_e)$  and  $(1 - \gamma_i)$ , and it has been set to 0.105. Such value has been chosen for empirical and regulatory reasons. (i) It is similar to the pre-crisis historical average of regulatory capital ratios. (ii) According to existing capital legislation, in general terms, the authority cannot impose any restriction on dividend payouts as long as the bank meets the minimum capital requirement (0.08) plus a conservation buffer of 0.025.

Expression (45) indicates that the capital requirement on corporate loans is slightly more than two times that on household loans. This is exactly the same proportion held by these two sectorial ratios according to the IRB-based calibration presented in Mendicino et al. (2018). For simplicity, a 100% risk weight has been assumed for each of the two asset types.<sup>45</sup> Table 3 offers an overview of selected target ratios that have been considered when calibrating the model.

Third, the size of shocks and certain adjustment cost parameters are calibrated to improve the fit of the model to the data in terms of relative volatilities (see tables 2C and 4). The investment adjustment cost parameter  $\psi_I$  is set to target a relative standard deviation of investment of 2.642%. The adjustment cost parameter on household loans  $\phi_i$  is fixed to a value of 0.504, thereby: (i) favoring corporate loans to be relatively more volatile than household loans, as supported by the evidence in the euro area (recall that corporate loans parameter  $\phi_e$  has been pre-set to 0.06), and (ii) roughly matching the relative volatility of bank assets.

I have matched the second moments of bank dividends and earnings (and, thus, accounted

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<sup>45</sup>This assumption is reasonable. As the Capital Requirements Regulation (EU) stipulates, exposures to corporates with an "average" credit rating or for which no credit assesment is available, shall be assigned a 100% risk weight. Unless certain conditions are met, exposures fully secured by a mortgage on immovable property shall also be assigned a risk weight of 100 %.

for the phenomenon of dividend smoothing) mostly by calibrating the elasticity of intertemporal substitution (EIS) of bankers and the size of the bank capital shock. Several important considerations are worth noting in this regard. First, I have targeted the relative standard deviation of bank dividends by calibrating bankers' EIS rather than adjustment cost parameter  $\kappa$  for various reasons: (i) I have found substantially more difficult to match such second moment with the latter than with the former.<sup>46</sup> (ii) Although a careful microfoundation of dividend smoothing is beyond the scope of this paper, assuming the origin of dividend smoothing to be related with individual preferences seems more reasonable than associating it to an external adjustment cost parameter. (iii) Given the values to which  $\sigma$  and  $\kappa$  have been fixed, dividend adjustment costs basically do not affect the dynamics of bank dividends or any other aggregates under the baseline scenario. Therefore, the role played by function  $\varphi(d_{b,t})$  under this calibration is basically limited to being an important part of the proposed regulatory scheme.<sup>47</sup> Second, calibrating the size of the bank capital shock is relevant to allow for dividends and earnings to be sufficiently volatile, while fixing the value of  $\sigma$  permits to create a wedge between the standard deviation of earnings and that of dividends.

As in the basic model, the autoregressive parameters of the five shocks that are present in the extended model correspond to the estimates proposed in Gerali et al. (2010).

## 5.2 Welfare Analysis

This section analyzes the main welfare consequences of complementing capital requirements with a dividend prudential target. Consider the expected life-time utility of savers and borrowers as the welfare criterion

$$V_0^\varkappa = E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U(C_{\varkappa,t}, H_{\varkappa,t}, N_{\varkappa,t}) \quad (46)$$

with  $\varkappa = p, i$ . The model is solved by using second-order perturbation techniques in Dynare (Adjemian et al. 2011). Unconditional lifetime utility is computed as the theoretical mean based on first order terms of the second-order approximation to the nonlinear model, resulting in a

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<sup>46</sup>Other authors have recently targeted second moments of aggregate dividends by calibrating parameter  $\kappa$  in a set up in which the objective function (i.e., bankers' preferences) is linear in dividends. Two examples are Jermann and Quadrini (2012), who calibrate  $\kappa$  by targeting the relative volatility of the dividends-to-GDP ratio (rather than dividends themselves), and Begenau (2019), who targets the relative standard deviation of US bank dividends, themselves.

<sup>47</sup>As a consequence, parameter  $\kappa$  could well be interpreted as an additional policy parameter. This is important to rule out a modeling of the economy in which the increased relative volatility of bank dividends induced by dividend prudential targets affects the value of parameter  $\kappa$ . Nevertheless, the welfare effects of the proposed rule are evaluated for alternative values of  $\kappa$  in the robustness checks exercise presented at the end of this section.

second-order accurate welfare measure (see e.g. Kim, Kim, Schaumburg, and Sims 2008). This approach ensures that the effects of aggregate uncertainty are taken into account.

Figure 3 plots the welfare effects of changing the value of parameter  $\rho_x$  in a policy rule of the type (16) while keeping  $\rho_d$  fixed at its baseline value.<sup>48</sup> There is a considerable range of  $\rho_x$  (positive) values for which both types of agents are better-off than under the baseline scenario. Interestingly, figure 3 makes clear that each agent class face a different trade-off, when being exposed to changes in  $\rho_x$ . Higher values of  $\rho_x$  are associated to less volatile financial aggregates (including deposits and aggregate loans), which improves welfare of savers and borrowers.

However, increasing  $\rho_x$  is not free of charge. A more responsive dividend prudential target leads to a higher bank dividend volatility, that negatively affects borrowers' welfare (as bank owners). In addition, changes in  $\rho_x$  modify the optimal composition of the representative banker's loan portfolio. Given that corporate loans are subject to higher capital requirements, a countercyclical dividend prudential target yields a "loan portfolio readjustment effect" by which bankers tend to increase the weight of household loans (in their balance sheet) at the expense of corporate ones. Such effect has a negative impact on savers' welfare (as owners of entrepreneurial firms).

Next, a normative approach is adopted to define a measure of social welfare and maximize it with respect to  $\rho_x$  in order to quantify the welfare gains of introducing an optimized dividend prudential rule. As in Schmitt-Grohe and Uribe (2007), welfare gains of agent type " $\varkappa$ " are defined as the implied permanent differences in consumption between two different scenarios. Formally, consumption equivalent gains can be specified as a constant  $\lambda_\varkappa$ , that satisfies

$$E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U(C_{\varkappa,t}^a, H_{\varkappa,t}^a, N_{\varkappa,t}^a) = E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U[(1 + \lambda_\varkappa) C_{\varkappa,t}^b, H_{\varkappa,t}^b, N_{\varkappa,t}^b] \quad (47)$$

where superscripts  $a$  and  $b$  refer to the alternative policy scenario (optimized prudential rules) and the baseline case, respectively. In addition, social welfare is defined as a weighted average of the expected lifetime utility of each agent class. Similar to the approach followed in Mendicino et al. (2018), social welfare maximization is subject to certain conditions. The solution: (i) must be a Pareto improvement relative to the baseline scenario, and (ii) it has to yield the same consumption equivalent gains for savers and borrowers, given a pre-set grid of values for  $\rho_x$ . Such grid is set as follows:  $\rho_x \in \{0 - 180\}$ .<sup>49</sup> Formally, the optimization problem under consideration reads

<sup>48</sup>Without loss of generality, the macroeconomic indicator  $x_t$  incorporated in prudential rule (16) has chosen to be final output,  $Y_t$ .

<sup>49</sup>Note in figure 3 that borrowers suffer from welfare losses for values of  $\rho_x$  approximately larger than 180.



$$\arg \max_{\Theta} V_0 = \zeta V_0^p + (1 - \zeta)V_0^i \quad (48)$$

$$s.t. \quad \lambda_p = \lambda_i$$

$$\lambda_p \geq 0, \lambda_i \geq 0$$

where  $\zeta \in [0, 1]$  is the weight of patient households' welfare and  $\Theta$  is the vector of policy parameters with respect to which the objective function is maximized. Problem (48) is also subject to all the competitive equilibrium conditions of the extended model.<sup>50</sup>

The optimized prudential rule within the class (16) that solves (48) is associated to  $\rho_x = 143.741$ , and  $\lambda_x = 0.002604$ . Table 5 reports the main results of shutting down, one-by-one, each of the shocks. The differences in welfare gains generated by shutting down a particular shock vary across shocks. Figure 4 plots the welfare impact of changing  $\rho_x$  for each agent class under the different shock scenarios considered in table 5. Some results are worth commenting. Given the solution to problem (48), the wedge in welfare gains created between savers and borrowers when shutting down non financial shocks (i.e., housing preference and technology shocks) is relatively large. The potential the proposed prudential rule has to smooth credit supply is relatively larger under housing preference shocks (than under any other shock), among other reasons, due to the relatively large size of these shocks under this calibration (see figures 9 to 13). That explains why shutting down this shock considerably deteriorates the welfare trade-off experienced by borrowers under a countercyclical dividend prudential target (i.e.,  $\rho_x > 0$ ). By way of contrast, shutting down technology shocks notably improves the welfare trade-off faced by borrowers under this regulatory scheme, since bank dividend volatility induced by countercyclical DPTs in the face of these shocks is notably larger than under any other shock. This strong response of dividend prudential targets triggers a smoothing effect on certain aggregates to the point that the correlation of output with some other variables (e.g., NFC loans) experiences a change in its sign. Savers benefit from the benchmark optimized DPT (i.e.,  $\rho_x = 143.741$ ), especially when the economy is hit by technology shocks; credit supply to entrepreneurs expands when financing is needed the most, during the downturn. Thus, shutting down this shock worsens the welfare trade-off faced by non-financial corporations' owners (i.e., savers).

The wedge in welfare gains created between savers and borrowers when shutting down financial

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<sup>50</sup>In particular, the only difference between the approach followed in Mendicino et al. (2018) and the one followed in this paper is that they search over the grid  $\zeta \in [0, 1]$  to find the value of the savers' welfare weight that solves the problem while this paper maximizes with respect to the policy parameter,  $\rho_x$ . By construction, given the approach followed here, social welfare gains are going to coincide with those of savers and borrowers regardless of the value  $\zeta$  takes.

shocks is more moderate. The proposed policy rule leads to positive welfare effects for both types of agents under financial shocks, although these effects tend to be quantitatively larger for the case of borrowers since they directly benefit from credit smoothing (while savers only indirectly benefit from that effect through their ownership of non-financial corporations).

### 5.2.1 Welfare Effects and Capital Requirements

Angeloni and Faia (2013), analyze optimized monetary policy rules under alternative Basel regimes. Inspired in their approach, this paper examines the welfare effects of optimized dividend-based macroprudential rules under alternative capital scenarios.

**Microprudential Capital Regulation** Absent a countercyclical dividend prudential target (baseline scenario), in this model an increase in the capital requirement affects welfare through two main transmission channels. On the one hand, non financial corporations and impatient households suffer from a more restrictive credit supply. From optimality condition (15), it follows that a higher capital requirement  $(1 - \gamma)$  in the left-hand side of the equation has to go hand in hand with an increase in the discounted marginal lending spread. The implied reduction in the debt-to-assets ratio does not account for the entire adjustment and bankers optimally reduce their credit supply to induce an increase in their loans rate. On the other hand, in a higher capital requirements scenario, bankers retain more earnings and benefit from an increased marginal lending spread. That allows them to attain a higher and smoother dividend payout (at the expense of a more volatile and restricted credit supply).

From the above explanation, it follows that an increase in capital requirements unambiguously leads to a negative welfare effect on savers (as owners of entrepreneurial firms), while borrowers have to face a welfare trade-off resulting from two conflicting effects. Subfigures in the left and right columns of figure 5 plot the welfare effects of changing the value of parameters  $\gamma_i$  and  $\gamma_e$  in a policy rule of the type (20), respectively. The range of  $\gamma_i$  and  $\gamma_e$  values for which the welfare functions of both agent classes have been plotted are based on the Basel III Accord as well as on results presented in the literature (see, e.g., Mendicino et al. 2018 and Begenau 2019). Ceteris paribus, the risk-adjusted capital ratio on HH loans,  $(1 - \gamma_i)$ , that maximizes borrowers' welfare corresponds to a value of 6.72%, which is close but below the one calibrated in the baseline scenario (7.05%). Ceteris paribus, the risk-adjusted capital ratio on NFC loans,  $(1 - \gamma_e)$ , that maximizes borrowers' welfare corresponds to a value of 13.68%, which is also close but below the one calibrated in the baseline scenario (14.92%).

Table 6(i) reports the welfare gains from increasing the capital ratio by 1 percentage point (from 10.5% to 11.5%) under two different scenarios in terms of dividend regulation. In the first

case, the hike in the capital ratio occurs absent any dividend regulation. Savers and borrowers suffer welfare losses induced by a more restrictive and volatile credit supply. Note, however, that the losses experienced by savers are considerably larger than those suffered by borrowers. As bank owners, borrowers benefit from higher and smoother dividend payouts, an effect that partially compensates the impact of the mentioned decline in loans supply. In the second case, the increase in the capital requirements is combined with the adoption of the dividend prudential target that solves (48) under the baseline capital scenario (i.e., scenario in which  $\gamma = 0.895$ ). The loans and deposits smoothing effect generated by the dividend-based rule helps in moderating the welfare losses experienced by savers. The combination of a higher dividend payout and a smoother credit supply ensures that borrowers benefit from the macroprudential policy mix.

The remainder of table 6 reports the welfare gains generated by the proposed policy rule under alternative capital scenarios, with and without reoptimizing with respect to  $\rho_x$ .<sup>51</sup> In particular, table 6(ii) evaluates the welfare implications of solving problem (48) for two capital scenarios alternative to the baseline (i.e.,  $\gamma = 0.895$ ).<sup>52</sup> Not surprisingly, the optimized countercyclical responsiveness of the dividend prudential target increases with the capital requirement. Higher capital ratios are associated to lower and more volatile credit supply. Thus, they increase the potential of dividend prudential targets to improve welfare. As noted in table 6(iii), this is particularly true for the case of borrowers. Given a pre-set value for  $\rho_x$  that implies a countercyclical and sufficiently responsive dividend prudential target (e.g.,  $\rho_x = 143.741$ ), increases in the capital ratio have particularly positive effects on the welfare of impatient households. This is so because they benefit from an improved trade-off. Given that the dividend-based rule is responsive enough so as to notably smooth loans, higher capital ratios induce higher dividend payouts and contribute to offset the dividend volatility generated by the policy rule under consideration.

Figure 6 plots the welfare effects of changing the value of parameter  $\rho_x$  in a policy rule of the type (16) while keeping  $\rho_d$  fixed at its baseline value, for the three above mentioned capital scenarios and for each of the two types of agents. The figure allows to differentiate between the welfare gains potentially attainable by means of a countercyclical DPT, for each capital scenario, and the welfare level associated to each capital scenario, for a given value of  $\rho_x$ . There are at least two considerations which deserve some discussion: (i) Even if savers' welfare level decreases in capital requirements, the shape of their welfare function remains approximately unchanged across capital scenarios, implying that sufficiently responsive, countercyclical DPTs are welfare increasing

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<sup>51</sup>There is an important difference between part (i) and parts (ii) and (iii) of table 6 which may not be noticeable in terms of reporting. In part (i) the capital ratio differs between the "alternative" and the "baseline scenario", whereas in parts (ii) and (iii) do not.

<sup>52</sup>The three considered capital scenarios (including the baseline) are inspired in the Basel III Accord. 0.08 refers to the minimum capital requirement. Adding the conservation buffer (0.025) to it yields a capital ratio of 0.105. As of November 2018, all euro area G-SIBS were required a surcharge lying between 0.01 and 0.02. For that reason, the paper considers a third scenario with a capital adequacy ratio of 0.12.

for the case of savers (regardless of the capital scenario). (ii) With respect to borrowers, figure 6 suggests that their maximum attainable welfare level (by means of a countercyclical DPT) is related to a capital ratio similar to the one calibrated in the baseline scenario. At the same time, however, higher capital requirements are associated to higher attainable welfare gains as well as to a larger range of  $\rho_x$  values for which countercyclical DPTs are welfare increasing. That is, countercyclical DPTs have the potential to complement existing capital regulation and to compensate the welfare costs of capital ratio increases in two main dimensions. First, they moderate the welfare costs capital increases unambiguously have for savers. Second, they have the potential to more than offset the welfare losses suffered by borrowers in the event of a capital requirements hike.

**Macroprudential Capital Regulation** Given the properties of dividend prudential targets as a macroprudential tool, it is relevant to also investigate its interactions with the macroprudential component of existing capital regulation, the so-called countercyclical capital buffer (CCyB). Figures 7 and 8 plot the welfare effects of ceteris paribus changes in the value of parameters  $\gamma_x$  and  $(\rho_x, \gamma_x)$ , respectively. When solving problem (48) with respect to macroprudential policy parameter  $\gamma_x$ , there is no solution found such that  $\lambda_p = \lambda_i$  and  $\lambda_p > 0$ ,  $\lambda_i > 0$ . In addition, there is no interior solution for the problem of maximizing borrowers' welfare with respect to  $\gamma_x$  (for a regulatory meaningful range of  $\gamma_x$ ). Thus, I maximize savers' welfare with respect to  $\gamma_x$ , for alternative values of  $\rho_x$ .<sup>53</sup> Figure 8 and part (i) of table 7 make clear that savers prefer a highly responsive countercyclical DPT (and a mildly responsive CCyB), whereas borrowers have a preference for a highly responsive CCyB (and a mildly responsive countercyclical DPT). Part (ii) of table 7 summarizes the welfare gains from solving problem (48) with respect to macroprudential policy parameters  $\rho_x$  and  $\gamma_x$ . The optimized macroprudential toolkit comprises a joint capital-and-dividend based countercyclical regulation (i.e.,  $\rho_x > 0$ , and  $\gamma_x < 0$ ) that can be interpreted as a compromise between the preferences of the two agent classes, which allows patient and impatient households to enjoy higher welfare gains than under a policy scenario in which problem (48) is only solved with respect to  $\rho_x$ .

Figures 9 to 13 plot the impulse-responses of key economic aggregates to the 5 different shocks that hit this economy. The solid line refers to the responses under the baseline scenario, while the diamond, starred, and dotted lines correspond to alternative policy scenarios in which problem (48) has been solved with respect to  $\{\rho_x, \gamma_x\}$ ,  $\rho_x$ , and  $\gamma_x$ , respectively.<sup>54</sup> Several conclusions can be drawn from the analysis. First, both macroprudential instruments are effective in smoothing

<sup>53</sup>Such values for  $\rho_x$   $\{0, 143.741, 180.0\}$  have been chosen to ensure that, ceteris paribus, neither savers nor borrowers are worse-off due to the adoption of a countercyclical DPT (when compared to the baseline scenario).

<sup>54</sup>When solved with respect to  $\gamma_x$ , there is no solution to problem (48) such that  $\lambda_p = \lambda_i$  and  $\lambda_p > 0$ ,  $\lambda_i > 0$ . Thus, in this case, I set  $\gamma_x$  to -0.538 for two reasons: (i) It represents a compromise between the preferences of the two types of agents, and (ii) it allows for an easy comparison between a world in which only a CCyB applies and that in which both, the DPT and the CCyB are active (see table 7).

the economic and the financial cycles (credit supply, housing prices, etc). Second, for most of the shocks, the jointly optimized macroprudential rule (diamond line) is more effective in smoothing the business and the financial cycles than any of the two individual macroprudential rules on their own (starred and dotted lines), suggesting that both rules are mutually reinforcing for economic stabilization and financial stability purposes.

### 5.3 Robustness Checks

So far, the robustness of the main results associated to the welfare analysis presented in the previous section has been tested for capital adequacy parameters  $\gamma$  and  $\gamma_x$ . However, there are other parameters to which welfare effects may also be sensitive and which may change over time. First, the introduction of a dividend prudential target can potentially affect certain structural parameters, especially dividend adjustment cost parameter  $\kappa$ . Given a sensible range of values for  $\kappa$ , the shape of savers and borrowers' lifetime utility as a function of  $\rho_x$  are not significantly affected, although as the value of  $\kappa$  increases, the welfare trade-off faced by savers under a countercyclical DPT tends to improve while the one faced by borrowers tends to deteriorate (see figure 14). This result does not come as a surprise since bank owners are those who borne the direct cost of adjusting dividends. Therefore, as  $\kappa$  increases, the value of  $\rho_x$  that solves problem (48) and the associated welfare gains tend to decline.

Second, the fraction of banks owned by savers,  $\omega_b$ , (and, thus, by borrowers) may change over time. As noted in figure 15, as  $\omega_b$  increases, the welfare level of savers goes up while that of borrowers declines. This is so, because the bank dividend payout received by a given household increases in the fraction of banks it owns,  $\omega_b$ . However, the shape of lifetime utility (as a function of  $\rho_x$ ) remains basically unchanged for alternative values of  $\omega_b$  and for each of the two agent classes.

Third, the public authority may consider to modify the fraction of net transfer that savers receive according to their bank property,  $\chi$ . Not surprisingly, regardless of the  $\rho_x$  value, the welfare level of borrowers declines (whereas that of savers increases) as the fraction of the net tranfer received by bank owners (i.e., borrowers) declines (and that received by savers increases).

In a nutshell, although quantitative differences may arise, the main conclusions of this exercise are very robust across calibrated values of key parameters and across alternative specifications of policy scenarios. Countercyclical dividend prudential targets induce welfare gains for savers and borrowers through their smoothing effect on financial aggregates.

## 6 Conclusion

Available evidence on euro area bank dividends and earnings suggests there is a potential link between payout policies and the adjustment mechanisms through which bankers opt to meet their target regulatory capital ratios. When shocks hit bank profits, managers adjust retained earnings to smooth dividends. This generates bank equity and credit supply volatility.

This paper develops a DSGE model that features a banking sector and certain financial frictions that account for this empirical phenomenon. Then, it defines a dividend-based regulatory scheme that is shown to be an effective macroprudential complement to capital requirements. In particular, what shall be called dividend prudential targets: (i) are effective in smoothing the financial and the business cycle by means of less volatile bank retained earnings, (ii) induce welfare gains associated to a Basel III-type of capital regulation, (iii) mainly operate through their cyclical component, ensuring that long-run dividend payouts remain unaffected, and (iv) are associated to a sanctions regime which acts as an insurance scheme for the real economy and allows bankers to optimally deviate from the target. The latter is a property that may be crucial to tackle one of the main potential critiques dividend-based prudential rules may face in practice. The negative impact dividend regulation could have on market volatility.

The simplicity of the model is instrumental to clearly identify the transmission mechanism through which the proposed policy rule operates. Yet, it comes at the cost of abstracting from a number of considerations that potentially constitute promising avenues for future research. Modeling one or more of the market imperfections that may be behind bank dividend policies should be helpful to match the data by means of an improved microfoundation of the macroeconomic model.

Moreover, additional ingredients which are present in reality and that could possibly change some of the results have been omitted. On the one hand, assuming a positive probability of bank failure, as in Clerc et al. (2015), should reinforce the argument in favour of this complement to the existing macroprudential toolkit. On the other hand, incorporating outside equity in an environment in which bank owners can substitute their bank shares for alternative assets at a relatively low cost, may make the policy proposal less attractive. In addition, the literature has shown that the approach to modeling bank risk taking and systemic risk can notably influence macroprudential policy prescriptions (see, e.g., Martinez-Miera and Suarez 2014).

Lastly, optimal coordination between this type of prudential regulation and other macroeconomic policies should be considered as well (e.g., monetary policy). Based on the ECB annual report of 2016, one of the critiques the European Parliament (2017) has recently made to the ECB relates to this issue. *"The European Parliament is concerned that euro area banks did not use the advantageous environment created by the ECB to strengthen their capital bases but rather, according to the Bank for International Settlements, to pay substantial dividends sometimes exceeding*

*the level of retained earnings."*

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Table 1: Optimized rules and prudential losses; collateral shock (basic model)

		$\sigma_B^2$	$\sigma_{B/Y}^2$	$\sigma_{K_b}^2$	$\sigma_q^2$
(i) Baseline	<i>Loss</i>	0.002012	0.002232	0.000020	0.000640
(ii) $\{\rho_d, \rho_x\}$	<i>Loss</i>	0.000394	0.000381	0.000004	0.000416
	<i>Loss Variation</i> <sup>(1)</sup>	-80.41	-82.29	-80.42	-34.00
	$\rho_d$ <sup>(2)</sup>	0.5417	0.5598	0.5443	0.1684
	$\rho_x$	67.2409	67.8427	67.3268	16.9175
(iii) $\{\rho_x\}$	<i>Loss</i>	0.000527	0.000535	0.000005	0.000519
	<i>Loss Variation</i>	-73.80	-76.37	-73.80	-18.91
	$\rho_x$	54.9622	54.9622	54.9622	29.4588

Note:(1) Percentage changes in the value of the loss function under the policy scenario associated to the optimized dividend prudential target, with respect to the baseline scenario. (2) Values of the autonomous component of the policy rule have been normalized by expressing them in terms of steady state bank profits.

Table 2: Baseline parameter values

Parameter	Description	Value	Source/Target ratio
A) Pre-set params			
$\varphi$	Inverse of the Frisch elasticity	1	Standard
$\sigma_h$	HH Risk aversion param	2	standard
$m_{Hi}; m_{He}$	LTV ratio on HH and NFC housing	0.7	Standard
$\delta^k$	Depreciation rate of physical capital	0.025	Standard
$\delta_1^k; \delta_2^k$	Endogenous depr. rate params	$r_{ke}^{ss}; 0.1 * r_{ke}^{ss}$	Gerali et al. (2010)
$\kappa$	Dividend adj. cost parameter	0.426	Jermann & Quadrini (2012)
$\phi_e$	NFC credit adj.cost param	0.06	Iacoviello (2015)
B) First moments			
$\beta_p$	Savers' discount factor	0.9943	$R_h^{ss} = (1.023)^{1/4}$
$\beta_i$	Borrowers' discount factor	0.95	$(r_b^{ss} - r_d^{ss})400 = 3.4$
$j_p$	Savers' housing weight	0.0805	$H_p^{ss}/H_i^{ss} = 1.3585$
$j_i$	Borrowers' housing weight	0.4802	$B_i^{ss}/(Y^{ss}) = 2.1403$
$\omega_e$	Fraction of firms owned by HH <sub>p</sub>	1	$B_e^{ss}/B^{ss} = 0.4510$
$\omega_b$	Fraction of banks owned by HH <sub>p</sub>	0	$B_e^{ss}/Y^{ss} = 1.7530$
$\alpha$	Capital share in production	0.2699	$I^{ss}/Y^{ss} = 0.2119$
$\eta$	Real estate share in production	0.0385	$(q^{ss} H^{ss})/(4Y^{ss}) = 2.802$
$\gamma_e$	Debt-to-assets, NFC risk-adjusted	0.8522	$\gamma_e/\gamma_i = 2.1176$
$\gamma_i$	Debt-to-assets, HH risk-adjusted	0.9302	$K_b^{ss}/B^{ss} = 0.105$
$\delta$	Depreciation rate of bank capital	0.041	$d^{ss}/J_b^{ss} = 0.5625$
C) Second moments			
$\psi$	Investment adj. cost param	0.092	$\sigma_I/\sigma_Y = 2.642$
$\phi_i$	HH credit adj.cost param	0.504	$\sigma_B/\sigma_Y = 6.473$
$\sigma$	Banker EIS	2.76	$\sigma_{d_b}/\sigma_Y = 15.050$
$\sigma_h$	Std. housing pref. shock	0.1999	$\sigma_q/\sigma_Y = 2.429$
$\sigma_{kb}$	Std. bank capital depr. shock	0.0495	$\sigma_{K_b}/\sigma_Y = 6.554$
$\sigma_{mh}$	Std. NFC collateral shock	0.0024	$\sigma_{J_b}/\sigma_Y = 59.102$
$\sigma_{mk}$	Std. HH collateral shock	0.0026	$\sigma_C/\sigma_Y = 0.748$
$\sigma_A$	Std. productivity shock	0.0020	$\sigma_Y = 2.138$

Note: Parameters in A) are set to standard values in the literature, whereas those in B) and C) are calibrated to match data targets. Abbreviations HH and NFC refer to households and non-financial corporations (entrepreneurs), respectively. HH<sub>p</sub> stands for patient households.

Table 3: Steady state ratios

Variable	Description	Model	Data
$C^{ss}/Y^{ss}$	Total consumption-to-GDP ratio	0.7632	0.7607
$I^{ss}/Y^{ss}$	Gross fixed capital formation-to-GDP ratio	0.2196	0.2119
$4 \times r_b^{ss}$	Annualized bank rate on loans (per cent)	6.020	5.6
$4 \times r_d^{ss}$	Annualized bank rate on deposits (per cent)	2.293	2.3
$(r_b^{ss} - r_d^{ss})$	Annualized Bank Spread (per cent)	3.727	3.4
$(1 - \gamma_e)/(1 - \gamma_i)$	Capital requirement of NFC loans-to-mortgage loans	2.1176	2.1176
$K_b^{ss}/B^{ss}$	Capital requirements on mortgage and NFC loans	0.105	0.105
$B_i^{ss}/(Y^{ss})$	HH loans-to-GDP ratio	2.1875	2.1291
$B_e^{ss}/(Y^{ss})$	NFC loans-to-GDP ratio	1.7938	1.7530
$B_i^{ss}/B^{ss}$	Fraction of HH loans	0.5494	0.5490
$B_e^{ss}/B^{ss}$	Fraction of NFC loans	0.4506	0.4510
$d_b^{ss}/J_b^{ss}$	Bank dividend payout-ratio	0.5621	0.5625
$h_p^{ss}/h_i^{ss}$	Savers-to-borrowers housing ratio	1.4763	1.3585
$(q^{ss}H^{ss})/(4Y^{ss})$	Housing wealth-to-GDP ratio	2.6104	2.8018

Note: All series in Euros are seasonally adjusted and deflated. Data targets have been constructed from euro area quarterly data for the period 2002:I-2018:II. The exceptions are the following: annualized bank rates, which have been taken from constructed series presented in Gerali et al. (2010), and the target for capital requirements, which has been based on the Basel III regime. Data sources are Eurostat, ECB and Bloomberg.

Table 4: Second moments

Variable	Description	Model	Data
Banking data (SX7E)			
$\sigma_{d_b} / \sigma_Y$	Std. bank dividends	15.989	15.050
$\sigma_{J_b} / \sigma_Y$	Std. bank profits	43.428	59.102
$\sigma_{K_b} / \sigma_Y$	Std. bank capital	5.959	6.554
$\sigma_B / \sigma_Y$	Std. bank assets	6.760	6.473
Macro data (EA)			
$\sigma_q / \sigma_Y$	Std. housing prices	2.123	2.429
$\sigma_I / \sigma_Y$	Std. investment	3.139	2.642
$\sigma_C / \sigma_Y$	Std consumption	0.938	0.748
$\sigma_Y$	Std(GDP)*100	2.138	2.138

Note: All series are seasonally adjusted and deflated, and their log value has been linearly detrended before computing standard deviation targets. Since some observations in the series "bank profits" (i.e., earnings) take negative values, in this case a constant has been added to all observations before taking logs, such that the minimum of the transformed series is equal to one. The standard deviation (Std) of GDP is in quarterly percentage points.

Table 5: Welfare Gains

<i>Shocks</i>	Savers	Borrowers
All shocks	0.2604	0.2604
<b>(i) No financial shocks</b>	0.2488	0.2201
*No HH collateral shock	0.2487	0.2376
*No NFC collateral shock	0.2605	0.2598
*No equity shock	0.2602	0.2436
<b>(ii) No housing pref shock</b>	0.2824	-0.5189
<b>(iii) No technology shock</b>	-0.0105	0.8097

Note: Second-order approximation to the welfare gains associated to the benchmark optimized dividend prudential target in which none or some of the shocks are shut down. welfare gains are expressed in percentage permanent consumption.

Table 6: Welfare Gains and capital regulation

$(1 - \gamma)$	$\rho_x$	Savers	Borrowers
<b>Capital ratio increases</b>			
(i) 1.0 p.p. increase in $(1 - \gamma)$			
*0.11.5	0	-0.3629	-0.2761
*0.11.5	143.741	-0.1021	0.2671
<b>Alternative capital scenarios</b>			
(ii) Reoptimization wrt. $\rho_x$			
*0.08	71.46	0.0694	0.0694
*0.105	143.741	0.2604	0.2604
*0.12	197.66	0.3916	0.3916
(iii) No reoptimization wrt. $\rho_x$			
*0.08	143.741	0.3367	-0.5332
*0.105	143.741	0.2604	0.2604
*0.12	143.741	0.2685	0.7183

Note: Part (i) highlights the differences in welfare gains between increasing the capital ratio with and without the introduction of a dividend prudential target, with respect to the baseline scenario. Parts (ii) and (iii) summarize the welfare effects of dividend-based prudential rules under alternative capital scenarios. Hence, in this case, the baseline and the policy scenarios are associated to the same capital ratio. A capital ratio that may no longer coincide with its baseline calibration value.



Table 7: Welfare Gains and the CCyB

	$\gamma_x$	$\rho_x$	Savers	Borrowers
<b>(i)</b> $\{\gamma_x\}$				
*arg max $V_0^p$ $\gamma_x$	-1.345	0	0.1716	1.4795
*arg max $V_0^p$ $\gamma_x$	-0.549	143.741	0.3073	0.3567
*arg max $V_0^p$ $\gamma_x$	-0.322	180.0	0.3752	0.0626
<b>(ii)</b> $\{\gamma_x, \rho_x\}$				
*arg max $V_0$ $\gamma_x, \rho_x$	-0.538	149.215	0.3175	0.3175

Note: Part (i) presents a second-order approximation to the savers' welfare gains associated to the optimized countercyclical-capital buffer (CCyB), for alternative values of the DPT (cyclical parameter). Part (ii) presents a second-order approximation to the welfare gains associated to the jointly optimized countercyclical-capital buffer (CCyB) and dividend prudential target (cyclical parameter).

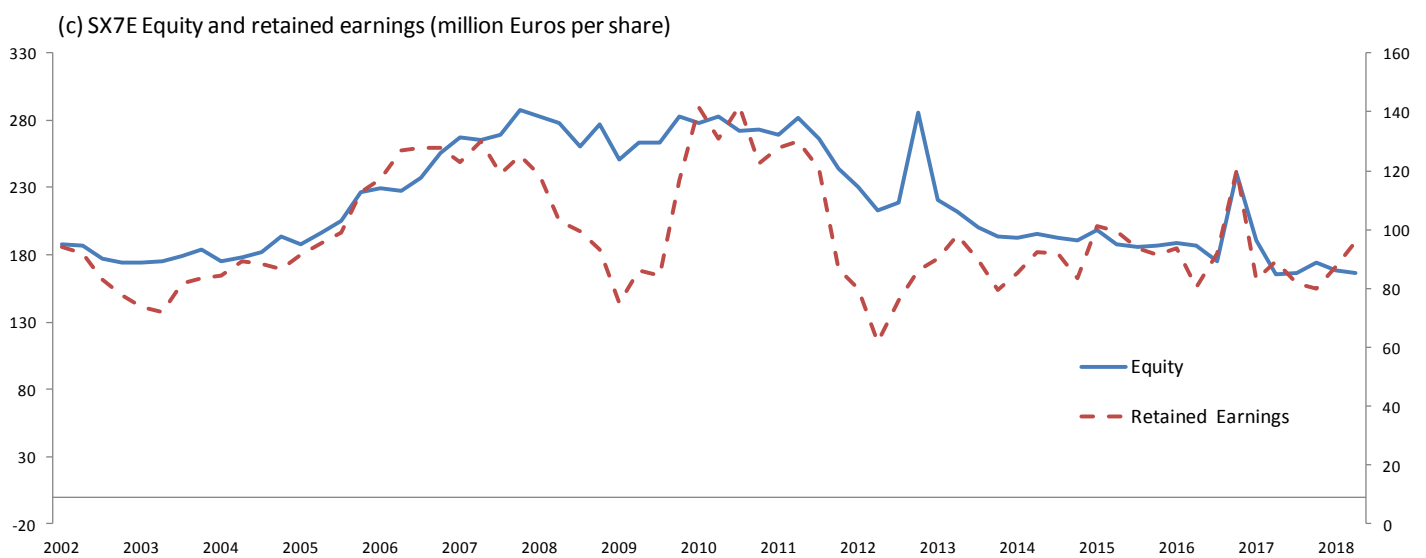
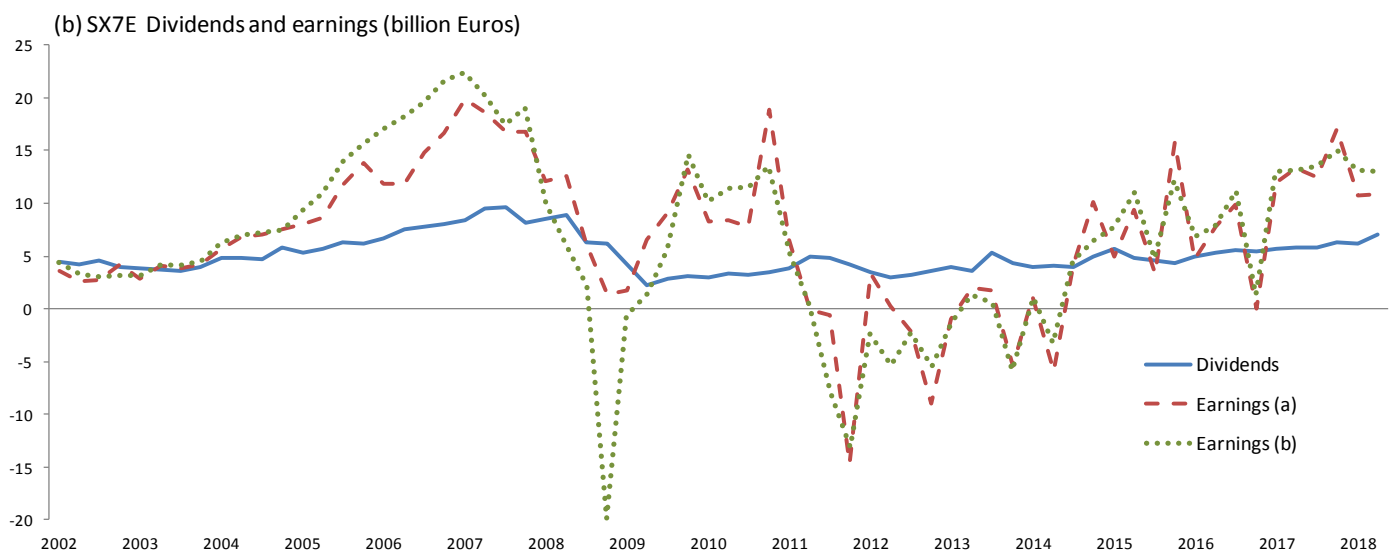
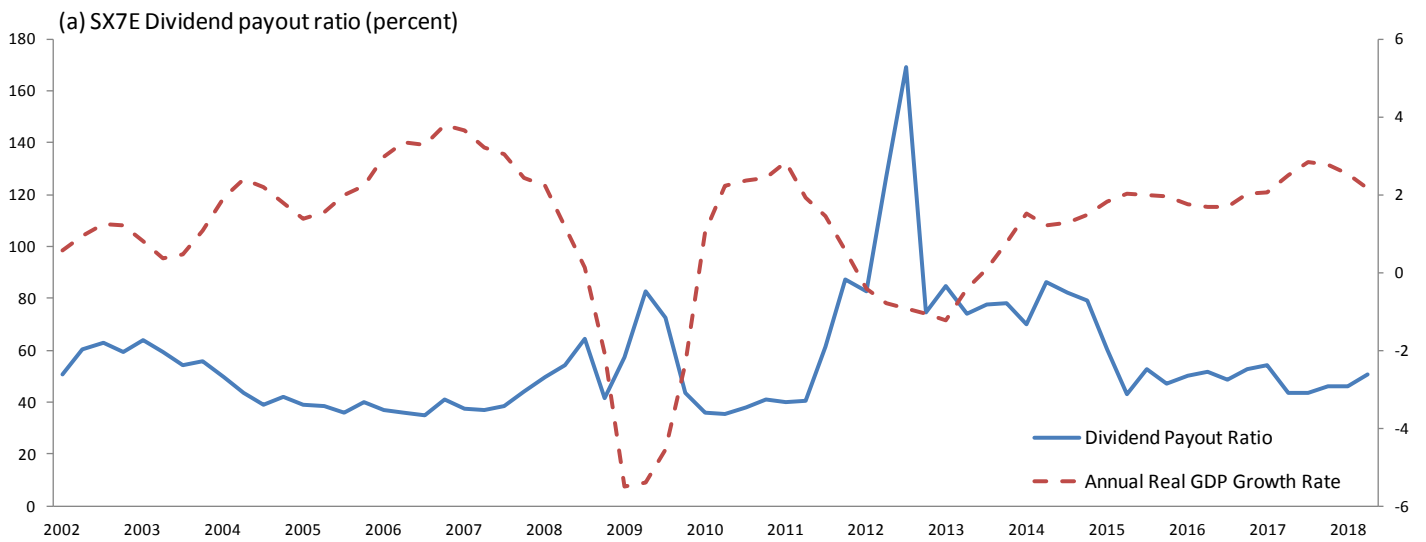
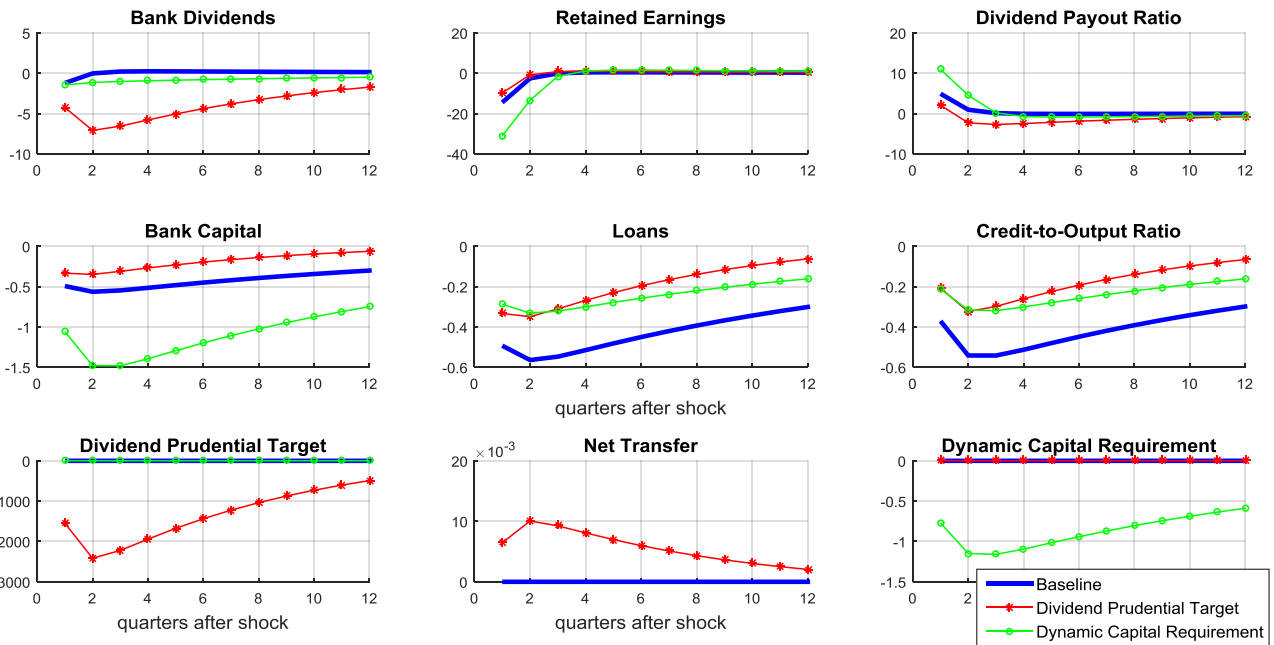


Figure 1: Bank dividends and earnings in the euro area. 2002:I – 2018:II

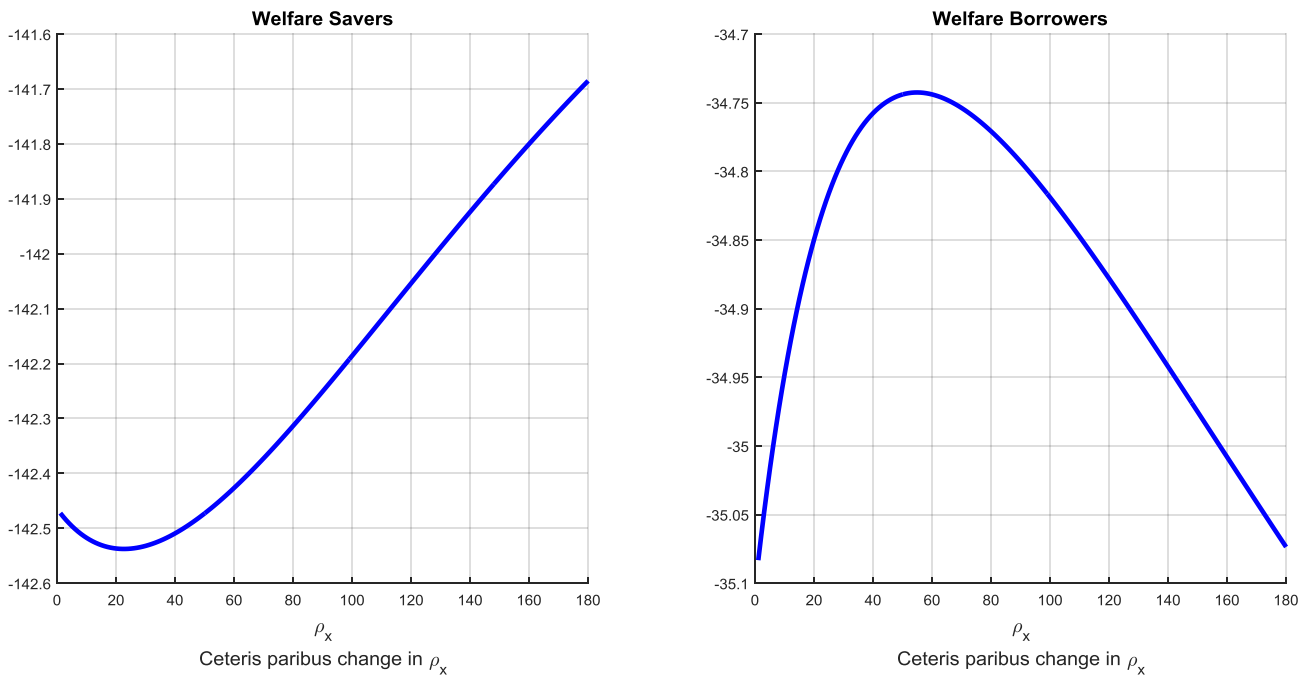
Note: SX7E refers to the Euro Stoxx Banks Index. When applicable, the secondary y-axis corresponds to the dashed line. See Appendix A for details on data construction. Data sources: Bloomberg, Eurostat, and own calculations.

Figure 2: The transmission mechanism. IRFs to a negative financial shock (basic model)



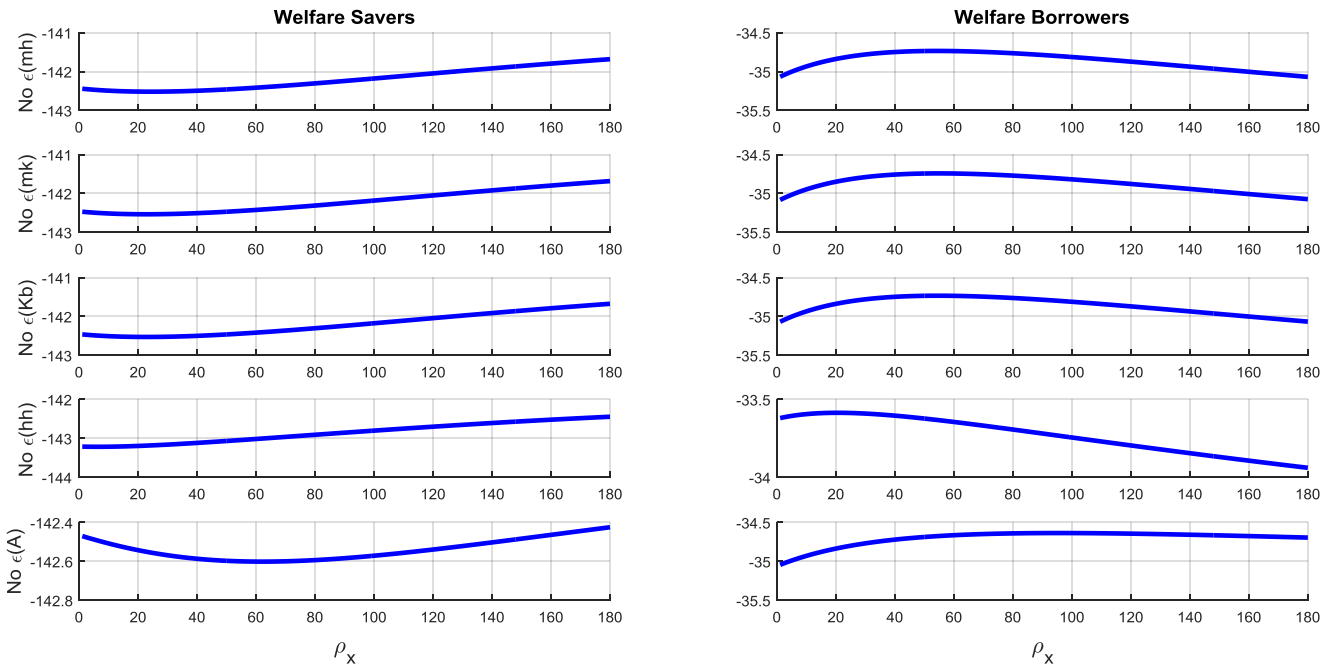
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which the optimized prudential rule is a dividend prudential target. The dotted line relates to an alternative (policy) scenario in which the optimized prudential rule is a dynamic capital requirement.

Figure 3: Welfare effects of ceteris paribus changes in  $\rho_x$



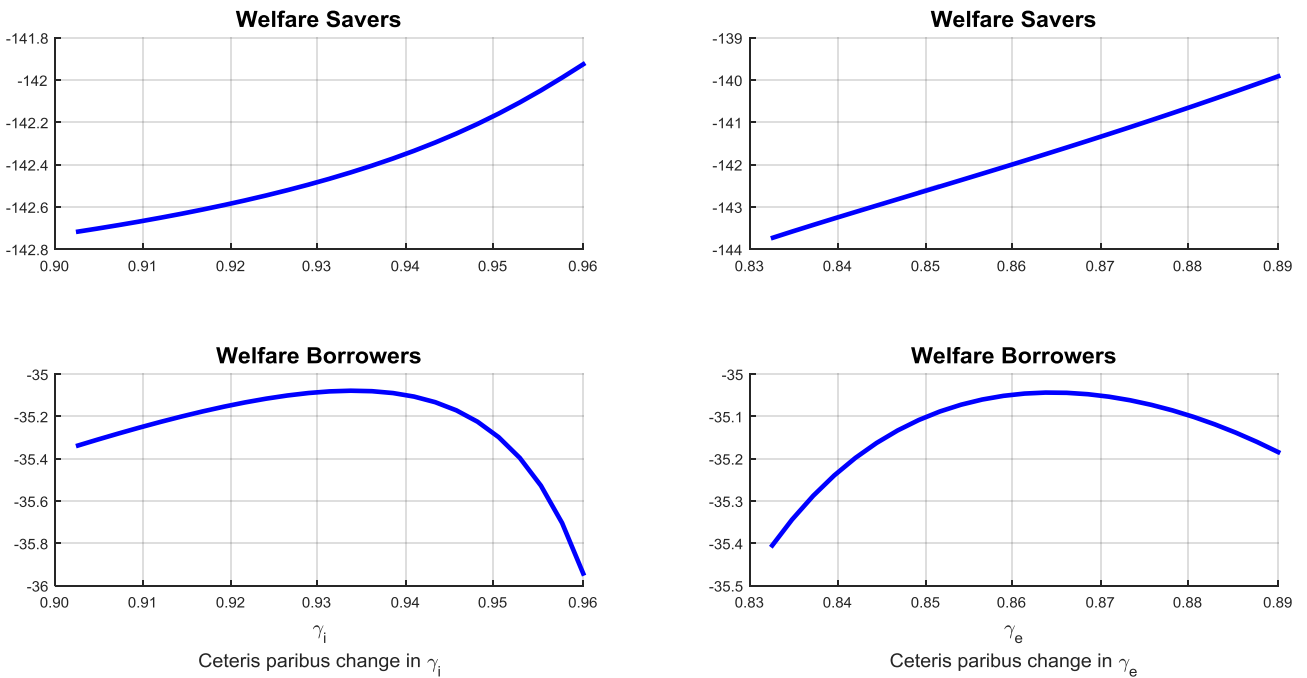
Note: Each subfigure represents a second-order approximation to the unconditional welfare of a specific agent type (saver or borrower) as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , while keeping the other policy parameter,  $\rho_d$ , to its baseline calibration value.

Figure 4: Welfare effects of ceteris paribus changes in  $\rho_x$  (shutting down shocks one by one)



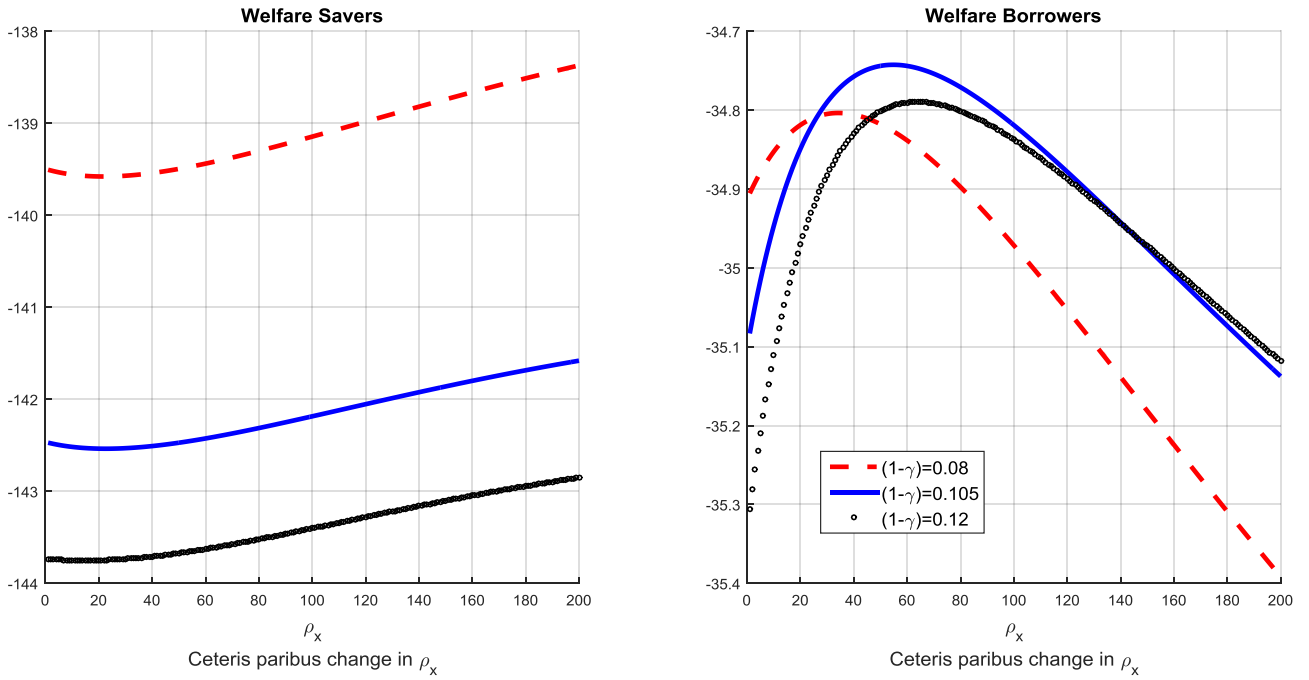
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , while individually shutting down each of the shocks.

Figure 5: Capital ratios (welfare effects of ceteris paribus changes in  $\gamma_i$  and  $\gamma_e$ )



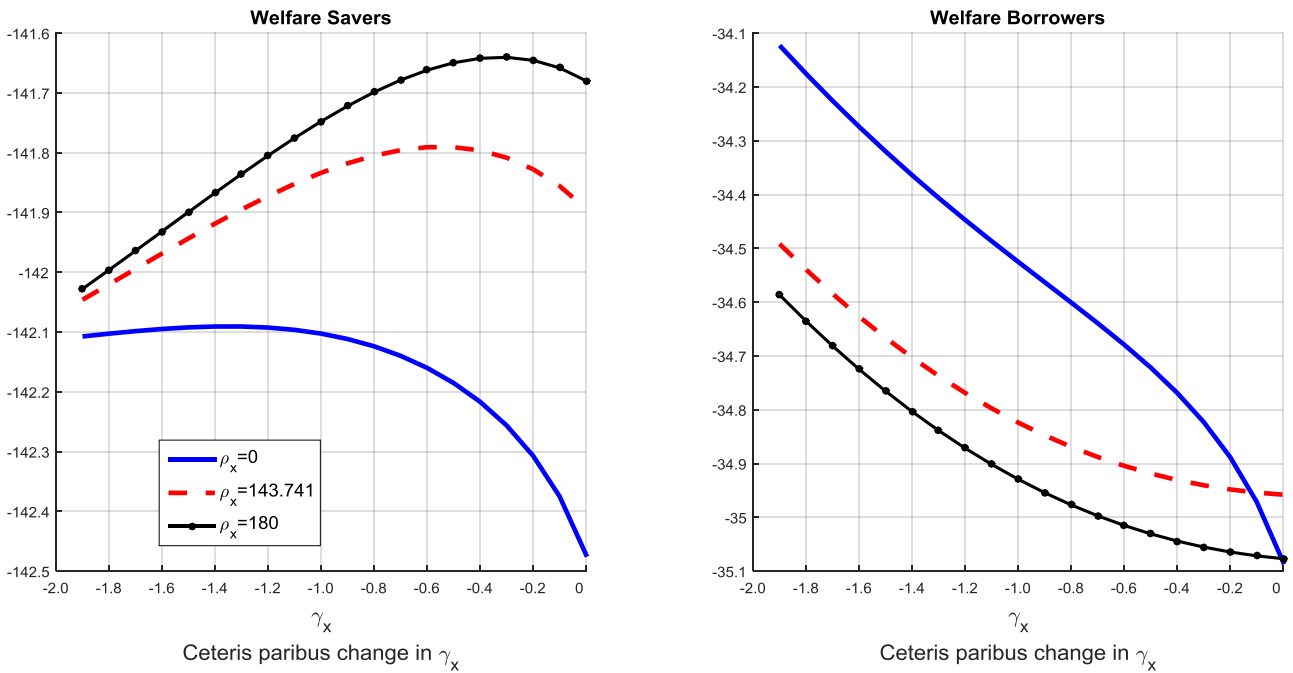
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of capital adequacy parameters  $\gamma_i$  and  $\gamma_e$ . Note that the steady-state capital ratio for NFC loans is  $(1 - \gamma_e)$  whereas the steady-state capital ratio for HH loans is  $(1 - \gamma_i)$ .

Figure 6: Welfare effects of DPTs under alternative capital scenarios



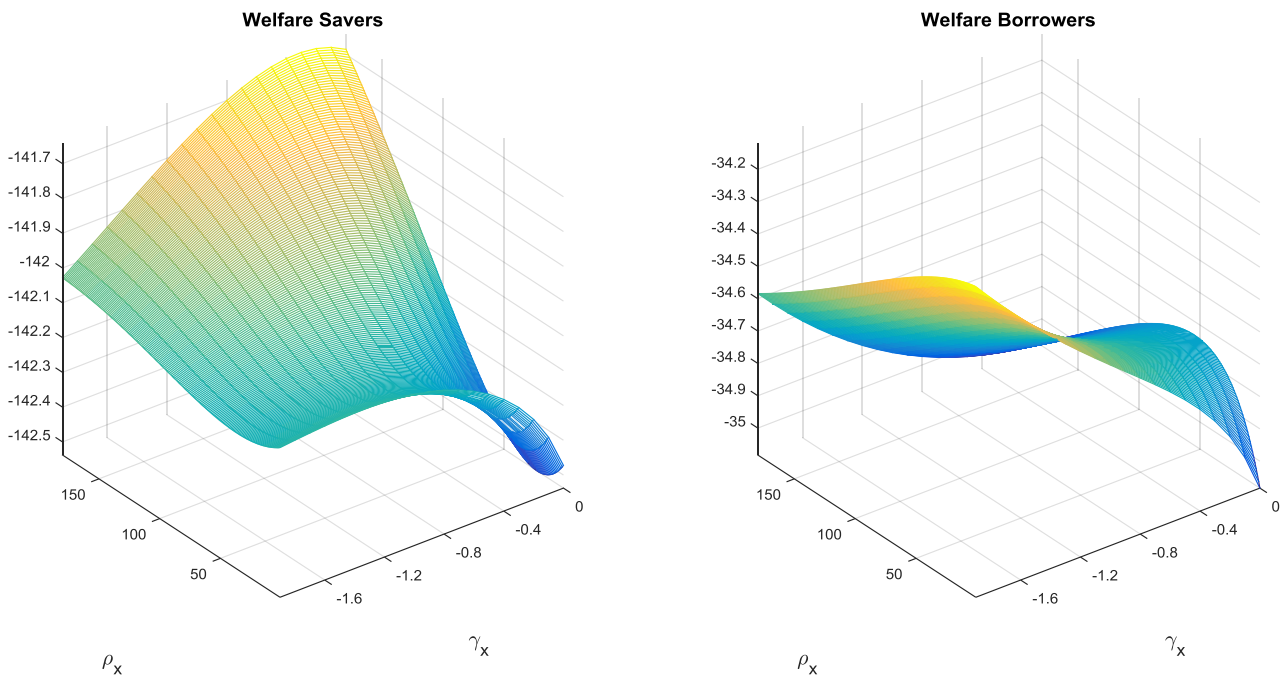
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , for three alternative capital scenarios  $(1-\gamma)$ .

Figure 7: The CCyB (welfare effects of ceteris paribus changes in  $\gamma_x$ )



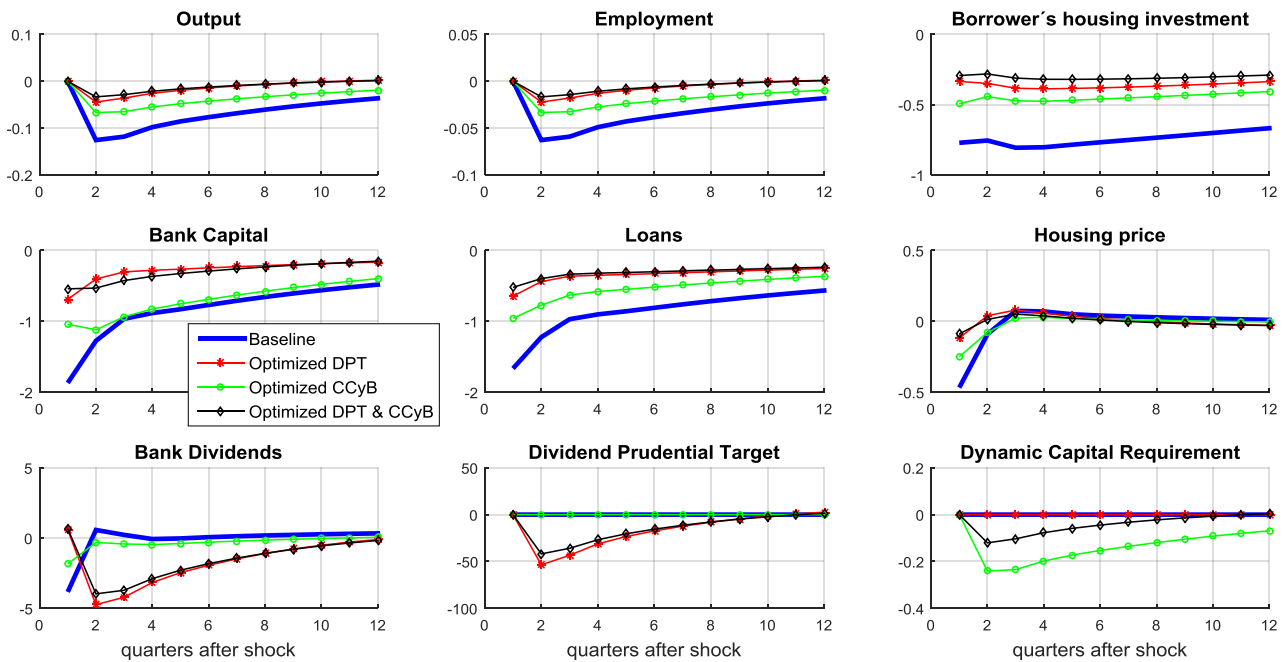
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ , for alternative values of the cyclical parameter of the dividend prudential target,  $\rho_x$ .

Figure 8: Interactions between the DPT and the CCyB (welfare effects of ceteris paribus changes in  $\rho_x - \gamma_x$ )



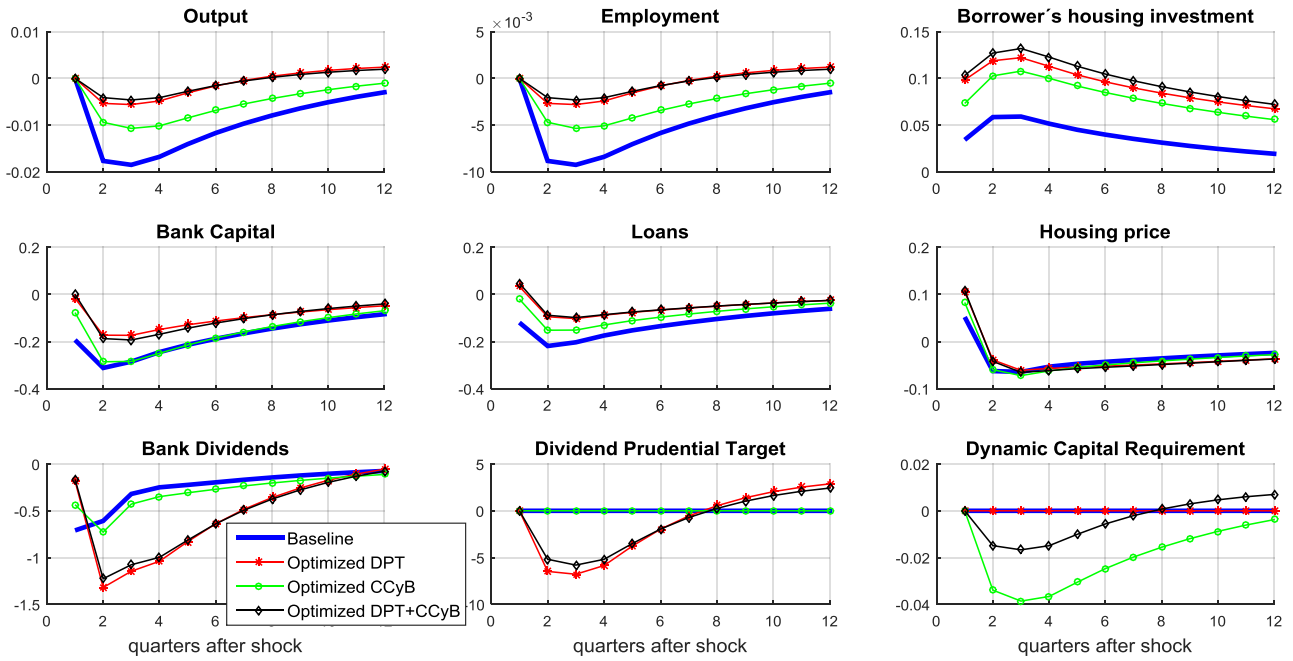
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of cyclical parameters of the dynamic capital requirement and the dividend prudential target,  $\gamma_x$  and  $\rho_x$ .

Figure 9: Impulse-responses to a negative HH collateral shock (extended model, macroprudential policy scenarios)



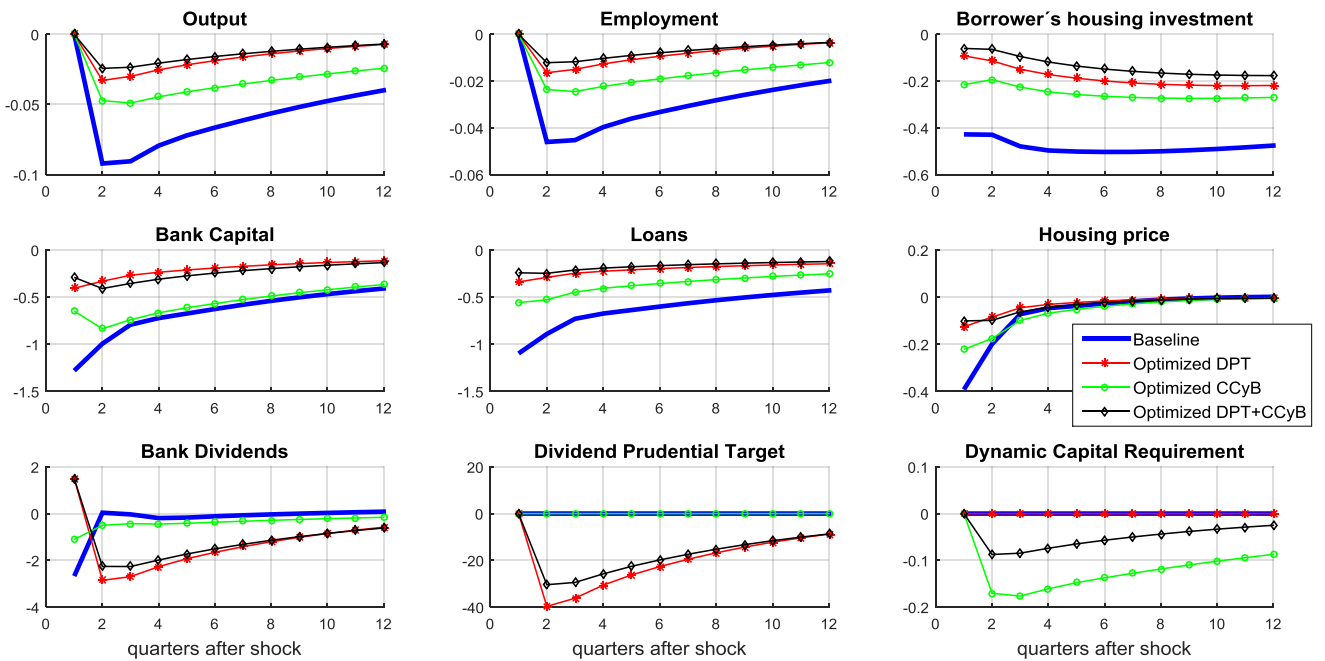
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,  $\rho_x$ . The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ . The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters  $\rho_x$  and  $\gamma_x$ .

Figure 10: Impulse-responses to a negative NFC collateral shock (extended model, macroprudential policy scenarios)



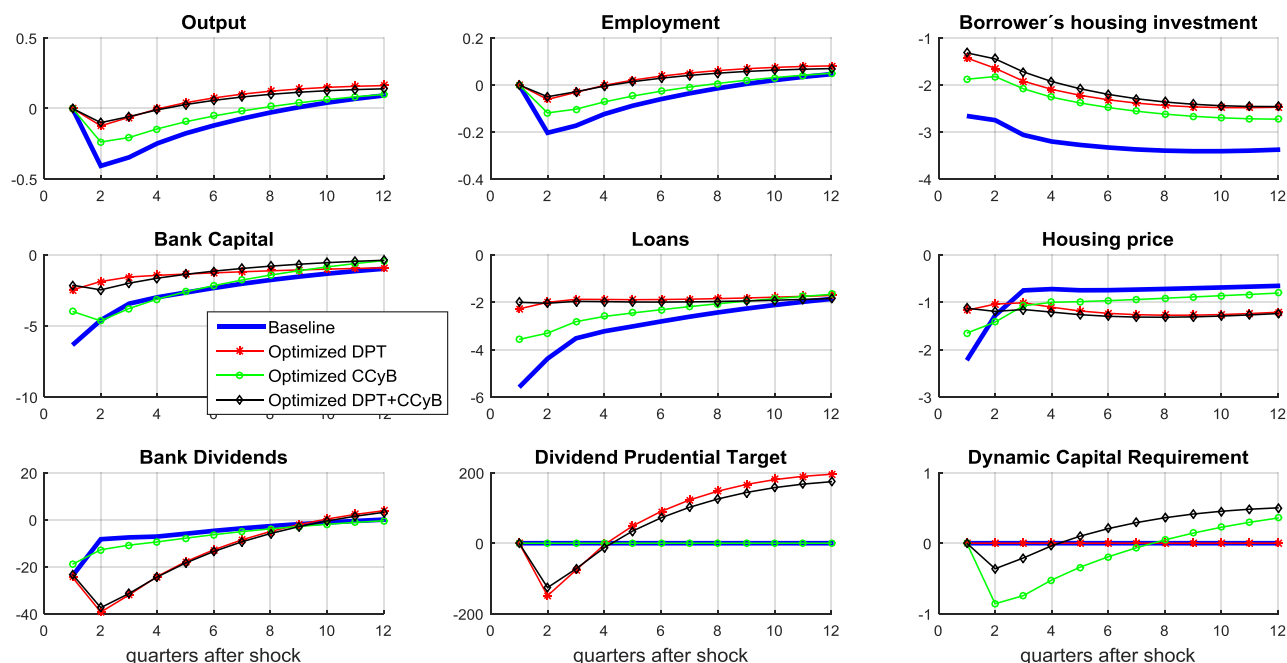
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,  $\rho_x$ . The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ . The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters  $\rho_x$  and  $\gamma_x$ .

Figure 11: Impulse-responses to a negative bank capital shock (extended model, macroprudential policy scenarios)



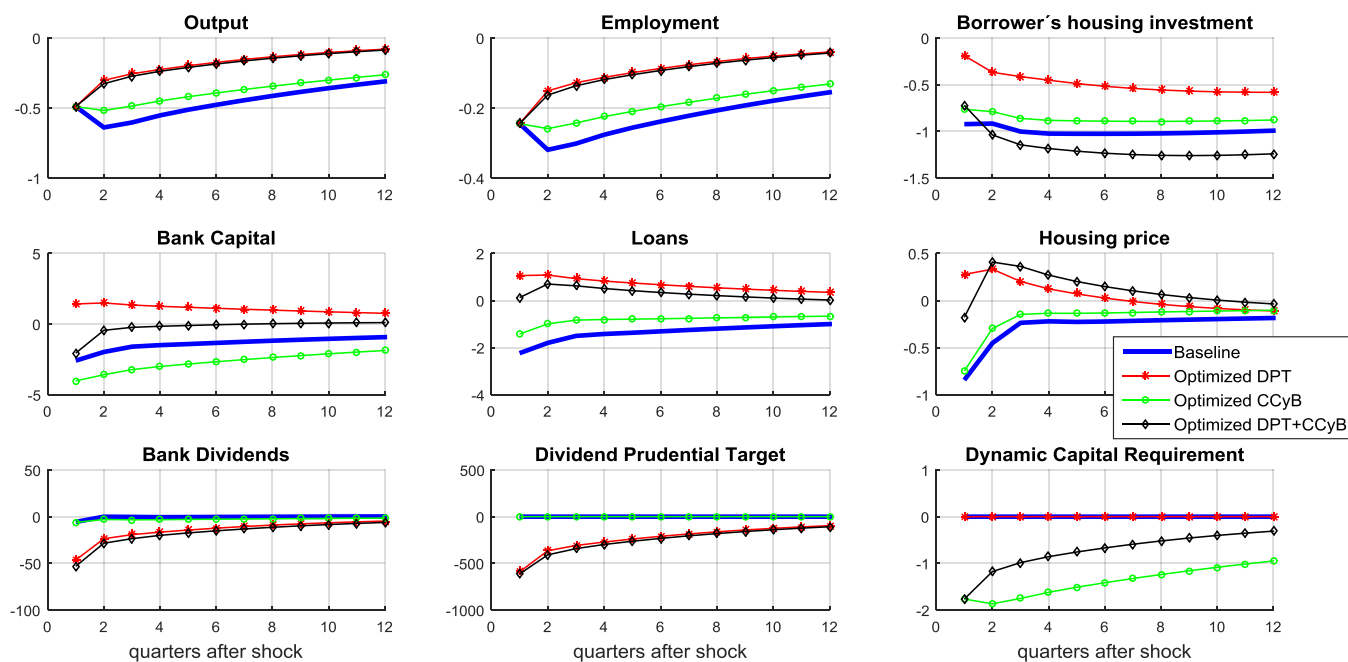
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,  $\rho_x$ . The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ . The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters  $\rho_x$  and  $\gamma_x$ .

Figure 12: Impulse-responses to a negative housing preference shock (extended model, macroprudential policy scenarios)



Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,  $\rho_x$ . The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ . The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters  $\rho_x$  and  $\gamma_x$ .

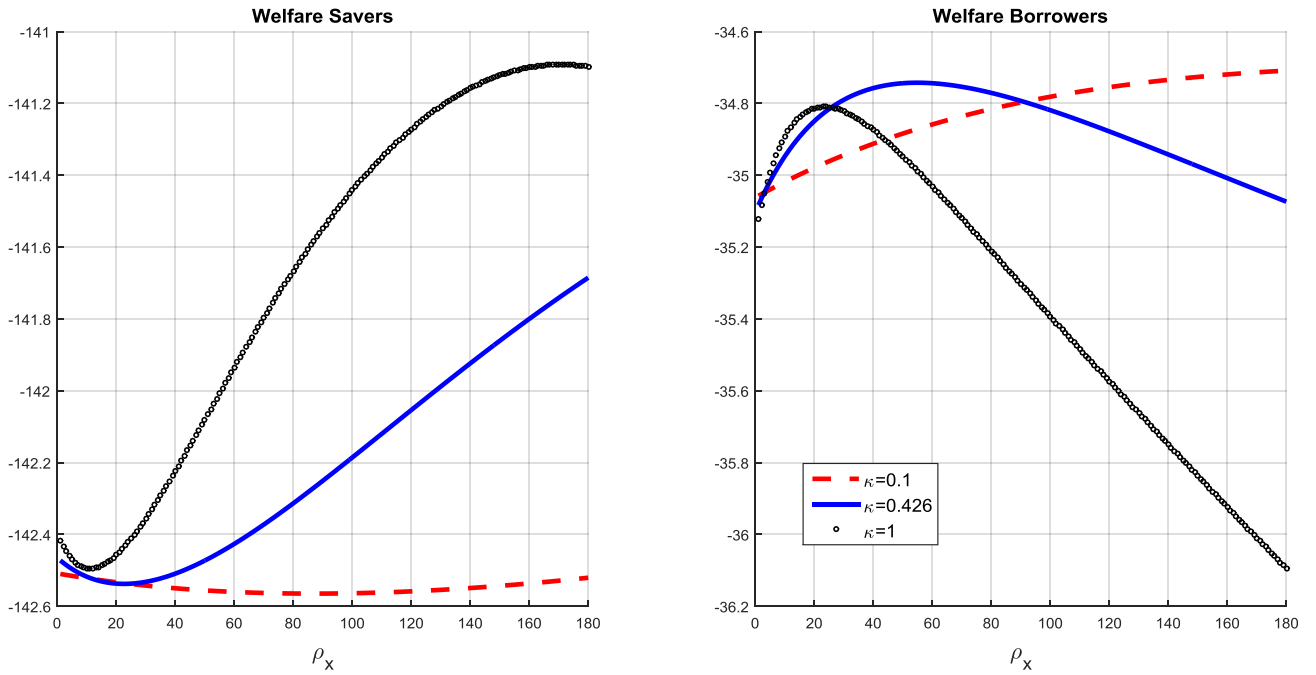
Figure 13: Impulse-responses to a negative technology shock (extended model, macroprudential policy scenarios)



Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,  $\rho_x$ . The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dynamic capital requirement,  $\gamma_x$ . The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters  $\rho_x$  and  $\gamma_x$ .

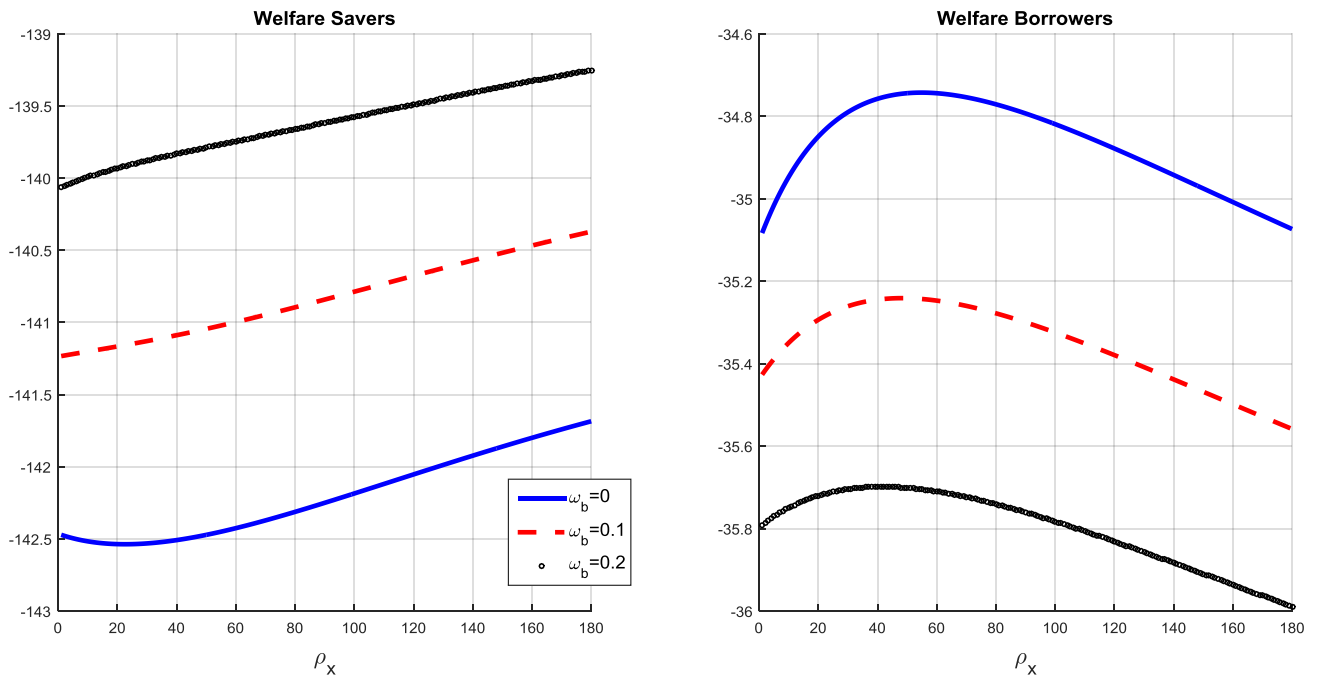


Figure 14: Robustness checks:  $\kappa$  (welfare effects of ceteris paribus changes in  $\rho_x$ )



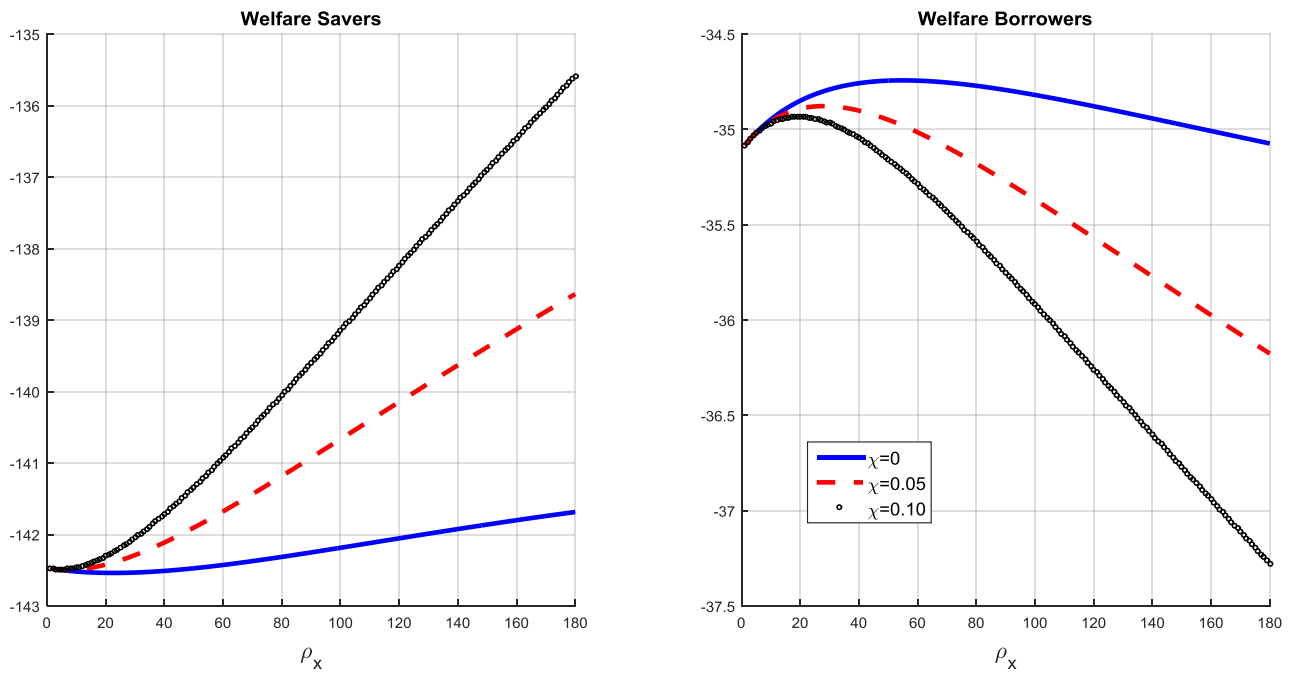
Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , for alternative values of the dividend adjustment cost parameter,  $\kappa$ . The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios.

Figure 15: Robustness checks:  $\omega_b$  (welfare effects of ceteris paribus changes in  $\rho_x$ )



Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , for alternative fractions of banks owned by savers. The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios.

Figure 16: Robustness checks:  $\chi$  (welfare effects of ceteris paribus changes in  $\rho_x$ )



Note: Second-order approximation to the unconditional welfare of savers and borrowers as a function of the cyclical parameter of the dividend prudential target,  $\rho_x$ , for alternative fractions  $\chi$  of the net transfer that savers receive according to their bank property. The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios.

## A Data and Sources

This section presents the full data set employed to present some evidence on euro area bank dividends and earnings in section 2 and to calibrate the extended model in section 5.

**Gross Domestic Product:** Gross domestic product at market prices, Chain-linked volumes (rebased), Domestic currency (may include amounts converted to the current currency at a fixed rate), Seasonally and working day-adjusted. Source: Eurostat.

**GDP Deflator:** Gross domestic product at market prices, Deflator, Domestic currency, Index (2010 = 100), Seasonally and calendar adjusted data - ESA 2010 National accounts. Source: Eurostat.

**Final Consumption:** Final consumption expenditure at market prices, Chain linked volumes (2010), Seasonally and calendar adjusted data. Source: Eurostat.

**Gross Fixed Capital Formation:** Gross fixed capital formation at market prices, Chain linked volumes (2010), Seasonally and calendar adjusted data. Source: Eurostat.

**Households Housing Wealth:** Housing wealth (net) of Households and non profit institutions serving households sector (NPISH), Current prices, Euros, Neither seasonally adjusted nor calendar adjusted - ESA 2010. Source: European Central Bank.

**Housing Prices:** Residential property prices; New and existing dwellings, Residential property in good and poor condition. Neither seasonally nor working day adjusted. Source: European Central Bank.

**Business Loans:** Outstanding amounts at the end of the period (stocks) of loans from MFIs excluding ESCB reporting sector to Non-Financial corporations (S.11) sector, denominated in Euros. Source: MFI Balance Sheet Items Statistics (BSI Statistics), Monetary and Financial Statistics (S/MFS), European Central Bank.

**Households Loans:** Outstanding amounts at the end of the period (stocks) of loans from MFIs excluding ESCB reporting sector to Households and non-profit institutions serving households (S.14 & S.15) sector, denominated in Euros. Source: MFI Balance Sheet Items Statistics (BSI Statistics), Monetary and Financial Statistics (S/MFS), European Central Bank.

**Dividend Payout Ratio:** Fraction of net income payed to shareholders in dividends, in percentage. Calculated as:  $\text{Total Common Dividends} \times 100 / \text{Income Before Extraordinary Items Less Minority and Preferred Dividends}$ . Capitalization-weighted sum of the SX7E members. Source: Bloomberg.

**Dividends:** Dividends paid to common shareholders from the profits of the company. Includes regular cash as well as special cash dividends for all classes of common shareholders. Excludes return of capital and in-specie dividends. For the cases in which dividends attributable to the period are not disclosed, dividends are estimated by multiplying the Dividend per Share by the

number of Shares Outstanding. Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.

**Earnings (a):** Income before extraordinary items and discontinued operation but after minority interest, preferred dividend, and other adjustments. Calculated as: Pretax Income - Income Tax - After Tax (Income) Loss from Affiliates - Minority Interest - Preferred Dividends - Other Adjustments. Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.

**Earnings (b):** Net income available to common shareholders. Calculated as: Net Income - Total Cash Preferred Dividend - Other Adjustments.<sup>55</sup> Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.

**Retained Earnings:** Cumulative undistributed earnings. Includes net unrealized gain (loss) on securities held for sale and other items included in accumulated comprehensive income (net of tax). Includes deferred compensation to officers. Retained earnings are decreased by the amount of treasury stock. Reserves resulting from revaluation of assets in many countries are included as a part of shareholders' equity and are included. Normalized by the number of shares outstanding. Capitalization-weighted sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.

**Total Equity:** Firm's total assets minus its total liabilities. Calculated as: Common Equity + Minority Interest + Preferred Equity.<sup>56</sup> Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.<sup>57</sup>

**Total Assets:** Firm's total assets. Calculated as: Cash and bank balances + Fed funds sold and resale agreements + Investments for Trade and Sale + Net loans + Investments held to maturity + Net fixed assets + Other assets + Customers' Acceptances and Liabilities. Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.

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<sup>55</sup>"Other adjustments" include any adjustments to bottom-line net income (except for preferred dividends) that are needed to arrive at Basic Net Income Available for Common Shareholders. Examples of Other Adjustments are exchangeable preferred membership interest buyback premium, earnings allocated to participating securities, interest expense for hybrid securities, accretion of preferred stock issuance cost, and net income allocated to general partners.

<sup>56</sup>"Common Equity" refers to the amount that all common shareholders have invested in a company. Calculated as: Share Capital & additional paid in capital (APIC) + Retained Earnings and Other Equity.

<sup>57</sup>For calibration purposes, total equity has been constructed as the simple sum of all SX7E member's total equity. For reporting purposes (see figure 1), and following investors and Bloomberg's convention, total equity has been constructed as the capitalization-weighted sum of the SX7E members, after having normalized raw data by the number of total shares outstanding (as retained earnings have been constructed).

## B Equations of the Extended Model

This section presents the full set of equilibrium equations of the extended model.

### B.1 Patient Households

Patient households seek to maximize (23) subject to the following budget constraint

$$C_{p,t} + D_t + q_t(H_{p,t} - H_{p,t-1}) = (R_{d,t-1})D_{t-1} + W_t N_{p,t} + \omega_b d_{b,t} + \chi T_t + \omega_e d_{e,t} \quad (\text{B.1})$$

Their choice variables are  $C_{p,t}$ ,  $D_t$ ,  $H_{p,t}$  and  $N_{p,t}$ . The optimality conditions of the problem read

$$\lambda_t^p = \left( C_{p,t} - \frac{N_{p,t}^{1+\phi}}{(1+\phi)} \right)^{-\sigma_h} \quad (\text{B.2})$$

$$\lambda_t^p = \beta_p R_{d,t} E_t \lambda_{t+1}^p \quad (\text{B.3})$$

$$q_t \lambda_t^p = \frac{j \varepsilon_t^h}{H_{p,t}} + \beta_p E_t (q_{t+1} q_t \lambda_{t+1}^p) \quad (\text{B.4})$$

$$W_t = N_{p,t}^\phi \quad (\text{B.5})$$

where  $\lambda_t^p$  is the Lagrange multiplier on the budget constraint of the representative patient household.

### B.2 Impatient Households

The representative impatient household chooses the trajectories of consumption  $C_{i,t}$ , housing  $H_{i,t}$ , demand for labor  $N_{i,t}$  and bank loans  $B_{i,t}$  that maximize (23) subject to a budget constraint and a borrowing limit

$$\begin{aligned} C_{i,t} + R_{i,t-1} B_{i,t-1} + q_t(H_{i,t} - H_{i,t-1}) + \Phi_i(B_{i,t}) \\ = B_{i,t} + W_t N_{i,t} + (1 - \omega_b) d_{b,t} + (1 - \chi) T_t + (1 - \omega_e) d_{e,t} \end{aligned} \quad (\text{B.6})$$

$$B_{i,t} \leq m_{i,t}^H E_t \left[ \frac{q_{t+1}}{R_{i,t}} H_{i,t} \right] \quad (\text{B.7})$$

The resulting optimality conditions are

$$\lambda_t^i = \left( C_{i,t} - \frac{N_{i,t}^{1+\phi}}{(1+\phi)} \right)^{-\sigma_h} \quad (\text{B.8})$$

$$W_t = N_{i,t}^\phi \quad (\text{B.9})$$

$$\lambda_t^i \left[ q_t - \left( 1 - \frac{\partial \Phi_i(B_{i,t})}{\partial B_{i,t}} \right) E_t \left( m_{i,t}^H \frac{q_{t+1}}{R_{i,t}} \right) \right] = \frac{j \varepsilon_t^h}{H_{i,t}} + \beta_i E_t [q_{t+1} \lambda_{t+1}^i (1 - m_{i,t}^H)] \quad (\text{B.10})$$

where  $\lambda_t^i$  is the Lagrange multiplier on the budget constraint of the representative patient household.

### B.3 Entrepreneurs

Entrepreneurs seek to maximize (27) subject to a budget constraint, the available technology and the corresponding borrowing limit

$$d_{e,t} + R_{b,t} B_{e,t-1} + q_t^k [K_{e,t} - (1 - \delta_t^k) K_{e,t-1}] + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t} \quad (\text{B.11})$$

$$Y_t = A_t (u_t k_{e,t-1})^\alpha H_{e,t-1}^\eta N_t^{(1-\alpha-\eta)} \quad (\text{B.12})$$

$$B_{e,t} \leq m_{e,t}^H E_t \left( \frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_t N_t \quad (\text{B.13})$$

Their choice variables are  $d_{e,t}$ ,  $K_{e,t}$ ,  $u_t$ ,  $B_{e,t}$  and  $N_t$ . The following optimality conditions can be derived from the first order conditions of the problem

$$\begin{aligned}
d_{e,t}^{-\frac{1}{\sigma}} \left[ q_t - \left( 1 - \frac{\partial \Phi_e(B_{e,t})}{\partial B_{e,t}} \right) m_{e,t}^H E_t \left( \frac{q_{t+1}}{R_{e,t+1}} \right) \right] \\
= \Lambda_{0,t}^e E_t \left\{ d_{e,t+1}^{-\frac{1}{\sigma}} \left[ q_{t+1} (1 - m_{e,t}^H) + \eta \left( \frac{Y_{t+1}}{H_{e,t}} \right) \right] \right\}
\end{aligned} \tag{B.14}$$

$$d_{e,t}^{-\frac{1}{\sigma}} \left[ W_t + m^N W_t \left( 1 - \frac{\partial \Phi_e(B_t)}{\partial B_t} \right) - (1 - \alpha - \eta) \frac{Y_t}{N_t} \right] = \Lambda_{0,t}^e E_t \left[ d_{e,t+1}^{-\frac{1}{\sigma}} m^N W_t R_{e,t+1} \right] \tag{B.15}$$

$$d_{e,t}^{-\frac{1}{\sigma}} q_t^k = \Lambda_{0,t}^e E_t \left\{ d_{e,t+1}^{-\frac{1}{\sigma}} \left[ q_{t+1}^k (1 - \delta_t^k) + \alpha \left( \frac{Y_{t+1}}{k_{e,t}} \right) \right] \right\} \tag{B.16}$$

$$\delta_1^k + \delta_2^k (u_t - 1) = \alpha \left( \frac{Y_t}{u_t k_{e,t-1}} \right) \tag{B.17}$$

## B.4 Bankers

The representative banker chooses the trajectories of dividend payouts  $d_{b,t}$ , loans to households  $B_{i,t}$ , loans to entrepreneurs  $B_{e,t}$ , and deposits  $D_t$  that maximize (32) subject to a cash flow restriction and a borrowing limit (capital adequacy constraint)

$$\begin{aligned}
d_{b,t} + B_{it} + B_{e,t} - D_t - (1 - \delta_t) (B_{i,t-1} + B_{e,t-1} - D_{t-1}) \\
= r_{e,t} B_{e,t-1} + r_{i,t-1} B_{i,t-1} - r_{d,t-1} D_{t-1} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - \varphi(d_{b,t})
\end{aligned} \tag{B.18}$$

$$D_t = \gamma_{i,t} B_{i,t} + \gamma_{e,t} B_{e,t} \tag{B.19}$$

In order to incorporate the information of the balance sheet constraint in the optimization problem, there has been rearranged in equation (33) to substitute  $K_{b,t}$  in expression (34). The law of motion for bank equity reads

$$K_{b,t} = J_{b,t} - d_{b,t} + (1 - \delta_t) K_{b,t-1} \tag{B.20}$$

The resulting optimality conditions read

$$\frac{(1 - \gamma_{i,t}) + \frac{\partial \Phi_{bi}(B_{i,t})}{\partial B_{i,t}}}{d_{b,t}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t} - d_t^*)]} = \Lambda_{0,t}^b E_t \left\{ \frac{(r_{i,t} - \gamma_{i,t} r_{d,t}) + (1 - \gamma_{i,t})(1 - \delta_t)}{d_{b,t+1}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t+1} - d_t^*)]} \right\} \quad (\text{B.21})$$

$$\frac{(1 - \gamma_{e,t}) + \frac{\partial \Phi_{be}(B_{e,t})}{\partial B_{e,t}}}{d_{b,t}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t} - d_t^*)]} = \Lambda_{0,t}^b E_t \left\{ \frac{(r_{e,t+1} - \gamma_{e,t} r_{d,t}) + (1 - \gamma_{e,t})(1 - \delta_t) \varepsilon_t^{kb}}{d_{b,t+1}^{\frac{1}{\sigma}} [1 + \kappa(d_{b,t+1} - d_t^*)]} \right\} \quad (\text{B.22})$$

## B.5 Capital Goods Producers

Capital-good-producing firms seek to maximize (36) with respect to net investment in physical capital,  $I_t$ . The resulting optimal condition is

$$1 = q_{k,t} \left[ 1 - \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 - \psi_I \left( \frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} \right] + E_t \left[ \Lambda_{0,t}^e q_{k,t+1} \psi_I \left( \frac{I_{t+1}}{I_t} - 1 \right) \left( \frac{I_{t+1}}{I_t} \right)^2 \right] \quad (\text{B.23})$$

As standard in the literature, the law of motion for physical capital reads

$$K_{e,t} = (1 - \delta_t^k) K_{e,t-1} + I_t \left[ 1 - \frac{\psi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \quad (\text{B.24})$$

## B.6 Macroprudential Authority

As in the basic model, the dividend prudential target is specified as follows

$$d_t^* = \rho_d + \rho_x \left( \frac{x_t}{x^{ss}} - 1 \right) \quad (\text{B.25})$$

Bank dividend deviations from such target are penalized with a proportional payment that takes the form of a sanction. Such penalty payments are transferred within the same period to bank owners. The corresponding net subsidy reads

$$T_t = \frac{\kappa}{2} \left[ (d_{b,t}^a - d_t^*)^2 - (d_{b,t} - d_b^{ss})^2 \right] \quad (\text{B.26})$$



The prudential authority has full control over the banker's regulatory capital ratio  $(1 - \gamma_t)$  through the leverage ratio imposed by the borrowing limit (35)

$$\gamma_t = \gamma + \gamma_x \left( \frac{x_t}{x^{ss}} - 1 \right) \quad (\text{B.27})$$

where  $\gamma = \gamma_i \frac{B_i}{B} + \gamma_e \frac{B_e}{B}$ .

## B.7 Aggregation and market clearing

Market clearing is implied by the Walras's law, by aggregating all the budget constraints. The aggregate resource constraint of the economy represents the equilibrium condition for the final goods market.

$$Y_t = C_{p,t} + C_{i,t} + q_t^k I_t + \delta_t K_{b,t-1} + Adj_t \quad (\text{B.28})$$

where the term  $Adj_t$  corresponds to the sum of all resources dedicated in the economy to adjust loans and bank dividends in period  $t$ .

In equilibrium, the housing market clears. The endowment of housing supply is fixed and normalized to unity

$$\bar{H} = H_{p,t} + H_{i,t} + H_{e,t} \quad (\text{B.29})$$

## B.8 Shocks

The following zero-mean, AR(1) shocks are present in the extended model:  $\varepsilon_t^{mh}$ ,  $\varepsilon_t^{mk}$ ,  $\varepsilon_t^{kb}$ ,  $\varepsilon_t^h$ ,  $A_t$ . These shocks follow the processes given by:

$$\log \varepsilon_t^{mh} = \rho_{mh} \log \varepsilon_{t-1}^{mh} + e_{mh,t}, \quad e_{mh,t} \sim N(0, \sigma_{mh}) \quad (\text{B.30})$$

$$\log \varepsilon_t^{mk} = \rho_{mk} \log \varepsilon_{t-1}^{mk} + e_{mk,t}, \quad e_{mk,t} \sim N(0, \sigma_{mk}) \quad (\text{B.31})$$

$$\log \varepsilon_t^{kb} = \rho_{mk} \log \varepsilon_{t-1}^{kb} + e_{kb,t}, \quad e_{kb,t} \sim N(0, \sigma_{mk}) \quad (\text{B.32})$$

$$\log \varepsilon_t^h = \rho_h \log \varepsilon_{t-1}^h + e_{h,t}, \quad e_{h,t} \sim N(0, \sigma_h) \quad (\text{B.33})$$

$$\log A_t = \rho_A \log A_{t-1} + e_{A,t}, \quad e_{A,t} \sim N(0, \sigma_A) \quad (\text{B.34})$$

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