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Rethinking capital regulation: the case for a dividend prudential target

Abstract

Recent empirical studies have documented two remarkable patterns shown by euro area banks in the aftermath of the Great Recession: (i) their tendency to boost capital ratios by shrinking assets (contraction of loans supply), and (ii) their reluctance to cut back on dividends (fall in retained earnings). First, I provide evidence of a potential link between these two trends. When shocks hit their profits, banks tend to adjust retained earnings to smooth dividends. This generates bank equity and credit supply volatility. Then I develop a DSGE model that incorporates this mechanism to study the transmission and effects of a novel macroprudential policy rule - that I shall call Dividend Prudential Target (DPT) - aimed at complementing existing capital regulation by tackling this issue. Welfare-maximizing DPTs are effective (more than the CCyB) in smoothing the financial and the business cycle (by means of less volatile retained earnings) and induce significant welfare gains associated to a Basel III-type of capital regulation through various channels.

Keywords: dividend restrictions, countercyclical capital buffer (CCyB), capital requirements, macroprudential policy, DSGE models.

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

Non-technical Summary

In the aftermath of the Great Recession, euro area banks presented two remarkable patterns that are potentially intertwined: (i) their reluctance to cut back on dividends (despite the environment of low profitability) and, (ii) their tendency to boost their capital ratios primarily by shrinking assets (while virtually the rest of the world was doing so by increasing capital). A reduction in total assets that mainly took the form of a contraction in outstanding customer loans. The strong preference bankers have for smoothing dividends in a context of capital requirements in which the economy is hit by a severe negative shock provides managers with incentives to meet their target capital ratios by shrinking assets rather than by retaining earnings.

Beyond the impact they may have on bank solvency, current dividend payout policies seem to exacerbate the credit cycle, with the corresponding negative effects this may have on financial stability and social welfare. Current capital legislation allows for this unintended macroeconomic effect since it says little about the channels through which banks should adjust their capital ratios and gives such institutions "full discretion" to set their own payout policies provided that they comply with their corresponding capital requirements.

Against this background, I develop a DSGE model that incorporates this mechanism in order to study the transmission channels and effects of a novel macroprudential rule - that I shall call Dividend Prudential Target (henceforth DPT) - aimed at complementing existing capital regulation by tackling this issue. The model: (i) emphasizes the relevance of retained earnings for the capital generation capacity of banks by assuming that equity accumulates out of retained earnings, (ii) reproduces the patterns of euro area banking aggregates such us earnings, dividends, or the payout ratio, (iii) highlights how banks' strong preference for smoothing dividends in a context of capital requirements induces lending volatility, and (iv) implicitly assumes that banks never fail to meet their capital requirements in order to focus the analysis on a possibility that has not been incorporated in the Basel III Accords; to regulate bank dividend policies even when credit institutions comply with their capital requirements.

The Dividend Prudental Target can be defined as a macroprudential policy rule that sets a regulatory target which banks should take as a reference when setting their dividend payouts. Such target reacts to deviations of a macroeconomic indicator of the choice of the regulator (e.g., the credit-to-GDP gap) from its trend. If the DPT increases in response to

positive deviations of the selected macroeconomic indicator from its trend, the rule is said to be countercyclical as it presumably favors retained earnings and lending smoothing. In order for the policy rule to be effective, the DPT is associated to a sanctions regime that penalizes bankers who deviate from the regulatory target.

Regardless of whether the objective of the prudential authority is to minimize a measure of the credit cycle or to maximize a measure of social welfare, the optimal DPT calls for pro-cyclical an relatively more volatile dividend payouts (i.e., the optimal rule is countercyclical). Interestingly, optimized DPTs are more effective in smoothing the financial and the business cycle than highly responsive counter-cyclical capital buffers (henceforth CCyB) due to the difference between the transmission mechanisms through which each of these instruments operate. Under the CCyB, bank capital readjusts in the face of shocks, permitting debt to evolve in a smoother fashion. By way of contrast, the DPT directly attacks the root of the "problem" (i.e., dividend smoothing in a context of capital requirements) by providing bank managers with incentives to tolerate a higher degree of dividend volatility. That is, while the CCyB induces lending smoothing through less volatile bank debt (i.e., the adjustment in the face of exogenous shocks is borne by bank equity), the DPT does it by stabilizing retained earnings and bank equity (i.e., a higher proportion of the adjustment in the face of exogenous shocks is now borne by dividends).

The quantitative analysis presented in the paper points to the existence of important complementarities between a countercyclical DPT and a Basel III-type of capital regulation. First, the DPT is particularly effective in mitigating the negative effects induced by capital ratio adjustments in terms of more restricted and volatile lending. Second, and with regards to the relationship between the DPT and the CCyB, while households who do not own banks have a strict preference for the DPT (as it is more effective in smoothing lending than the CCyB), those who own banks prefer the CCyB (as it allows them to avoid the negative effect of the DPT in terms of higher bank dividend volatility while still benefitting from a non-negligible lending smoothing effect). Third, jointly calibrating the DPT and the CCyB allows to improve the effectiveness of macroprudential capital regulation in smoothing the financial (and the business) cycle when financial shocks hit the economy. In addition, optimal DPTs seem to perform considerably better than the CCyB in the face of non-financial shocks (in line with this finding, several studies have recently suggested that the effectiveness of the CCyB is higher under financial shocks than under non-financial shocks).

1 Introduction

As a result of the pressure exerted by the private and the public sector, banks in the euro area (and elsewhere) had to increase their risk-weighted capital ratios in the aftermath of the global financial crisis. However, contrary to what happened in the rest of the world, European banks primarily improved such ratios by shrinking assets, thereby exacerbating the problem of credit supply procyclicality.

Cohen and Scatigna (2016) show that for the period 2009-2013 the euro area banking sector boosted regulatory capital ratios mainly via asset shrinking, while virtually the rest of the world did so by accumulating retained earnings. Gropp et al. (2018), show that European banks which had to raise their core tier 1 capital ratios in response to the EBA 2011 capital exercise did it by shrinking assets. A reduction in total assets that has been mainly attributed to a contraction in outstanding customer loans.

As suggested in the 84th BIS Annual Report (2014) and Shin (2016), banks in the euro are failed to boost capital ratios by increasing retained earnings due to their relatively strong reluctance to cut back on dividends. According to the evidence, large and established corporations (including banks) distribute a significant percentage of their profits in the form of dividends and tend to smooth them over the cycle (see, e.g., Lintner 1956, Allen and Michaely 2003 and DeAngelo et al. 2009). There is, however, little agreement on why managers have such a preference for smoothing dividends and what determines their propensity to smooth (see, e.g., Leary and Michaely 2011).

The joint consideration of all available evidence on these matters points to a potential link between these two trends. Bankers' preference for smoothing dividends implies that the bulk of the adjustment to exogenous shocks that hit bank profits is mainly borne by retained earnings, thereby generating bank equity and credit supply volatility (through a balance sheet effect). Current capital legislation allows for this unintended macroeconomic effect, since it says little about the channels through which banks should adjust their capital ratios and gives such institutions "full discretion" to set their own payout policies provided that they comply with the corresponding capital requirements.[1]

The main contribution of this paper is to define a very simple framework that incorporates this mechanism to study the transmission channel and effects of a novel macroprudential rule

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[1] For payout policy purposes, the relevant capital adequacy ratio that should be met by credit institutions comprises, for the general case, the minimum capital requirement (8%), the capital conservation buffer or CCoB (2.5%), and the countercyclical capital buffer or CCyB ($\geqslant 0\%$) as an add-on to the CCoB.

- that I shall call Dividend Prudential Target (henceforth DPT) - aimed at complementing existing capital regulation by tackling this issue.

In order to do so, I develop a quantitative DSGE model with a banking sector. Households (net savers), entrepreneurs (net borrowers) and bankers - interact in a real, closed, decentralized and time-discrete economy in which all markets are competitive. As in Iacoviello (2015): (i) borrowers and bankers are constrained in their capacity to borrow due to the existence of collateral constraints and regulatory capital ratios, respectively, and (ii) the relationship between the discount factors of the three types of agents is such that: (i) there are financial flows in equilibrium, and (ii) the borrowing constraints are binding in a neighborhood of the steady state. These implications are crucial to focus the analysis on a possibility neither considered in the macro-finance literature (to the best of my knowledge) nor incorporated in the Basel III Accords: To regulate bank dividend policies even when credit institutions comply with their capital requirements.

As in Gerali et al. (2010), bank equity accumulates out of retained earnings with a functional form identical to the standard law of motion for physical capital. Such assumption allows for the model to account for: (i) the crucial link between profit and capital generation capacity within the banking sector, and (ii) the non-trivial intertemporal decision bankers have to make when it comes to earnings distribution. The preference of the representative banker for paying large amounts of dividends and for smoothing such payouts over time (accounted for by a relatively low subjective discount factor and a CES utility function, respectively) conflicts with her obligation to retain earnings and meet capital requirements as well as with her will to expand the bank's profit generation capacity (and, thus, its earnings distribution capacity) over time. In addition, credit institutions face a balance sheet constraint, by which bank assets (one-period loans extended to borrowers) must be fully financed by equity and debt (one period deposits borrowed from savers) in each period. This allows for a simple mechanism through which: (i) adjustments in retained earnings affect credit supply, and (ii) exogenous shocks that hit the real economy through the financial sector get amplified. In a nutshell, the model incorporates a mechanism by which bankers' preference for dividend smoothing in a context of borrowing limits (including capital requirements), induces suboptimally high aggregate equity and credit supply volatility.

Against this background, I design a macroprudential policy rule aimed at giving incentives for bankers to tolerate a higher degree of dividend volatility in order to sustain retained earnings and loans supply in economic downturns. The DPT is a regulatory target for

bank dividend payouts that reacts to steady state deviations of a macroeconomic indicator of the choice of the regulator (i.e., it is dynamic) and enters a quadratic penalty function whose specification is analogous to the dividend adjustment cost assumed in Jermann and Quadrini (2012) and Begenau (2019). Such specification of the sanctions regime allows to strike a balance between enforcement (it penalizes bankers who deviate from the DPT) and flexibility of the policy rule (it allows for bankers to deviate from the target conditional on the payment of a sanction).

In the baseline scenario, the only existing prudential policy instrument is static capital requirements. In alternative policy scenarios, dynamic capital requirements and dividend prudential targets are introduced to study the interactions, transmission mechanisms and key macroeconomic effects of these policy instruments. Dynamic capital requirements are specified as the complementary of a bank debt-to-assets ratio that responds to steady state deviations of a macroeconomic indicator of the choice of the regulator.

First, I identify the mechanism through which the DPT operates and give a first quantitative assessment on its potential to smooth the credit cycle. Then, I extend the model to carry out a welfare analysis of the regulatory scheme under consideration. I incorporate another type of borrower (impatient households), physical capital, various macroeconomic and financial exogenous shocks, and additional ingredients (e.g., GHH preferences and investment adjustment costs) that allow me to calibrate the model to quarterly data of the euro area for the period 2002:I - 2018:II, and match a number of first and second moments from banking and macroeconomic aggregates (including bank assets, profits, dividends and the payout ratio, among others).

As in Clerc et al. (2015), I assume that households own all existing firms in the economy (including banks), which has two important implications. First, there is a separation between bank ownership and bank management that allows to capture the two main channels through which dividend smoothing operates according to the evidence; bank owners' risk aversion and managers' propensity to smooth dividends (see, e.g., Wu 2018). Second, the welfare analysis can be restricted to households without neglecting any consumption capacity generated in the economy. Optimized policy rules are obtained by maximizing a measure of social welfare - defined as a weighted average of the expected lifetime utility of the two types of households - with respect to the relevant policy parameter vector and for different welfare weighting criteria.

Optimized DPTs are countercyclical (i.e., they call for procyclical and relatively more

volatile dividends in order to smooth aggregate lending and output through more stable retained earnings) and trade off the key conflictive welfare effects induced by this macroprudential instrument. On the one hand, a more responsive countercyclical DPT favours credit smoothing, which is beneficial for borrowers. On the other hand, it induces bank dividend volatility, which has a negative impact on bank owners' welfare.[2] Such welfare trade-off primarily originates from households' risk aversion, by which such agents implicitly prefer their resources to evolve in a smooth fashion (including credit and distributed earnings). The shape of such trade-off (and, thus, the responsiveness degree of optimized DPTs) crucially depends on bank managers' CES preferences, which account for the stylized fact of managers' propensity to smooth dividends (while remaining agnostic about the underlying drivers of such preference) and permit to accurately match the second moment of bank dividends.

Welfare-maximizing dividend prudential targets are shown to have important properties. First, they are more effective in smoothing the financial and the business cycle than the counter-cyclical capital buffer (henceforth CCyB) due to a key difference between their corresponding transmission mechanisms.[3] Second, they complement existing capital regulation and induce welfare gains associated to a Basel III-type of framework through various channels: (i) they are particularly effective in mitigating the negative effects of hikes in static (or microprudential) capital requirements in terms of more restricted and volatile credit supply;[4] (ii) they reinforce the effectiveness of the CCyB in mitigating financial and economic fluctuations regardless of the nature of the shock and perform particularly better than the CCyB under non-financial shocks; and (iii) they allow to strike a balance between the strong preference households who do not own banks have for the DPT and the relevance the CCyB has for bank owners.[5] Third, they mainly operate through their cyclical component, ensuring

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[2]Although less determinant, if the degree of responsiveness of the DPT is sufficiently high, a third welfare effect, by which the macroprudential rule tends to moderately restrict credit provision, comes into play.

[3]Both macroprudential tools smooth loans supply, but operate through very different transmission mechanisms: Under the CCyB, bank capital readjusts in the face of shocks, permitting debt (which in the face of a negative shock represents a larger proportion of assets) to evolve in a smoother fashion. By way of contrast, the DPT directly attacks the root of the "problem" (i.e., bank dividend smoothing) by giving incentives for bank managers to optimally tolerate a higher degree of dividend volatility, thereby allowing for smoother retained earnings.

[4]Higher capital requirements translate into a higher fraction of bank loans being financed by bank capital accumulated out of "volatile" retained earnings and higher long run profits (and dividends). The former quantitatively magnifies the problem of a higher lending supply volatility induced by adjustments in retained earnings whereas the latter reinforces the effectiveness of DPTs in tackling the issue.

[5]While households who do not own banks have a strict preference for a countercyclical DPT (since it is more effective than the CCyB in smoothing loans supply and other aggregates of the real economy), bank

that long-run dividend payouts remain unaffected. Fourth, they are associated to a sanctions regime that acts as an insurance scheme for the real economy.[6]

The paper is organized as follows. Section 2 discusses how the paper fits into the existing literature. Section 3 presents empirical evidence on bank dividends and earnings in the euro area. Section 4 describes the basic model and identifies the transmission mechanism through which a dividend prudential target smooths the credit cycle. Section 5 presents the extended model to improve the matching of the model to the data. Section 6 develops a quantitative exercise to assess the welfare effects of the DPT and its interactions with regulatory capital ratios. Section 7 concludes.

2 Related Literature

This paper relates to recent work that attempts to motivate the desirability of regulating earnings distributions under certain conditions. Based on U.S. banking data for the period 2007-2009, Acharya et al. (2012), suggest the imposition of regulatory sanctions against large scale payments of dividends that erode common equity. Similarly, Admati et al. (2013) advocate dividend restrictions and capital conservation in bad times. Goodhart et al. (2010) and Acharya et al. (2017) provide theoretical rationale for the use of dividend restrictions for banks under various conditions, suggesting that this regulatory measure would be beneficial not only to debt holders but also to equity holders. In these two-period models, the justification for imposing dividend restrictions relates to a private equilibrium that features excessive dividends and inefficiently low bank capitalization.

This paper contributes to this strand of literature by adopting a DSGE modeling approach to assess the effectiveness of a very specific macroprudential policy rule aimed at breaking the nexus between bankers' preference for dividend smoothing and credit supply volatility. The proposed regulatory scheme plays a key role as a macroprudential tool in an environment in which banks are assumed to constantly meet their capital requirements (and there is no risk of bank failure). The key mechanism through which the regulatory scheme plays such

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owners prefer the CCyB (as it favours credit smoothing without inducing higher bank dividend volatility).

[6]During the economic downturn, deviations from the DPT are penalized with a sanction. The corresponding public revenues collected by the public authority are transfered - within the same period - to households (and/or entrepreneurs). Such transfer system acts as an insurance scheme to the real economy as it provides economic agents of the non-financial private sector with a positive payoff when they need it the most (i.e., when the marginal utility of their consumption is relatively high).

a role is by providing incentives to bank managers to tolerate a higher degree of dividend volatility, thereby smoothing retained earnings and credit supply. The proposed prudential tool is analyzed in a quantitative macro model that matches a number of first and second moments of macro and banking data of the euro area. That allows the paper to study the type of welfare trade-offs and effects that would be induced by this prudential tool in the euro area economy, as well as its interactions with a Basel III type of capital regulation. The design and key features of the proposed policy instrument notably differ from those of dividend restrictions presented in the literature.

The paper also connects to the banking literature that quantifies the effects of capital regulation (see, e.g., Van den Heuvel 2008, Angelini, Neri and Panetta 2014, De Nicolò, Gamba and Lucchetta 2014, Martinez-Miera and Suarez 2014, Mendicino et al. 2018, and Corbae and D'Erasmo 2019). A common feature of these models is that higher capital requirements lead to more restricted and volatile lending. Although the proposed model accounts for this effect, the channel through which it emerges is quite novel; a hike in capital requirements translates into a higher proportion of bank assets being financed by "volatile" equity, that induces larger fluctuations in credit supply (i.e., "balance sheet effect"). This effect is to be traded off against two other effects; (i) a "loan portfolio readjustment effect" that has an asymmetric impact on impatient households and entrepreneurs and only emerges when the corresponding hike in capital ratios is associated to a change in relative sectoral capital requirements, and (ii) a "profit generation capacity effect" through which increased capital requirements (and cumulative retained earnings) translate into higher long run dividend payouts. Furthermore, the DPT incorporates an important welfare trade-off that interacts with that of capital requirements. A countercyclical DPT smooths lending while it induces higher bank dividend volatility. In order to clearly identify these trade-offs and keep the complexity of the analysis to a minimum, the model abstracts from other effects of changing capital regulation parameters such as reducing the risk of bank failure (see, e.g., Angeloni and Faia 2013, and Clerc et al. 2015) or the risk taking by banks (see, for instance, Admati et al. 2012, and Begenau 2019).

Finally, the proposed model builds on recent work that attempts to incorporate banking in otherwise standard DSGE models. Among others, Gerali et al. (2010), Gertler and Kiyotaki (2010), Meh and Moran (2010), Gertler and Karadi (2011), Andrés and Arce (2012), Brunnermeier and Sannikov (2014), Christiano, Motto and Rostagno (2014), and Iacoviello (2015). As in most of these papers, the main role of the banking sector in this model is to

allow for resource transfers between savers and borrowers. In the tradition of Bernanke et al. (1999) and Kiyotaki and Moore (1997), the presence of certain frictions enables financial intermediation activities to endogenously propagate and amplify shocks to the macroeconomy.[7] However, most of this work makes assumptions that imply either that bank payout policies are exogenous and/or that the payout ratio is very low and constant over time. Aspects which are sharply at odds with reality and which do not permit to carry out the analysis proposed in this paper.

3   Patterns of Bank Dividends and Earnings in the Euro Area

This section presents the main empirical observations that motivate the paper. Financial data plotted in figures 1 and 2 is from the Euro Stoxx Banks Index, SX7E.[8] All time series are at quarterly frequency and have been seasonally adjusted.[9] Figure 1a plots aggregate dividends in cash and earnings (net income) of the SX7E members for the period 2002:I-2018:II. While both variables are procyclical, earnings are substantially more volatile than dividends. Bank managers in the euro area have a strong preference for smoothing dividends over the cycle and pay high and stable amounts of dividends in cash even in those quarters in which net income is negative. That is, the adjustment in the face of shocks that hit bank profits is mainly borne by undistributed net income. That has two important consequences. First, the dividend payout ratio of the euro area banking sector is notably countercyclical (figure 1b), implying that bankers distribute a higher proportion of total earnings precisely when their capital positions are prone to be weaker (i.e., during the economic slowdown).[10]

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[7]In the proposed set-up, borrowing limits emerge as the key distortion that separates this equilibrium economy from its first best and allows for the proposed regulatory scheme to potentially be welfare-improving.

[8]The Euro Stoxx Banks Index, SX7E, is a capitalization-weighted index in which the largest stocks in the EMU banking sector 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%).

[9]See Appendix A for details on data construction.

[10]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

Second, this fact significantly affects equity dynamics as retained earnings account for the bulk of total equity and the two variables are highly correlated (figure 1c).[11]

Figure 2 reports the cyclical component of selected aggregates to identify comovements (i.e., patterns of positive correlation) among bank (cumulative) retained earnings, equity, assets and real GDP.[12] Figure 2a confirms that retained earnings and total equity are highly correlated, suggesting that the former is an important driver of bank equity volatility. Due to the importance of bank capital as a funding source and to the extent that the balance sheet identity always has to hold, it does not come as a surprise that the correlation between bank equity and bank assets (as a proxy for aggregate bank loans supply) is also very high and positive (figure 2b). The bottom line is that there is a high degree of comovement among bank retained earnings, lending and real GDP (see figures 2c and 2d).

The reluctance of bankers to cut back on dividends in the face of negative shocks that hit their profits leads to falls in retained earnings and total equity. In order to meet their capital requirements in a context of falling equity and economic slowdown (a period in which issuing new equity is often a costly or even impossible task for banks), bank managers have incentives to shrink assets by cutting back on lending. At the aggregate level, this (individual) strategy is prone to exacerbate the credit and the business cycle.

4 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

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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 including a severe financial crisis and deep regulatory changes (in loan-loss provisioning rules, etc).

[11]Time series plotted in figure 1.a have been constructed as a simple sum of the SX7E members whereas those in figures 1b and 1c have been reported as the index itself (i.e., as a capitalization-weighted sum of the same group of banks).

[12]Financial data plotted in figure 2 has been constructed as a simple sum of the SX7E members. In order to compute their cyclical component, the log value of seasonally adjusted and deflated time series has been lineraly detrended. These are some of the constructed time series that have been used to calibrate the extended model by matching second moments of euro area quarterly data in section 6.

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, 2015), 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. Such financial frictions 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 policy operates. In doing so, the paper evaluates its effectiveness in favouring financial stability by smoothing the credit cycle.

4.1 Main Features

4.1.1 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

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

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. $\beta_h \in (0, 1)$ is the households' subjective discount factor, j is the preference parameter for housing services and ϕ 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.

4.1.2 Entrepreneurs (net borrowers)

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

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \log C_{e,t} \tag{2}$$

subject to the sequence of budget constraints

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

with $\beta_e < \beta_h$. $B_{e,t}$ stands for bank loans, $R_{e,t}$ is the gross interest rate on loans, and $\Phi_e(B_{e,t}) = \dfrac{\phi_e}{2} \dfrac{(B_{e,t} - B_{e,t-1})^2}{B_e^{ss}}$ is a quadratic loan portfolio adjustment cost, assumed to be external to the entrepreneur as in Iacoviello (2015).[13] Y_t is final output. B_e^{ss} is the steady-state value of $B_{e,t}$ and ϕ_e is the loans adjustment cost parameter. Each period, the representative entrepreneur devotes her resources in terms of produced final output and loans to consume, repay her 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:[14]

$$Y_t = H_{e,t-1}^v N_t^{1-v}. \tag{3}$$

In addition, entrepreneurs are subject to:

$$B_{e,t} \leq m_t^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_{h,t} N_t. \tag{4}$$

Expression (4) 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 ε_t^{mh} follows a zero-mean

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[13]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.

[14]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).

AR(1) process with autorregressive coefficient equal to ρ_{mh} and i.i.d innovations $e_{mh,t}$ that are normally distributed and have a standard deviation equal to σ_{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 Neumeyer and Perri (2005).[15]

4.1.3 Bankers

Let $d_{b,t}$ represent bank dividends (which are fully devoted to final consumption by bankers) in period t, and $\beta_b < \beta_h$. The representative banker seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_b^t \log d_{b,t}, \tag{5}$$

subject to

$$B_t = K_{b,t} + D_{b,t}, \tag{6}$$

$$d_{b,t} + K_{b,t} - (1-\delta)K_{b,t-1} = r_{e,t}B_{t-1} - r_{h,t-1}D_{b,t-1} - \Phi_b(B_t), \tag{7}$$

$$D_{b,t} \leq \gamma B_t, \tag{8}$$

where equations (6), (7) and (8) denote the balance sheet identity, the sequence of cash flow restrictions, and the borrowing constraint of the banker, respectively.

According to (6), 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, $D_{b,t}$, 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 proposed in Gerali et al. (2010):[16]

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[15]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.

[16]Expression (9) only differs from the law of motion for bank capital proposed in Gerali et al. (2010) in that these authors assume net profits are fully retained, period by period (i.e., there is no bank payout policy whatsoever).

$$K_{b,t} = J_{b,t} - d_{b,t} + (1-\delta)K_{b,t-1}, \tag{9}$$

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 (9), bank net profits can be decomposed into three terms:

$$J_{b,t} = \underbrace{\underbrace{(K_{b,t} - K_{b,t-1})}_{\text{reinvested profits}} + \underbrace{\delta K_{b,t-1}}_{\text{eroded equity}}}_{\text{retained earnings}} + \underbrace{d_{b,t}}_{\text{distributed earnings}}, \tag{10}$$

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.

The definition of bank equity as a stock variable that accumulates over time out of retained earnings is a crucial assumption due to empirical-related reasons. First, an important proportion of total bank equity is accumulated out of retained earnings in practice (see figure 1c). Second, expression (9) plays a key role in incorporating the empirical link between payout policies and capital ratio adjustments (discussed in section 3) in the model by connecting the profit generation capacity of the representative banker (which is essential to distribute high and stable dividends over the cycle) with her capital generation capacity (that is crucial to meet capital requirements). Third, equation (9) allows to map the model to first and second moments of data on bank dividends and earnings (see section 6).

Equation (7) 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 adjustment cost.[17] $r_{e,t}$ and $r_{h,t}$ denote the net interest rates on loans and deposits, respectively.

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[17]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.

Expression (8) 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 regulatory capital ratio.

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

$$\frac{(1 - \gamma) + \dfrac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t}} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma (R_{h,t} - \delta)}{d_{b,t+1}} \right\}. \tag{11}$$

Expression (11) stands for the optimality condition for intertemporal substitution between the part of net income devoted to the dividend payout policy (denominator on each side of equation 11) and that dedicated to the financial intermediation activity (numerator on each side of equation 11). 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 representative banker as a consumer, in the optimum she 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 (11) 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.[18]

Given the interest rate on deposits, expression (11) 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 (11) synthesizes the information of a powerful mechanism for transmission and amplification of shocks that hit bank profits. The preference for dividend smoothing (expression 5) implies that the bulk of the adjustment to shocks that hit profits is going to be made

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[18]By equations (6) and (8), such decision automatically involves borrowing additional γ units of deposits and lending an extra unit of assets.

via retained earnings. Due to the strong link between equity and loans (equations 6 and 8), such fluctuations in retained earnings are going to translate into loans supply volatility.

4.1.4 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 spent in the form of final private consumption, credit adjustment costs and resources devoted to manage the capital position of the bank, $\delta K_{b,t-1}$ (also interpretable as eroded equity):

$$Y_t = C_t + \delta K_{b,t-1} + \Phi_b(B_t) + \Phi_e(B_t), \tag{12}$$

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

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

4.1.5 Macroprudential Policy

Consider two prudential policy scenarios alternative to the above presented baseline case.

Dividend Prudential Target (DPT)   First, assume a policy scenario in which the static capital requirement, $(1-\gamma)$, is complemented by a regulatory scheme comprised of

$$d_t^* = \rho_d + \rho_\chi(\frac{x_t}{x^{ss}} - 1), \tag{13}$$

and

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2} \left(d_{b,t} - d_t^* \right)^2, \tag{14}$$

where d_t^* refers to the dividend prudential target (DPT). ρ_d is the bank dividend payout targeted by the prudential authority in the steady state. x_t is a macroeconomic indicator of the choice of the regulator. ρ_χ, the macroprudential policy parameter of policy rule (13), measures the degree of responsiveness of d_t^* to deviations of x_t from its steady state level.

d_t^* enters a quadratic penalty function of the type (14). $\kappa \geqslant 0$ is the penalty parameter. When $\kappa > 0$, deviating from the dividend prudential target, d_t^*, is costly to bankers. If $d_{b,t} \neq d_t^*$ in period t, the resources paid by the representative banker as a sanction for having deviated, $T(d_{b,t}, d_t^*)$, are transferred by the public authority within the same period to the non-financial sector of the economy (to households and/or to entrepreneurs).[19]

Expression (14) shall be interpreted as a sanctions regime the DPT is associated to with the aim of: (i) striking a balance between enforcement (it penalizes bankers who deviate from the DPT) and flexibility of policy rule (13) (it allows for bankers to deviate from the target conditional on the payment of a sanction), and (ii) penalizing large deviations relatively more than small ones.

Importantly, the transmission of the regulatory scheme mainly takes place through the optimality condition of the representative banker, which now reads

$$
\frac{(1 - \gamma) + \dfrac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t} \left[1 + \kappa(d_{b,t} - d_t^*)\right]} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma(R_{h,t} - \delta)}{d_{b,t+1} \left[1 + \kappa\left(d_{b,t+1} - d_{t+1}^*\right)\right]} \right\}. \tag{15}
$$

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 11). Under a dividend prudential target within the class (13), the regulator aims at discouraging bankers from making adjustments via credit supply by means of more responsive bank dividends (denominator on each side of equation 15).

Dynamic Capital Requirements (CCyB)   In order to compare the transmission channel and effects of the DPT with those of the main macroprudential tool of the Basel III Accord (i.e., the counter-cyclical capital buffer or CCyB), I consider a third scenario in which the debt-to-assets ratio, γ, is augmented with a cyclical component

$$
\gamma_t = \gamma + \gamma_x \left(\frac{x_t}{x^{ss}} - 1\right), \tag{16}
$$

where γ_x is the macroprudential policy parameter associated to the regulatory capital ratio implied by equation (16), $(1 - \gamma_t)$. Note that equations (8) and (11) are directly affected by this new policy environment.

There is a strand of literature on macro-banking models that attempts to evaluate the

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[19]Note that such transfer will be reflected in the corresponding budget and flow of funds constraints.

effects of the so-called countercyclical capital buffer (CCyB) by specifying a dynamic regulatory capital ratio similar to the one associated to policy rule (16) (see, e.g., Angelini et al. 2014, Clerc et al. 2015, and Mendicino et al. 2018). However, most of these models do not capture an implicit characteristic of the CCyB that is relevant for the purpose of this paper.

Since this buffer is specified as a dynamic add-on to the conservation buffer, in practice the CCyB can be interpreted as a very particular "one-sided" dynamic restriction on banks' payout policies.[20] The combination of expressions (9) and (16) accounts for the essence of this characteristic. As it will become evident in the numerical exercise, countercyclical dynamic capital requirements tend to restrict bankers' capacity to distribute earnings during the upturn (since they have to meet a higher capital ratio, to some extent by accumulating more capital out of retained earnings).

4.2 Numerical Exercise

The aim of this numerical exercise is to identify the transmission mechanism through which the DPT works and to quantitatively assess its potential to tame the credit cycle in the face of financial (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 corresponding vector of policy parameters.[21]

4.2.1 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 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, β_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%.

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[20] "One-sided" because the CCyB can never be negative. Recall that according to the Basel III Accord, banks can only distribute earnings as long as they meet their minimum capital requirements plus the conservation buffer. Thus, changes in the CCyB involve changes in this restriction on equity distribution.

[21] 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 6 for the extended model.

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, υ, 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.

The loan-to-value ratio on housing, m_H and the inverse of the Frisch elasticity of labor, ϕ, are set to standard values of 0.7, 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.

4.2.2 The Transmission Mechanism of Dividend Prudential Targets

Figure 3 plots the response of some key banking and financial aggregates to a negative collateral shock.[22] The shock triggers a credit crunch that negatively affects bank net profits. In line with the evidence shown in section 3, 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 countercyclical since the adjustment is mainly borne by retained earnings.

The starred and dotted lines correspond to an economy in which the macroprudential authority is assumed to solve the following problem with respect to selected parameters of policy rules (13), and (16) respectively

$$\arg\min_{\Theta} L^{mp} = \omega_z \sigma_z^2, \qquad \omega_z > 0 \ , \tag{17}$$

where Θ refers to the vector of policy parameters with respect to which the policymaker solves the optimization problem and σ_z^2 is the asymptotic variance of a macroeconomic indicator of

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[22]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 6 of this paper discusses the main macroeconomic effects of the proposed prudential instrument to a variety of shocks.

the choice of the regulator. Due to its relevance in macroprudential policy decision-making, x_t and z_t have both been chosen to be the loans-to-output ratio. Based on the literature, the preference parameter ω_z and the parameter of the penalty function (14), κ, are set to 1 and 0.426, respectively.[23]

In order to identify the optimal simple rule within the class (13) that solves (17), it has been searched over a multidimensional grid of parameter values, which can be defined as follows. ρ_d $\{0-1\}$, ρ_x $\{(-150)-150\}$. The choice of the search grid deserves a thorough explanation. First, ρ_d refers to the dividend payout targeted by the prudential authority in the steady state. Taking that into account and normalizing the values for ρ_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 has been chosen for ρ_x, as the dynamics of this policy rule is largely unknown.

There has been searched within the baseline calibration model. The values that correspond to the optimized policy rule are the following: $\rho_d = 0.504$, $\rho_x = 66.003$. The optimal simple rule within the class (13) that solves (17) under full commitment calls for a countercyclical (i.e., $\rho_x > 0$) and highly responsive dividend prudential target and a steady state dividend payout not far from the one targeted by bankers absent any dividend regulation.[24]

Then, I solve (17) with respect to parameter γ_x of policy rule (16) for the following grid of parameter values: γ_x $\{(-1)-1\}$. Such grid is based upon the Basel III Accord and has been chosen to assess whether the optimized capital buffer in this model is countercyclical (i.e., $\gamma_x < 0$) or not. The optimized policy rule within the class (16) that solves (17) under full commitment corresponds to: $\gamma_x = -0.461$.[25]

Both macroprudential policy rules are effective in smoothing loans supply and the loans-to-output ratio. However, the DPT seems to be relatively more effective than the CCyB due to the different transmission channels through which each of the policy rules operate. Under an optimized dynamic capital requirement, the target capital ratio of the representative banker readjusts. The bulk of such adjustment in the face of an exogenous shock is borne

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[23]0.426 is the estimate Jermann and Quadrini (2012) provide for the parameter of a dividend adjustment cost whose functional form is identical to expression (14), and falls within the range of values typically considered for this parameter in the literature.

[24]Recall that the baseline calibration implies a dividend payout ratio of roughly 0.6.

[25]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.

by bank capital (i.e., ultimately by retained earnings).[26] Consequently, debt - which now represents a larger proportion of total assets - evolves in a smoother fashion (than under the baseline scenario), unambiguously generating a smoothing effect on credit supply. By way of contrast, dividend prudential targets directly attack the root of the "problem" (i.e., dividend smoothing). They provide incentives for bankers to optimally tolerate a higher degree of dividend volatility, thereby allowing for smoother retained earnings, equity and loans supply.

Table 1 reports the prudential losses and optimized policy parameters related to the solution to problem (17), for two alternative arguments of the loss function, $\sigma_z^2 \equiv \left\{ \sigma_B^2; \sigma_{B/Y}^2 \right\}$, two different macroeconomic indicators, $x \equiv \{B; B/Y\}$, and three alternative policy scenarios, $\Theta \equiv \{(\rho_d, \rho_x); \rho_x; \gamma_x\}$. Parts (A) and (B) refer to the cases in which $x_t = B_t$ and $x_t = B_t/Y_t$, respectively. For each part of the table, sections (i), (ii), and (iii) present the results of the solution to the mentioned problem when optimizing with respect to $\Theta = (\rho_d, \rho_x)$, $\Theta = \rho_x$, and $\Theta = \gamma_x$, respectively.

The main findings of this exercise can be summarized as follows. First, and due to the different transmission mechanisms through which they operate, the DPT is more effective in smoothing credit supply and the loans-to-output ratio than dynamic capital requirements.[27] Second, the DPT mainly reduces loans supply volatility through its cyclical component, allowing for tangible macroeconomic effects over the cycle without having to affect long run dividend payouts.[28] Third, the transfer system defined by equation (14) can be interpreted as a sanctions regime that acts as an insurance scheme for the real economy. As noted in figure 2, the net transfer associated to the optimized DPT, $T_t^*(d_{b,t}, d_t^*)$, is countercyclical. That is, its recipients (households and/or entrepreneurs) benefit from a positive payoff when the marginal utility of their consumption is relatively high.

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[26] Note that, under an optimized dynamic capital requirement, the "problem" of dividend smoothing exacerbates (i.e., the proportion of the adjustment suffered by bank profits in the face of an exogenous shock that is borne by retained earnings is larger than under the baseline scenario).

[27] Note that one of the goals of this numerical exercise is to evaluate and compare the potential of policy rules (13) and (16) in taming the credit cycle rather than that of reproducing the precise effects they would generate in reality. Percentage changes induced by such rules in the asymptotic variance of credit gaps are relatively high in this numerical exercise, among other reasons, because the model assumes one-period loans (rather than long-term debt) and the asymptotic variance of the policy instrument does not enter the loss function of problem (17).

[28] Note that the differences in terms of macroprudential losses between solving the optimization problem with respect to ρ_d and ρ_x, and solving it only with respect to ρ_x are small.

5 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.

In this version of the model households own all existing firms (final-good-producing firms, banks and capital-good-producing firms), which has two important implications. First, there is a separation between bank ownership and bank management that allows to capture the two main channels through which dividend smoothing operates according to the evidence (i.e., bank owners' risk aversion and managers' propensity to smooth dividends). Second, as in Clerc et al. (2015) and Mendicino et al. (2018), the welfare analysis can be restricted 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.[29] (ii) By generalizing log utility functions of entrepreneurs and 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 a policy scenario in which both, the DPT and dynamic capital

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[29] 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 Uríbe (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).

requirements operate. The full set of equilibrium equations can be found in Appendix C.

5.1 Overview of the Model

5.1.1 Households

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

$$E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t \left[\frac{1}{1 - \sigma_h} \left(C_{\varkappa,t} - \frac{N_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} + \varepsilon_t^h j \log H_{\varkappa,t} \right], \qquad (18)$$

where $\varkappa = p, i$ denotes the type of household the problem refers to. σ_h stands for the risk aversion parameter of households and ε_t^h captures exogenous housing preference shocks. 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 (18) is restricted to the sequence of budget constraints:

$$C_{p,t} + D_t + q_t(H_{p,t} - H_{p,t-1}) = R_{d,t-1}D_{t-1} + W_t N_{p,t} + \omega_b d_{b,t} + \chi T(d_{b,t}, d_t^*) + \omega_e d_{e,t}, \quad (19)$$

where $d_{e,t}$ refers to earnings distributed by entrepreneurs, $\omega_b \in [0, 1]$ is the fraction of banks owned by patient households and $\omega_e \in [0, 1]$ the proportion of entrepreneurial firms owned by the same agent type. χ 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 proposed regulatory scheme. This is relevant under policy scenarios in which the DPT operates, in which the following inequality may hold, $T(d_{b,t}, d_t^*) \neq 0$.

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

$$C_{i,t} + R_{i,t-1}B_{i,t-1} + q_t(H_{i,t} - H_{i,t-1}) + \Phi_i(B_{i,t})$$
$$= B_{i,t} + W_t N_{i,t} + (1 - \omega_b)d_{b,t} + (1 - \chi)T(d_{b,t}, d_t^*) + (1 - \omega_e)d_{e,t}, \quad (20)$$

$$B_{i,t} \le m_{i,t}^H E_t \left[\frac{q_{t+1}}{R_{i,t}} H_{i,t} \right]. \quad (21)$$

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. $m_{i,t}^H$ captures exogenous shocks to such collateral.

5.1.2 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 λ_t^p and λ_t^i being the Lagrange multipliers of the patient and impatient households' optimization problems, respectively. Then, the representative entrepreneur maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \quad \frac{1}{\left(1 - \frac{1}{\sigma}\right)} d_{e,t}^{\left(1 - \frac{1}{\sigma}\right)}, \quad (22)$$

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

$$d_{e,t} + R_{b,t}B_{e,t-1} + q_t^k \left[K_{e,t} - (1 - \delta_t^k)K_{e,t-1} \right] + q_t(H_{e,t} - H_{e,t-1}) + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t}, \quad (23)$$

$$Y_t = A_t(u_t k_{e,t-1})^\alpha H_{e,t-1}^\eta N_t^{(1-\alpha-\eta)}, \quad (24)$$

$$B_t \le m_{e,t}^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_{h,t} N_t. \quad (25)$$

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 shocks, captured by 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:

$$\delta_t^k \left(u_t \right) = \delta_0^k + \delta_1^k (u_t - 1)^2 + \frac{\delta_2^k}{2} \left(u_t - 1 \right)^2. \tag{26}$$

5.1.3   Bank Managers

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

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

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

$$B_{it} + B_{e,t} = K_{b,t} + D_{b,t}, \tag{28}$$

$$d_{b,t} + K_{b,t} - (1 - \delta_t) K_{b,t-1} = r_{e,t} B_{e,t-1} + r_{i,t-1} B_{i,t-1} - r_{d,t-1} D_{b,t-1} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - T(d_{b,t}, d_t^*), \tag{29}$$

$$D_{b,t} = \gamma_{i,t} B_{i,t} + \gamma_{e,t} B_{e,t}. \tag{30}$$

As for the case of entrepreneurs, in the extended model there is a separation between ownership and management of banks. Importantly, both mechanisms through which dividend smoothing operates in the model - households' risk aversion and managers' propensity to smooth), are incorporated in the bank manager's problem via the stochastic discount factor

and managers' CES preferences, respectively. The loan portfolio is composed of two types of assets, $B_{i,t}$ and $B_{e,t}$, which may differ in two aspects: (i) the complementary of their associated capital requirements, $\gamma_{i,t}$ and $\gamma_{e,t}$, and (ii) their respective adjustment cost parameters. $\delta_t = \delta \varepsilon_t^{kb}$ denotes a possibly time-varying erosion rate of bank equity, where $\delta \in [0,1]$ and ε_t^{kb} captures exogenous shocks to bank capital.[30] The solution to this optimization problem yields two optimality conditions analogous to expression (11), one for each asset class.

5.1.4 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

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \left(q_{k,t} \Delta x_{k,t} - I_t \right),\tag{31}$$

subject to

$$x_{k,t} = x_{k,t-1} + I_t \left[1 - \frac{\psi_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right],\tag{32}$$

where $\Delta x_{k,t} = K_{e,t} - (1 - \delta_t^k)K_{e,t-1}$ 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.

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[30] ε_t^{kb} captures bank capital shocks similar to those considered in Angelini et al. (2014). However, in this paper I assume that ε_t^{kb} hits eroded bank equity, $\delta K_{b,t-1}$, rather than uneroded bank capital, $(1-\delta)K_{b,t-1}$. Since the term $\delta_t K_{b,t-1}$ enters the resource constraint, this is an important consideration in order to ensure that all statistical moments of output as defined in equation (24) are identical to those of aggregate demand as defined in the resource constraint of the model economy (see the aggregate resource constraint in Appendix C) and, thus to guarantee that the model is "properly closed".

6 Quantitative Analysis

6.1 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.[31] First, several parameters are set following convention (table 2A). 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 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 δ_t^k; δ_0^k is fixed to a standard value of 0.025 while, following convention, δ_1^k and δ_2^k are defined as specific fractions of the steady state interest rate on physical capital. 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 (tables 2B and 3). 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%. 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 calibration 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 main types of welfare

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[31] All time series expressed in Euros are seasonally adjusted and deflated. With regards to the matching of second moments, 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.

trade-offs triggered by optimized dividend prudential targets. [32] [33]

The shares in final-good-production of physical capital α and commercial real estate η 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 δ is set to 0.041, which is consistent with a payout ratio of 0.563, in line with the evidence of the SX7E banks' index presented in section 3.[34] Note that after having rearranged in the steady state expression of equation (9)

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

from which the influence parameter δ has on the steady state payout ratio becomes evident. The calibrated values of the complementaries of capital requirements on household loans γ_i and corporate loans γ_e are obtained by solving a system of two linear equations:

$$0.895 = \gamma_i \frac{B_i^{ss}}{B^{ss}} + \gamma_e \frac{B_e^{ss}}{B^{ss}}, \tag{33}$$

$$(1 - \gamma_e) = 2.1176(1 - \gamma_i). \tag{34}$$

Equation (33) is the result of equating the steady state leverage ratio to 0.895 after having normalized expression (30) to total loans. Its interpretation is straightforward. The equilibrium capital requirement is a weighted average of the two sectorial capital requirements,

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[32] The assumption by which both, patient and impatient households can potentially own banks and non-financial corporations in the model is empirically relevant. However, there is no evidence on what proportion of each type of firms are owned by each type of household. Thus, and given the targeted steady state ratios in the calibration, it is desirable to assume that each type of representative household fully owns in isolation one of the two main types of firms in order to clearly identify the relevant welfare trade-offs. Of course, that requires main results of the welfare analysis to be taken cautiously and interpreted accordingly.

[33] 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 β_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.

[34] This result is aligned with Lintner (1956), and subsequent literature, who found that corporations target a payout ratio of roughly 55%.

$(1 - \gamma_e)$ 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 (34) 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.[35]

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 ψ_I is set to target a relative standard deviation of investment of 2.642 %. The adjustment cost parameter on household loans ϕ_i is fixed to a value of 0.511, 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 ϕ_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 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 opted to account for the stylized fact of managers' preference for dividend smoothing by means of a CES utility function (and matched the second moment of bank dividends by calibrating parameter σ) rather than by assuming linear preferences and a dividend adjustment cost function (in the baseline scenario) of the type (14) (and attempted to match the second moment of dividends by calibrating parameter κ), as elsewhere in the literature (see, e.g., Jermann and Quadrini 2012 and Begenau 2019), for two main reasons: (i) the latter specification does not permit to match the relative volatility of aggregate bank dividends with a sufficient degree of accuracy, and (ii) even though a careful microfoundation of the potential forces underlying managers' preference for dividend smoothing is beyond the scope of this paper, assuming that the origin of this phenomenon relates to individual preferences seems more reasonable

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[35]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 %.

than associating it to an external adjustment cost parameter.[36] 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 σ 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).

6.2 Welfare Analysis

This section investigates the main welfare consequences of complementing capital requirements with a dividend prudential target. In order to do so, a normative approach is adopted and a measure of social welfare - specified as a weighted average of the expected life-time utility of savers and borrowers - is maximized with respect to the corresponding policy parameter/s. Formally:

$$\arg \max_{\Theta} V_0 = \zeta_p V_0^p + \zeta_i V_0^i, \tag{35}$$

where $V_0^\varkappa = E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U \left(C_{\varkappa,t}, H_{\varkappa,t}, N_{\varkappa,t} \right)$ is the expected life-time utility function of household type $\varkappa = p, i$; $\zeta_\varkappa$ denotes the utility weight of agent class $\varkappa = p, i$; and Θ refers to the vector of policy parameters with respect to which the objective function is maximized. Problem (35) is subject to all the competitive equilibrium conditions of the extended model. 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:

$$E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U \left(C_{\varkappa,t}^a, H_{\varkappa,t}^a, N_{\varkappa,t}^a \right) = E_0 \sum_{t=0}^{\infty} \beta_\varkappa^t U \left[(1 + \lambda_\varkappa) C_{\varkappa,t}^b, H_{\varkappa,t}^b, N_{\varkappa,t}^b \right], \tag{36}$$

where superscripts a and b refer to the alternative policy scenario and the baseline case, respectively.

Since there is no widely accepted criterion to assign values to ζ_p and ζ_i, I rely on two alternative but complementary criteria that have often been used in the recent macro-finance

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[36]In fact, there is no broad consensus on why managers have such a preference for smoothing dividends and what determines their propensity to smooth (see, e.g., Leary and Michaely 2011).

literature to prevent an overweight of savers' welfare related to a higher discount factor (see, e.g., Lambertini et al. 2013, Mendicino and Punzi 2014, and Mendicino et al. 2018). Welfare weighting criterion "A" solves problem (35) by further assuming that $\zeta_\varkappa = (1 - \beta_\varkappa)$, with $\varkappa = p, i$. That ensures the same utility weights across households discounting future utility at different rates. Welfare criterion "B" goes one step further in treating both types of agents equally and imposes additional restrictions on the solution to problem (35) by which welfare gains have to be non-negative and identical across households (i.e., $\lambda_p = \lambda_i$ and $\lambda_p \geqslant 0$, $\lambda_i \geqslant 0$) and $\zeta_p + \zeta_i = 1$. Under this criterion, social welfare gains are identical to those of savers and borrowers regardless of the weights assigned to each of them.

Figure 4 plots the individual and social welfare effects of changing the value of parameter ρ_x in a policy rule of the type (13), with $\kappa = 0.426$, $\rho_d = d^{ss}$, and $x_t = Y_t$.[37] There is a considerable range of positive ρ_x values for which both types of agents are better off than under the baseline scenario. Interestingly, figure 4 makes clear that each type of agent faces a different trade-off when being exposed to changes in ρ_x. Such trade-offs primarily depend on the smoothing effects DPTs trigger on household and entrepreneurial firm loans (which have a direct positive impact on borrowers and an indirect one on savers, as owners of non financial corporations) as well as on the welfare costs in terms of higher bank dividend volatility and modestly more restricted credit provision. Since the latter effect only comes into play under very highly responsive countercyclical DPTs and savers do not own banks in the baseline calibration, the welfare trade-off faced by patient households is more favorable than that experienced by borrowers.

Based on the information provided by these welfare trade-offs, I numerically solve problem (35) for the two proposed welfare criteria by searching over the following grid of parameter values: ρ_x $\{0 - 200\}$.[38] Table 5 reports the corresponding optimized parameter values and the welfare gains.

6.2.1 Interactions with Capital Requirements and Welfare Effects

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[37] As in Angelini, Neri and Panetta (2014), and without loss of generality, the macroeconomic indicator x_t incorporated in the policy rule under consideration (13) has chosen to be final output, Y_t. Social welfare effects have been plotted under welfare weighting criterion "A."

[38] In each case, 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 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.

Angeloni and Faia (2013), analyze optimized monetary policy rules under alternative Basel regimes. Inspired in their approach, this section examines the interactions between dividend prudential targets and existing capital regulation as well as the corresponding welfare trade-offs and effects.

Microprudential Capital Regulation   In the extended model adjustments in static capital requirements , $(1 - \gamma_e)$ and $(1 - \gamma_i)$, affect welfare through three main transmission channels. First, a ceteris paribus hike in a sectoral capital requirement (e.g., a reduction in γ_e) leads to a higher volatility in the corresponding type of lending (i.e., B_e) due to a "balance sheet effect" induced by banks' preference for dividend smoothing. Note that a higher capital ratio translates into a larger fraction of bank loans being financed by bank equity, a source of funding that accumulates out of "volatile" retained earnings. In particular, a ceteris paribus decrease in γ_e has a negative impact on savers' welfare through more restricted and volatile lending on entrepreneurial firms (see figure 5b). The same applies to the effect of ceteris paribus changes of γ_i on borrowers' welfare (see figure 5c).

Second, a decrease in the ratio of sectoral capital requirements, $(1 - \gamma_e) / (1 - \gamma_i)$ (which may be induced by a reduction in γ_i and/or by an increase in γ_e), triggers a "loan portfolio readjustment effect" by which the weight of household loans decreases in the bank's balance sheet in favour of entrepreneurial firm loans. That has a positive impact on savers' welfare (see figures 5a and 5b) and a negative effect on borrowers' welfare (see figures 5c and 5d).[39]

Note, however, that figures 5c and 5d display welfare trade-offs. This is the case because the previously mentioned effect conflicts with a third effect; higher capital ratios require bankers to retain more earnings, thereby inducing a positive "profit generation capacity effect" by which bank owners (i.e., borrowers) benefit from higher long run dividend payouts.

As it can be shown in figures 5e and 5f, the predominance of the effects leading to more restricted and volatile lending implies that, when keeping all other parameters at their baseline values, optimal sectoral capital adequacy parameters, $\gamma_i^* = 0.9418$ and $\gamma_e^* = 0.8636$, are - under welfare criterion "A" - associated to capital requirements which are somewhat lower than those calibrated for the baseline scenario and based on the Basel III Accord.

Figure 6 informs about how the welfare effects of ceteris paribus changes in ρ_x vary when capital requirements change due to an equiproportional variation in sectoral capital require-

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[39]The underlying reason for this readjustment in the banker's loan portfolio and the corresponding asymmetric effect (on savers and borrowers) is that household loans become relatively more restricted and volatile than entrepreneurial firm loans (recall the "balance sheet effect").

ments (i.e., a change in overall static capital requirements with respect to its baseline value, $(1 - \gamma) = 0.105$, for which the proportion implied by expression 34 is preserved).[40] Higher capital requirements lead to lower levels of savers' welfare through its negative effect on entrepreneurial firm lending but it does not significantly modify the effectiveness of countercyclical DPTs (proxied by the welfare trade-off they induce).

By way of contrast, a more stringent capital scenario has a positive impact on the effectiveness of dynamic DPTs in improving bank owners' welfare. A larger fraction of loans being financed by "volatile" cumulative retained earnings quantitatively magnifies the problem of higher credit supply volatility triggered by dividend smoothing, and higher expected dividends improve the potential of countercyclical DPTs to mitigate the negative effects of such problem. In particular, the higher capital requirements are, the larger potentially attainable borrowers' welfare gains (through increases in ρ_x) are and the wider the range of welfare increasing ρ_x values is.

As shown in figure 7, a similar reasoning can be followed for the case of the CCyB under alternative capital scenarios. Higher capital requirements translate into lower savers' welfare levels while they do not materially affect the effectiveness of the CCyB. In contrast, the tighter capital requirements are, the more effective a responsive CCyB is in improving borrowers' welfare level (note that the rate at which borrowers' welfare increases with the responsiveness of the CCyB tends to increase with static capital requirements).

Table 6 reports the welfare gains from a 1 percentage point hike in static capital requirements (from 10.5% to 11.5%), $(1 - \gamma)$, with and without introducing an optimal DPT (under the two proposed welfare criteria) in the alternative scenario (i.e., in the scenario under which $\gamma = 0.885$), with respect to the baseline scenario ($\gamma = 0.895$). Due to the above described reasons: (i) a hike in capital requirements has a relatively more severe impact on savers' welfare than on the expected life-time utility of borrowers and, accompanying such hike in the capital ratio with an optimal DPT has a relatively more significant positive effect on borrowers' welfare (than on the expected life-time utility of savers).

Table 7 describes the welfare effects of introducing an optimal DPT under the three capital scenarios already considered in figure 6. As already mentioned, hikes in capital requirements exacerbate the "problem" of dividend smoothing and enhance the potential of DPTs to tackle

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[40]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 whith a capital adequacy ratio of 0.12.

such issue. For each of the two proposed welfare criteria, the higher capital requirements are, the more reactive optimal DPTs become and the higher individual and social welfare gains attained are.

In a nutshell, higher capital requirements translate into a higher fraction of bank loans being financed by "volatile" bank capital and higher long run profits (and dividends). The former exacerbates the problem of induced credit supply volatility whereas the latter reinforces the effectiveness of DPTs in tackling such issue.

Macroprudential Capital Regulation   How do the DPT and the CCyB interact in this model? Does the DPT complement or substitute the CCyB? In order to answer these questions, I carry out several exercises. Figures 8, 9 and 10 display the welfare effects of ceteris paribus changes in ρ_x for alternative values of γ_x; the welfare effects of ceteris paribus changes in γ_x for alternative values of ρ_x; and the welfare effects of ceteris paribus changes in ρ_x and γ_x (i.e., interactions between the DPT and the CCyB), respectively.[41] There are two findings that stand out. First, if there were no boundaries to the values that ρ_x and γ_x could take, households who do not own banks (i.e., savers) would prefer to count with a highly responsive DPT and to have no CCyB in place (since the former is more effective in smoothing lending than the latter) whereas bank owners (i.e., borrowers) would be better off with a highly responsive CCyB and no DPT (as the former allows them to benefit from credit smoothing without having to incur the cost of bank dividend volatility induced by the latter). Second, under the considered grid of parameter values; ρ_x $\{0 - 200\}$ and γ_x $\{(-1) - 0\}$ - which are associated to what I shall refer to as "potentially implementable policy rules" - each type of household finds optimal to simultaneously have a countercyclical DPT and a CCyB in place.

The first finding suggests that in this case, the optimal macroprudential policy mix is going to be particularly sensitive to the selected weighting welfare criterion. Figure 11 informs about the maximum contribution the DPT can make to social welfare when activating the CCyB, for different values of $\gamma_x \in [-1, 0]$. In particular, figures 11b and 11d plot the welfare

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[41]I have set the grid of values that γ_x can take to: γ_x $\{(-1) - 0\}$.This range of values is based on information related to the cap that various economies, including the EU, have set on the CCyB in practice (see, e.g., BCBS 2017) as well as on a wide range of output gap estimates for the euro area based on quarterly data of real GDP for the period 2002:I-2018:II. In addition, table 8 shows that the CCyB for which the asymptotic variance of the credit gap and the loans-to-output gap are minimized relates to a value of γ_x that is in the vicinity of (-1). Note that in the limit case in which $\gamma_x = -1$, the CCyB is very highly responsive in the sense that a 1 percentage point increase in the output gap translates into a 1 percentage point increase in dynamic capital requirements.

gains of the CCyB, for the grid γ_x $\{(-1) - 0\}$, with and without introducing an optimal DPT (in the alternative policy scenario in which $\gamma_x < 0$), for the two proposed welfare criteria.[42] Figures 11a and 11b display the corresponding optimized ρ_x values for different values of $\gamma_x \in [-1, 0]$. Under criterion "A", the more responsive the CCyB is the larger welfare gains are and the less responsive the optimal DPT is. This result largely reflects the preferences of borrowers.

Under criterion "B", there is an important sub-grid of potentially implementable γ_x values (i.e., γ_x $\{(-1) - 0.4\}$) for which a more reactive CCyB calls for a more responsive DPT, a relationship aligned with the preferences of savers for the considered grid of ρ_x values (see figure 8). Even if this relationship is not the one advocated by borrowers, criterion B: (i) exploits the fact that there is a wide range of $\{\rho_x > 0, \gamma_x < 0\}$ combinations for which savers and borrowers are better-off than under the baseline scenario (se figure 10), and (ii) implicitly strikes a balance between this conflict and the fact that borrowers' welfare increases in the responsiveness of the CCyB at a higher rate than that of savers, $\forall \rho_x \in [0, 200]$ (see figure 9).

An important corollary of the above discussed findings is that even if the CCyB is very responsive (i.e., $\gamma_x \approx -1$) and regardless of the selected welfare criterion, it is optimal to complement such macroprudential policy with a countercyclical DPT (i.e., $\rho_x > 0$).

Figures 12 to16 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 (35) has been solved - under welfare criterion "B" - with respect to $\{\rho_x, \gamma_x\}$, ρ_x, and γ_x, respectively.[43] In the face of financial shocks, jointly optimizing with respect to $\{\rho_x, \gamma_x\}$ is more effective in smoothing financial and economic fluctuations than doing it with respect to any of the two macroprudential policy parameters separately (figures 12 to 14). Under non-financial shocks, the optimal DPT performs better than the optimal CCyB (figures 15 and 16).[44]

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[42]Social welfare gains of the CCyB without an optimal DPT cannot be computed under welfare criterion B since, in this case, problem (35) has no solution. In particular, there is no value of $\gamma_x \in [-1, 0]$ that satisfies: $\lambda_p = \lambda_i$, as the rate at which borrowers' welfare increases with γ_x is higher than the one at which savers' welfare does it, $\forall \gamma_x \in [-1, 0]$ (see figure 9). As an alternative, I plot the welfare gains of savers and borrowers induced by the CCyB when $\rho_x = 0$.

[43]The policy parameter values for which the problem of social welfare solves under criterion "B" are, for each of the three considered macroprudential policy scenarios: $\{\rho_x^* = 98.8$ and $\gamma_x^* = -1\}$; $\rho_x^* = 83.18$; and $\gamma_x^* = -1$

[44]The finding suggesting that the CCyB is relatively more effective in taming the cycle when financial shocks hit the economy than in the presence of other types of shocks (e.g., technology shocks) has been

In order to further explore the effectiveness of the three alternative macroprudential policy scenarios in taming the credit cycle, table 8 reports the main results of solving problem (17) in the extended model, for the three considered policy parameter vectors, $\Theta \equiv \{\rho_x; \gamma_x; (\rho_x, \gamma_x)\}$, and for $z \equiv \{B; B/Y\}$. The optimized DPT is substantially more effective than the optimized CCyB in smoothing bank lending and approximately as effective as jointly optimizing with respect to $\{\rho_x, \gamma_x\}$.

In conclusion, even though both instruments are effective in taming the credit cycle, the DPT complements the CCyB in at least two dimensions. First, an optimized DPT reinforces the effectiveness of the CCyB in mitigating financial and economic fluctuations regardless of the nature of the shock and performs particularly better than the CCyB under non-financial shocks. Overall, an optimized DPT is more effective in smoothing lending and output than the optimized CCyB.[45] Second, due to this fact households who do not own banks have a stronger preference for having a countercyclical DPT in place whereas those who own banks prefer to count with a CCyB, as the latter avoids the cost induced by DPTs in terms of higher bank dividend volatility. The bottom line is that, for a wide range of "potentially implementable poliy rules", there is a variety of standard optimization criteria suggesting that jointly calibrating both policy instruments is optimal.

6.3   Robustness Checks

In this section I first investigate the robustness of the welfare effects of the DPT to changes in key parameters. Since the main cost associated to optimized DPTs directly affects bank owners through higher bank dividend volatility, it could be the case that changes in the distribution of banks' ownership between savers and borrowers were to significantly affect the welfare trade-off faced by each agent class. However, figure 17 suggests that changes in the fraction of banks owned by savers, ω_b, (and, thus, in that of banks owned by borrowers) does not materially affect the shape of expected lifetime utility (as a function of ρ_x).[46]

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presented in several recent studies (see, e.g., Angelini et al. 2014). Thus, the comparative effectiveness of optimal DPTs in smoothing financial and economic fluctuations in the face of non-financial shocks should be regarded as an additional strength of this instrument as a complement to existing capital regulation.

[45] As in the basic model, this is the case because DPTs directly attack the root of the "problem" (i.e., dividend smoothing).

[46] Not surprisingly, increases in ω_b do affect the welfare level of savers (which goes up) and borrowers (which declines). This is so, because the bank dividend payout received by a given household increases with the fraction of banks it owns.

In addition, there are two policy parameters the public authority may consider to modify, and whose values are relevant from a redistributive perspective. Penalty parameter, κ, and the fraction of net transfer that savers receive according to their bank property, χ. Due to the insurance role it plays, as parameter χ increases (and regardless of the $\rho_x$value), the welfare level (and trade-off) attained by the representative saver improves while that of the representative borrower deteriorates (see figure 18). With regards to κ, given a sensible range of values for the penalty parameter, the shape of the welfare as a function of ρ_x is not significantly affected, although as the value of κ increases, welfare trade-offs become more pronounced and the optimal DPT becomes less responsive. As shown in figure 19, this is so because a more stringent sanctions regime makes the policy more effective (in smoothing lending through less volatile retained earnings) and more costly at the same time (e.g., higher bank dividend volatility).

As mentioned in subsections 4.1 and 6.1, expression (9) not only permits to account for several empirical regularities (through the calibration of parameters δ and σ_{kb}) but also plays an essential role in allowing the model to reproduce the key mechanism (that triggers the main welfare trade-off countercyclical DPTs exhibit due to individual preferences for dividend smoothing and lending smoothing), by connecting the profit generation capacity of the representative bank (which is essential to distribute high and stable dividends over the cycle) with its capital generation capacity (that is crucial to meet capital requirements). Figure 20 shows that, regardless of the value taken by $\delta \in [0, 1]$, the same welfare trade-off applies. Of course, as δ increases, the bank equity accumulated per unit of profits declines, which obliges the representative banker to reduce the size of her balance sheet by cutting on lending in order to meet her capital requirements. Consequently, the welfare level of savers and borrowers declines and the welfare trade-off faced by the latter deteriorates.[47]

Lastly, figure 21 confirms that regardless of the selected optimization criterion (from those considered in the quantitative analysis), the optimized DPT is more effective in smoothing credit supply and real output under technology and housing preference shocks than the optimized, highly responsive, CCyB.

In a nutshell, although quantitative differences may arise, the main conclusions of this

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[47]Interestingly, figure 20 also makes clear that the considered range of values for $\delta \in [0, 1]$ permits to match the steady state payout ratio of the banking industry virtually regardless of the value that such ratio shall take. Note that, from expression (9), it follows that if $\delta = 0$, in the steady state bank profits are fully distributed. As in subsection 6.2, for the alternative parameterization scenarios considered in figure 20, I have assumed that $\rho_d = d_b$.

exercise are robust across calibrated values of key parameters, across alternative specifications of policy scenarios and across alternative optimization criteria. Countercyclical dividend prudential targets are very effective in smoothing financial and business cycles and they complement and induce welfare gains associated to a Basel III-type of capital regulation through various mechanisms.

7   Conclusion

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

I develop a quantitative DSGE model with banking sector that incorporates this mechanism to examine the transmission and effects of a novel macroprudential policy rule - that I shall call Dividend Prudential Target (DPT) - aimed at complementing existing capital regulation by tackling this issue. Even though welfare maximizing DPTs are more effective in smoothing the financial and the business cycle than the CCyB, this instrument actually complements a Basel III-type of framework by mitigating the negative effects of capital ratio adjustments in terms of more restricted and volatile lending and output, they operate through a transmission mechanism that is different but complementary to that of the CCyB, and they have a comparative advantage in smoothing the cycle under non-financial shocks when compared to the latter.

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 omitting ingredients which are present in reality and that could possibly change some of the results. On the one hand, assuming a positive probability of bank failure, as in Clerc et al. (2015), should further reinforce the argument in favour of this complement to existing capital regulation. In addition, an heterogeneous agents model that accounts for the specific fraction of households who hold bank shares in practice and for the concrete weight of such shares in their asset portfolios would deliver a lower and much more realistic estimate of the costs induced by DPTs in terms of higher bank dividend volatility. 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 affect 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 comments 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)

		$\sigma_B^{2\,(1)}$	$\sigma_{B/Y}^2$
(A) $x_t = B_t$			
(i) $\{\rho_d, \rho_x\}$	Loss Variation[2]	(-83.81)	(-85.65)
	$\rho_d^{(3)}$	0.535	0.532
	ρ_x	66.811	66.786
(ii) $\{\rho_x\}$	Loss Variation	(-76.54)	(-78.28)
	ρ_x	52.755	52.755
(iii) $\{\gamma_x\}$	Loss Variation	(-65.11)	(-64.80)
	γ_x	-0.335	-0.335
(B) $x_t = B_t/Y_t$			
(i) $\{\rho_d, \rho_x\}$	Loss Variation	(-80.40)	(-82.61)
	ρ_d	0.546	0.504
	ρ_x	67.378	66.003
(ii) $\{\rho_x\}$	Loss Variation	(-73.86)	(-76.01)
	ρ_x	54.962	54.962
(iii) $\{\gamma_x\}$	Loss Variation	(-73.71)	(-73.43)
	γ_x	-0.461	-0.461

Note:(1) Asymptotic variance that enters the objective function of the prudential authority in problem (17). Such problem has been solved numerically by means of the osr (i.e., optimal simple rule) command in Dynare. (2) Percentage changes in the value of the loss function under the corresponding policy scenario with respect to the baseline scenario. (3) Values of the autonomous component of the dividend prudential target 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			
φ	Inverse of the Frisch elasticity	1	Standard
σ_h	HH Risk aversion param	2	standard
$m_{Hi}; m_{He}$	LTV ratio on HH and NFC housing	0.7	Standard
δ^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)
ϕ_e	NFC credit adj.cost param	0.06	Iacoviello (2015)
κ	Penalty parameter	0.426	Jermann & Quadrini (2012)
(B) First moments			
β_p	Savers' discount factor	0.9943	$R_h^{ss} = (1.023)^{1/4}$
β_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	$B_i^{ss}/(Y^{ss}) = 2.1403$
ω_e	Fraction of firms owned by HH_p	1	$B_e^{ss}/B^{ss} = 0.4510$
ω_b	Fraction of banks owned by HH_p	0	$B_e^{ss}/Y^{ss} = 1.7530$
α	Capital share in production	0.2699	$I^{ss}/Y^{ss} = 0.2119$
η	Real estate share in production	0.0385	$(q^{ss}H^{ss})/(4Y^{ss}) = 2.802$
γ_e	Debt-to-assets, NFC risk-adjusted	0.8508	$\gamma_e/\gamma_i = 2.1176$
γ_i	Debt-to-assets, HH risk-adjusted	0.9295	$K_b^{ss}/B^{ss} = 0.105$
δ	Depreciation rate of bank capital	0.041	$d_b^{ss}/J_b^{ss} = 0.5625$
(C) Second moments			
	Investment adj. cost param	0.092	$\sigma_I/\sigma_Y = 2.642$
ϕ_i	HH credit adj. cost param	0.511	$\sigma_B/\sigma_Y = 6.473$
σ	Banker EIS	2.40	$\sigma_{d_b}/\sigma_Y = 15.050$
σ_h	Std. housing pref. shock	0.1999	$\sigma_q/\sigma_Y = 2.429$
σ_{kb}	Std. bank capital depr. shock	0.0495	$\sigma_{K_b}/\sigma_Y = 6.554$
σ_{mh}	Std. NFC collateral shock	0.0024	$\sigma_{J_b}/\sigma_Y = 59.102$
σ_{mk}	Std. HH collateral shock	0.0026	$\sigma_C/\sigma_Y = 0.748$
σ_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. Abreviations HH and NFC refer to households and non-financial corporations (entrepreneurs), respectively. HHp 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)		
σ_{d_b} / σ_Y	Std. bank dividends	15.944	15.050
σ_{J_b} / σ_Y	Std. bank profits	43.358	59.102
σ_{K_b} / σ_Y	Std. bank capital	5.955	6.554
σ_B / σ_Y	Std.bank assets	6.752	6.473
	Macro data (EA)		
σ_q / σ_Y	Std. housing prices	2.118	2.429
σ_I / σ_Y	Std. investment	3.159	2.642
σ_C / σ_Y	Std consumption	0.940	0.748
σ_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 series is equal to one. The standard deviation (Std) of GDP is in quarterly percentage points.

Table 5: Welfare gains of optimal DPTs

	Savers	Borrowers	Social
(A) Welf criterion "A" (i.e., $\zeta_\varkappa = 1 - \beta_\varkappa$)			
$[\rho_x^* = 55.49]$	0.1711	0.3473	0.0183
(B) Welf criterion "B" (i.e., $\lambda_p = \lambda_i$)			
$[\rho_x^* = 83.18]$	0.2589	0.2589	0.2589

Note: Second-order approximation to the welfare gains associated to the optimal dividend prudential target and the corresponding optimized policy parameter for each of the two proposed welfare criteria. Welfare gains are expressed in percentage permanent consumption.

Table 6: Welfare Gains to a 1 p.p. hike in capital requirements

		Savers	Borrowers	Social
1.0 p.p. increase in $(1 - \gamma)$	ρ_x			
(A) Without countercyclical DPT	$[\rho_x = 0]$	-0.4082	-0.0908	-0.0069
(B) With countercyclical DPT				
Welf criterion "A"	$[\rho_x^* = 61.47]$	-0.1760	0.3748	0.0177
Welf criterion "B"	$[\rho_x^* = 92.95]$	-0.0771	0.2731	(0.0980)

Note: Second-order approximation to the welfare gains associated to a 1 p.p. hike (from 0.105 to 0.115) in the bank capital ratio (induced by an equiproportional increase in sectoral capital requirements) - with and without introducing an optimal DPT in the alternative scenario (i.e., in the scenario in which the capital ratio is set to a value of 0.115)- with respect to the baseline scenario (i.e., the scenario in which the capital ratio is set to a value of 0.105) and for the two proposed welfare criteria. Social welfare gains under welfare criterion "B" in part (B) of the table have been proxied by the arithmetic mean of savers and borrowers' welfare gains. Welfare gains are expressed in percentage permanent consumption.

Table 7: Welfare gains of optimal DPTs under alternative capital scenarios

Capital scenario $(1-\gamma)$	ρ_x	Savers	Borrowers	Social
(A) $(1-\gamma) = 0.08$				
Welf criterion "A"	$[\rho_x^* = 34.53]$	0.0364	0.1006	0.0052
Welf criterion "B"	$[\rho_x^* = 47.65]$	0.0699	0.0699	0.0699
(B) $(1-\gamma) = 0.105$ (baseline)				
Welf criterion "A"	$[\rho_x^* = 55.49]$	0.1711	0.3473	0.0183
Welf criterion "B"	$[\rho_x^* = 83.18]$	0.2589	0.2589	0.2589
(C) $(1-\gamma) = 0.12$				
Welf criterion "A"	$[\rho_x^* = 64.86]$	0.2754	0.5380	0.02847
Welf criterion "B"	$[\rho_x^* = 105.41]$	0.4015	0.4015	0.4015

Note: Second-order approximation to the welfare gains associated to the optimal dividend prudential target under three different Basel III-based capital scenarios, and the corresponding optimized policy parameter of the DPT for each of the two proposed welfare criteria. The ratio of sectoral capital requirements imposed by equation (34) remains unchanged across the three different capital scenarios. Welfare gains are expressed in percentage permanent consumption.

Table 8: Optimized rules and macroprudential losses (extended model)

		$\sigma_B^{2\ (1)}$	$\sigma_{B/Y}^2$
(A)$\{\rho_x\}$	Loss Variation[2]	(-59.15)	(-48.82)
	ρ_x	75.079	66.496
(B)$\{\gamma_x\}$	Loss Variation	(-42.92)	(-38.50)
	γ_x	-1.047	-1.013
(C)$\{\rho_x, \gamma_x\}$	Loss Variation	(-59.16)	(-49.08)
	ρ_x	74.792	63.805
	γ_x	-0.023	-0.152

Note:(1) Asymptotic variance that enters the objective function of the prudential authority in problem (17). Such problem has been solved numerically by means of the osr (i.e., optimal simple rule) command in Dynare. (2) Percentage changes in the value of the loss function under the corresponding policy scenario with respect to the baseline scenario.

Figure 1: Bank dividends and earnings in the euro area (SX7E). 2002:I - 2018:II
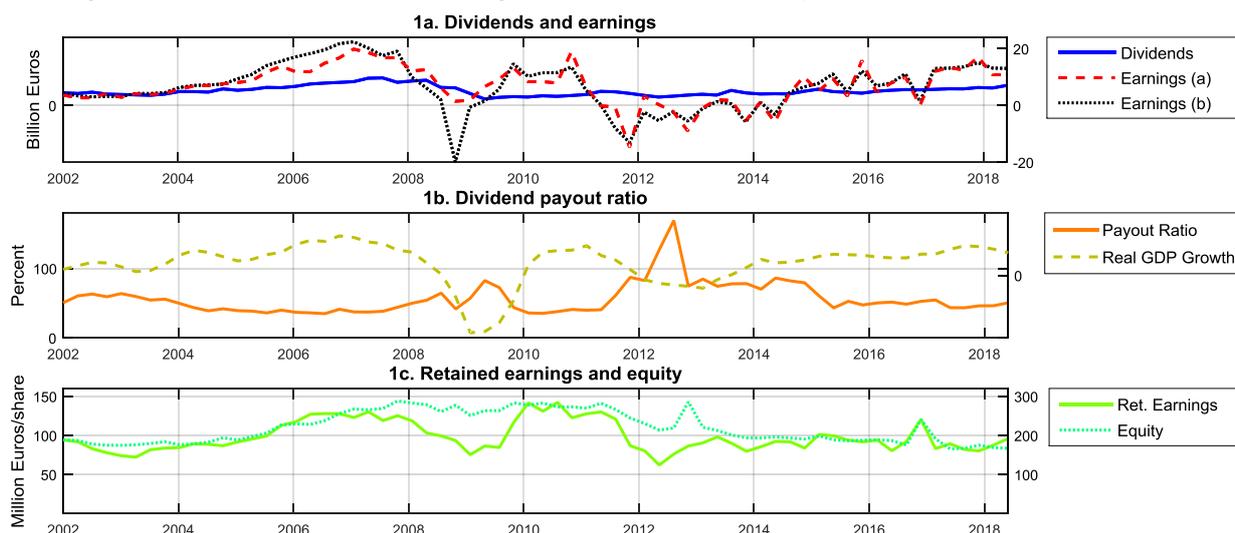
Note: SX7E refers to the Euro Stoxx Banks Index. Time series plotted in figure 1a have been constructed as a simple sum of the SX7E members whereas those in figures 1b and 1c have been reported as the index itself (i.e., as a capitalization-weighted sum of the same group of banks). See the online appendix for further details on data construction. In figure 1b the main y-axis and the secondary one differ, being the dashed line associated to the latter. In figure 1c the dotted line is associated to the secondary y-axis. Data sources: Bloomberg, Eurostat, and own calculations.

Figure 2: Co-movements among bank retained earnings, equity, assets and real GDP
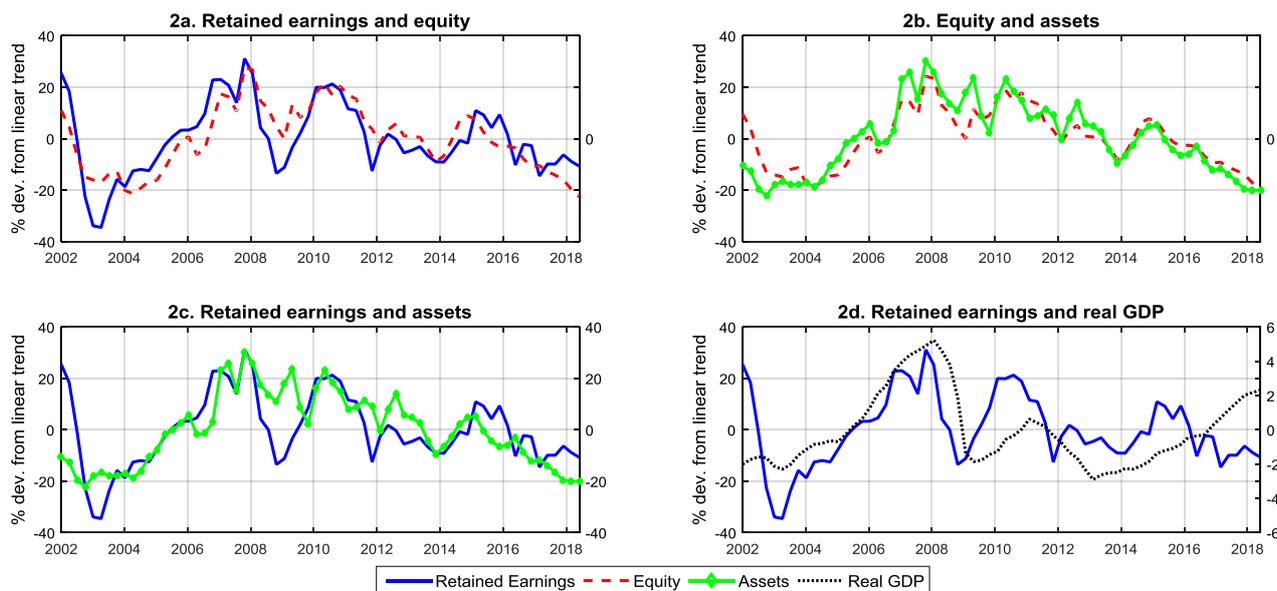
Note: This figure reports the cyclical component of euro area real GDP as well as of aggregate (cumulative) retained earnings, equity and assets of the SX7E members. In order to compute their cyclical component, the log value of seasonally adjusted and deflated time series has been linearly detrended. In figure 2d the main y-axis and the secondary one differ, being the dotted line associated to the latter. Data sources: Bloomberg, Eurostat, and own calculations.

Figure 3: The transmission mechanism. IRFs to a negative financial shock (basic model)
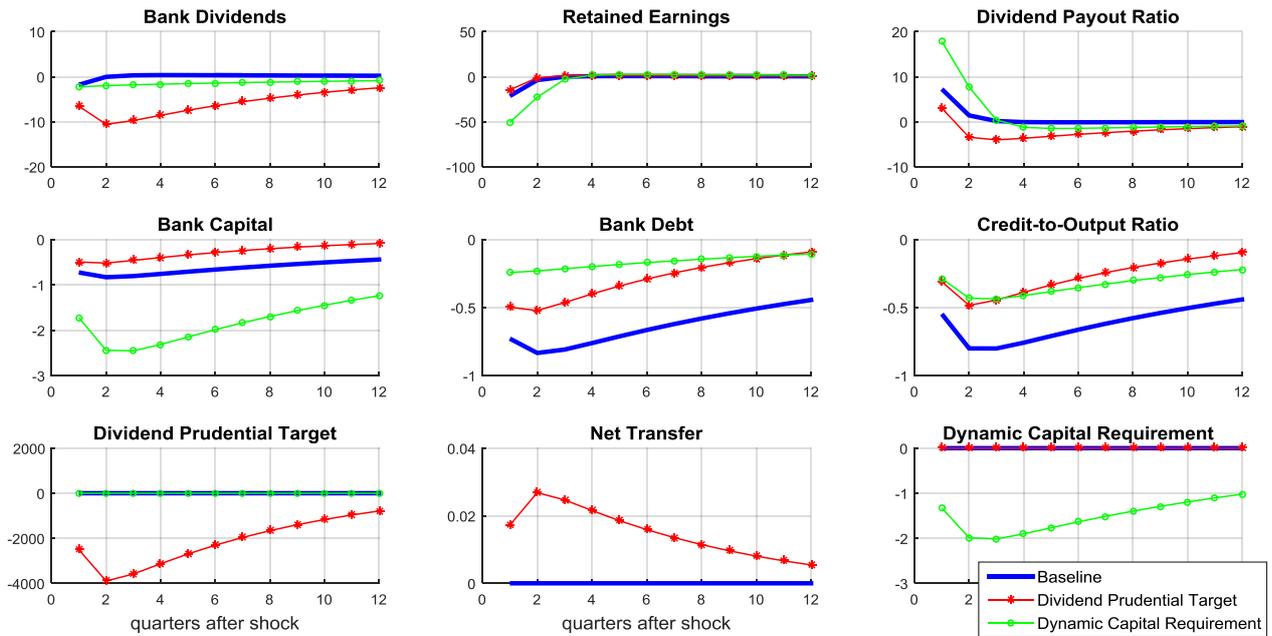
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which the optimized prudential rule is a dividend prudential target. The dotted line relates to an alternative (policy) scenario in which the optimized prudential rule is a dynamic capital requirement.

## Figure 4: Welfare effects of DPTs (welfare effects of ceteris paribus changes in ρ_x)
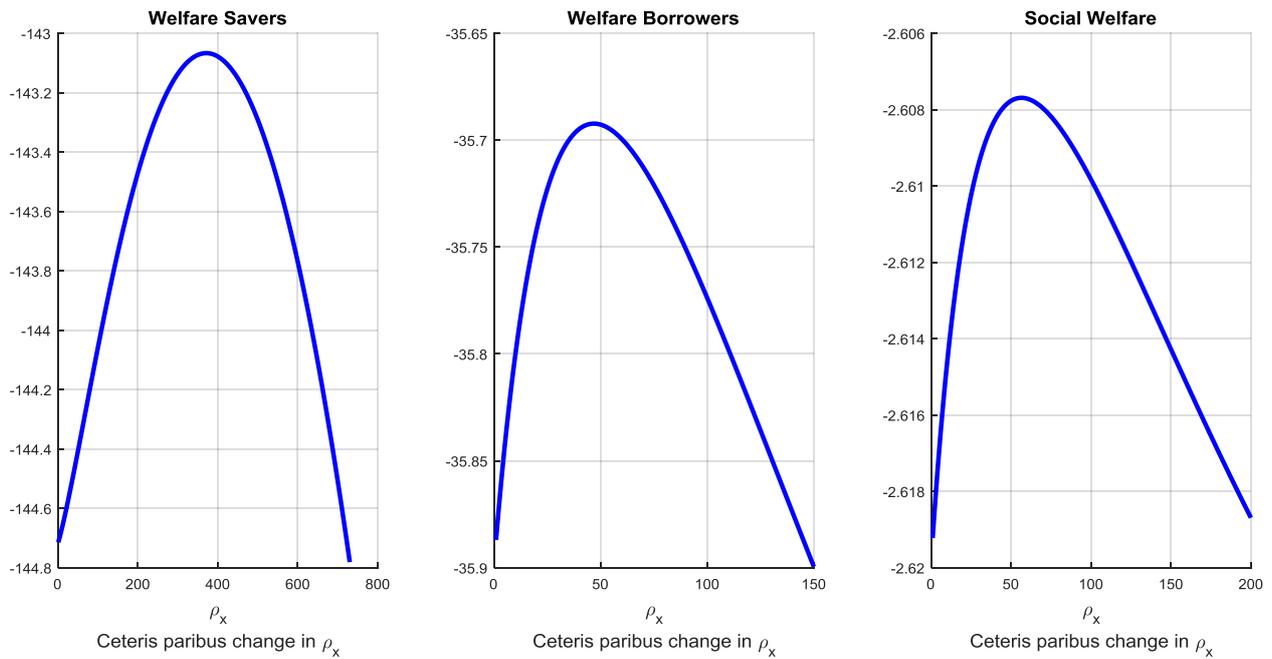
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, while keeping the other policy parameter, ρ_d, to its baseline calibration value.

Figure 5: Welfare effects of capital ratios (welfare effects of ceteris paribus changes in γ_i and γ_e)
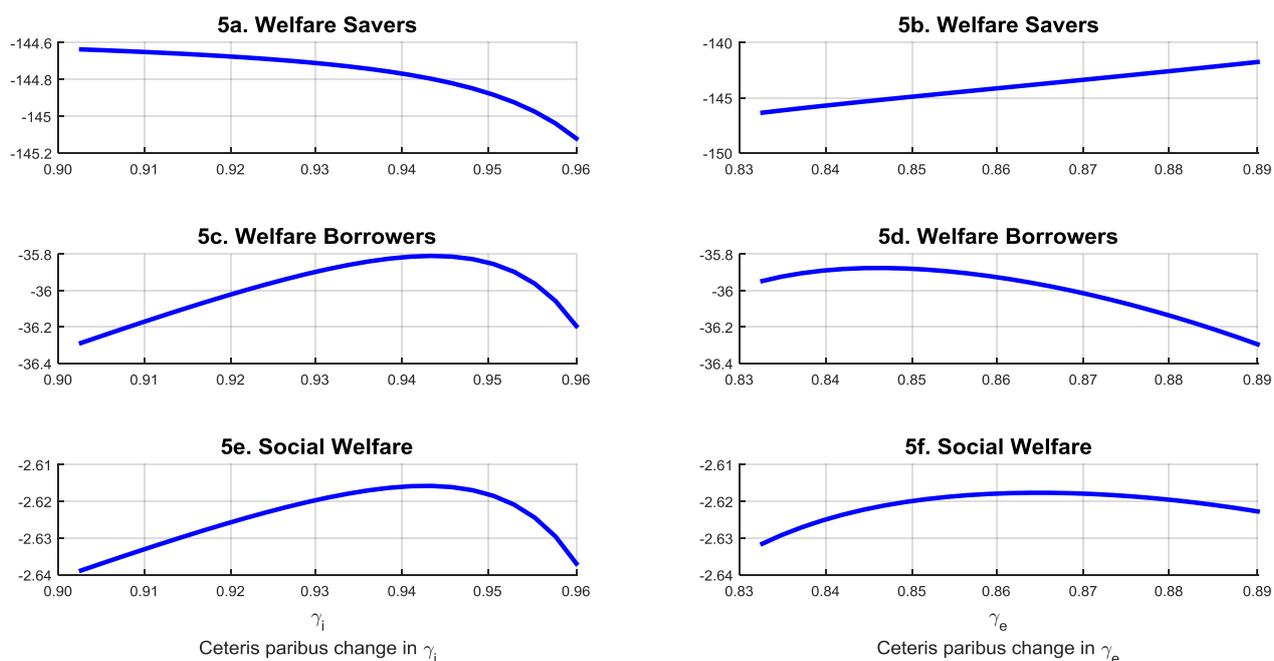
5a. Welfare Savers

5b. Welfare Savers

5c. Welfare Borrowers

5d. Welfare Borrowers

5e. Social Welfare

5f. Social Welfare

γ_i

Ceteris paribus change in γ_i

γ_e

Ceteris paribus change in γ_e

Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of capital adequacy parameters γ_i and γ_e. Note that the static capital requirement on NFC loans is $(1-\gamma_e)$ whereas the static capital requirement on HH loans is $(1-\gamma_i)$.

Figure 6: Welfare effects of DPTs under alternative capital scenarios
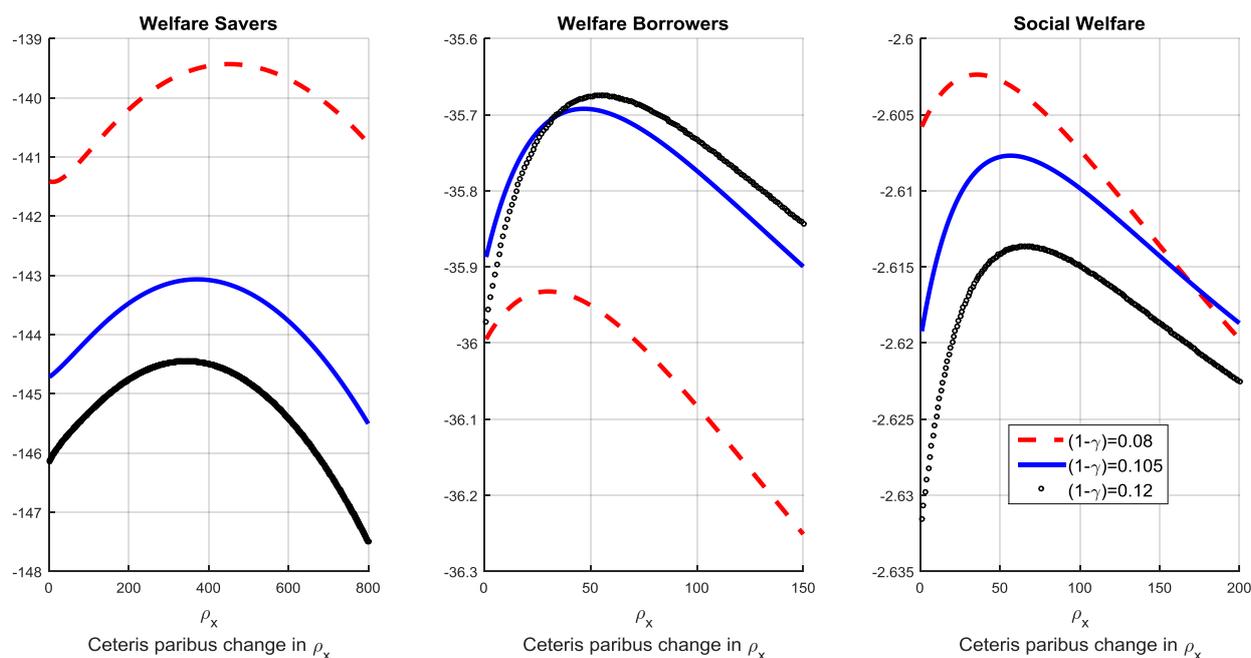
Welfare Savers

Welfare Borrowers

Social Welfare

ρ_x

Ceteris paribus change in ρ_x

ρ_x

Ceteris paribus change in ρ_x

ρ_x

Ceteris paribus change in ρ_x

$(1-\gamma)=0.08$
$(1-\gamma)=0.105$
$(1-\gamma)=0.12$

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

Figure 7: Welfare effects of the CCyB for alternative capital scenarios
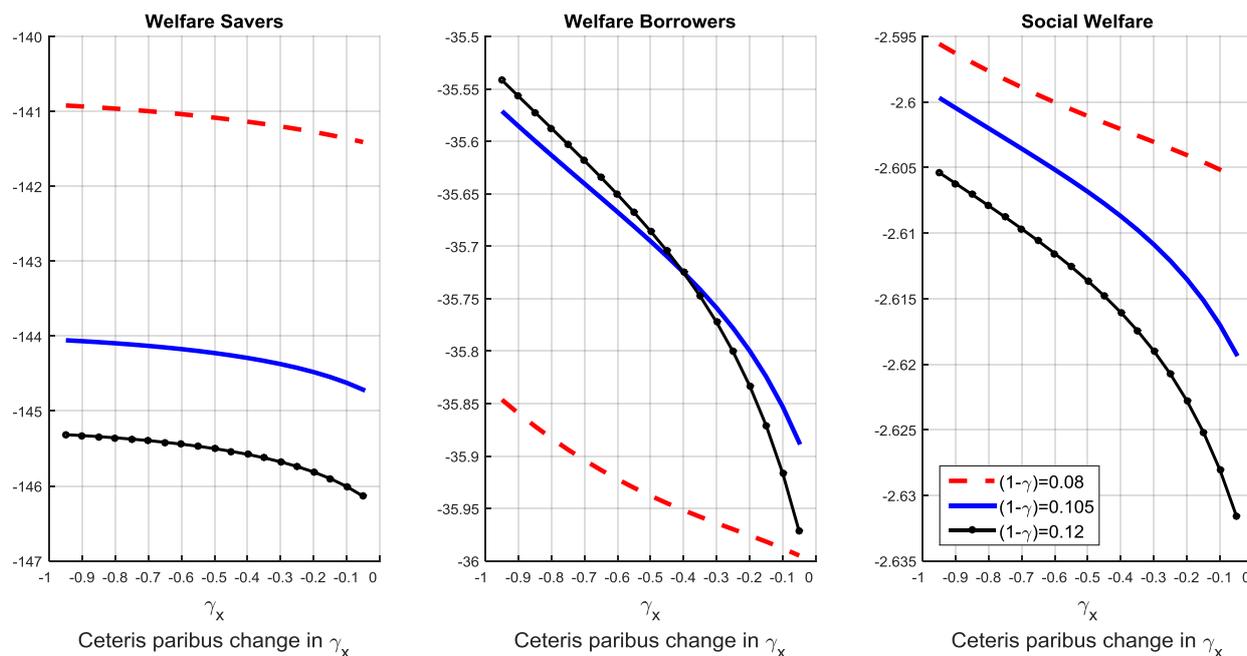
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of dynamic capital requirements, γ_x, for three alternative capital scenarios $(1-\gamma)$.

Figure 8: Welfare effects of DPTs for alternative CCyBs
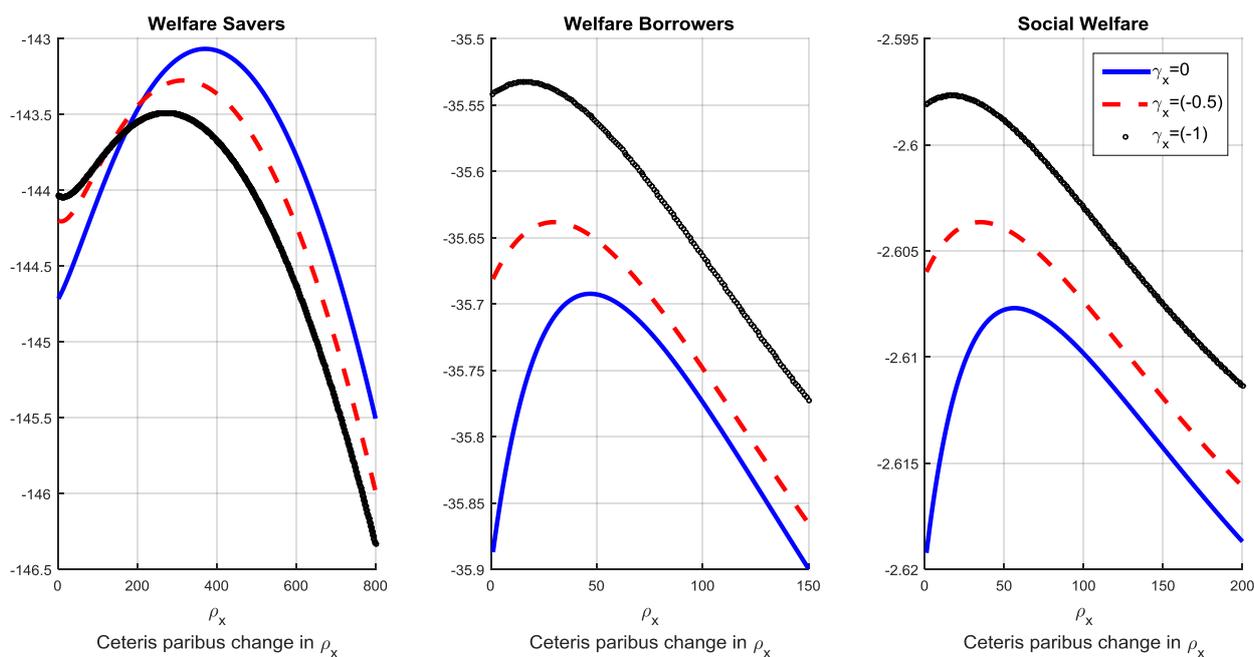
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the of the dividend prudential target, ρ_x, for alternative values of the cyclical parameter of dynamic capital requirements, γ_x,

Figure 9: Welfare effects of the CCyB for alternative DPTs
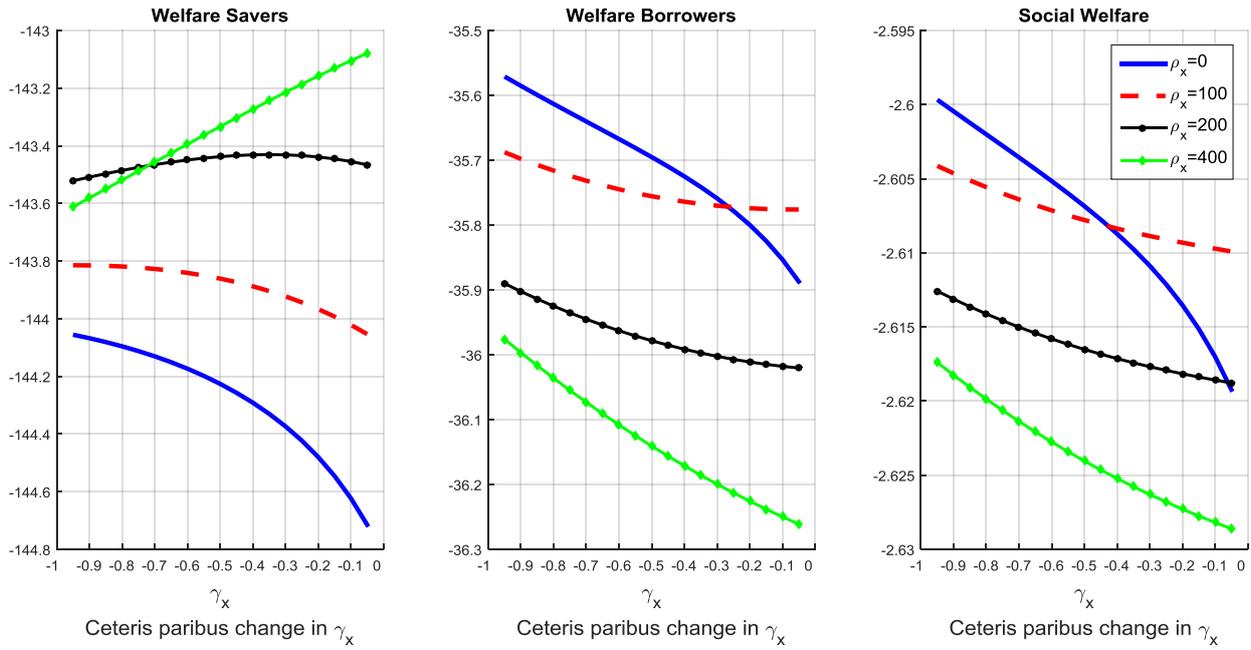
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of dynamic capital requirements, γ_x, for alternative values of the cyclical parameter of the dividend prudential target, ρ_x.

Figure 10: Interactions between the DPT and the CCyB (welfare effects of ceteris paribus changes in ρ_x - γ_x)
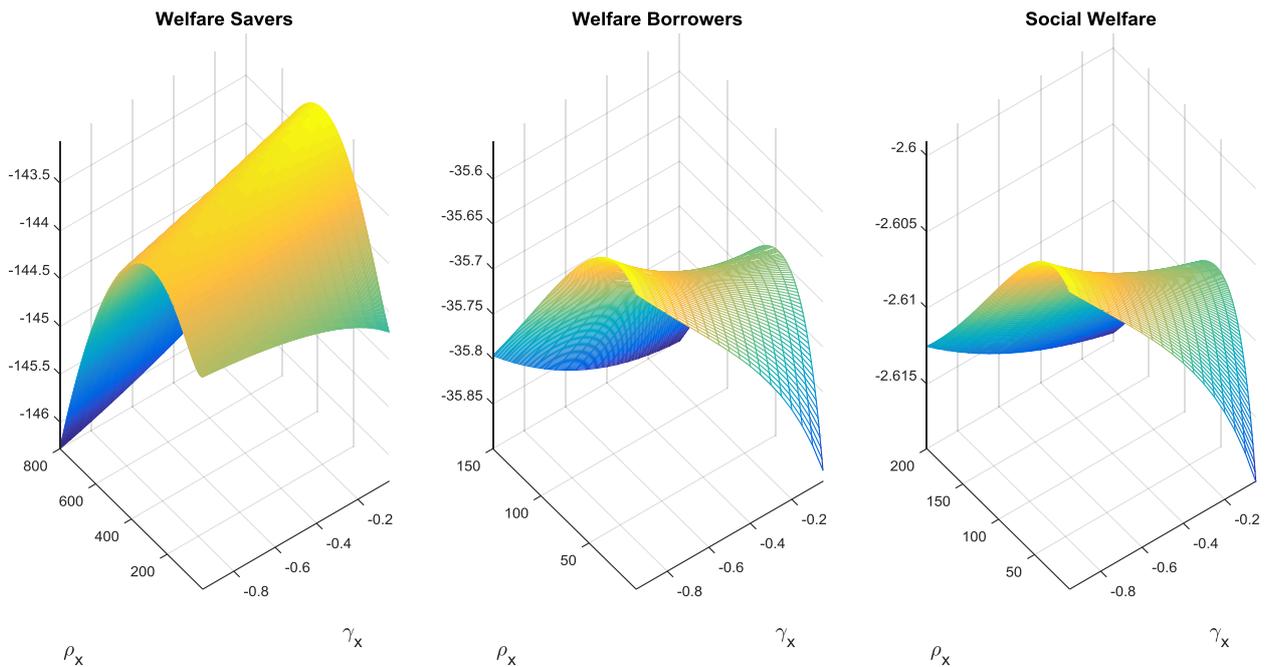
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameters of dynamic capital requirements and the dividend prudential target, γ_x and ρ_x.

Figure 11: Optimal DPT and welfare gains for alternative calibrations of the CCyB
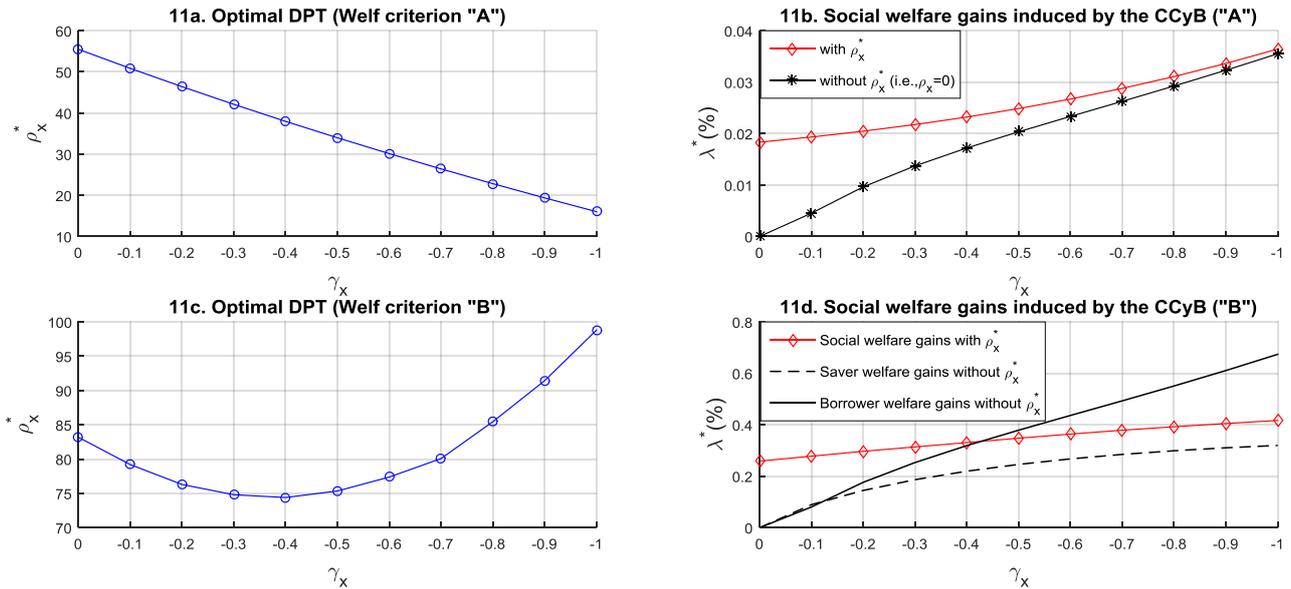
Note: Panels 11b and 11d report the second-order approximation to the unconditional social welfare gains induced by the CCyB, for different values of $\gamma_x \in [-1,0]$ - with and without introducing an optimal DPT (diamond line and starred line, respectively) in the alternative policy scenario (i.e., the scenario in which $\gamma_x < 0$) - with respect to the baseline scenario (i.e., $\rho_x = 0$, $\gamma_x = 0$), and for the two proposed welfare criteria. Under welfare criterion "B" and for all values of $\gamma_x \in [-1,0]$, there is no solution to problem (35) for the case in which an optimal DPT is not introduced. Instead, in that particular case panel 11d displays the welfare gains of savers and borrowers (dashed line and solid line, respectively). Panels 11a and 11b represent - for the same values of $\gamma_x \in [-1,0]$, the two proposed welfare criteria, and the case in which the CCyB is complemented with an optimal DPT - the corresponding optimized values of the cyclical parameter of the optimal DPT, ρ_x^*. For reporting purposes, x-axes have been reversed in all panels of the figure.

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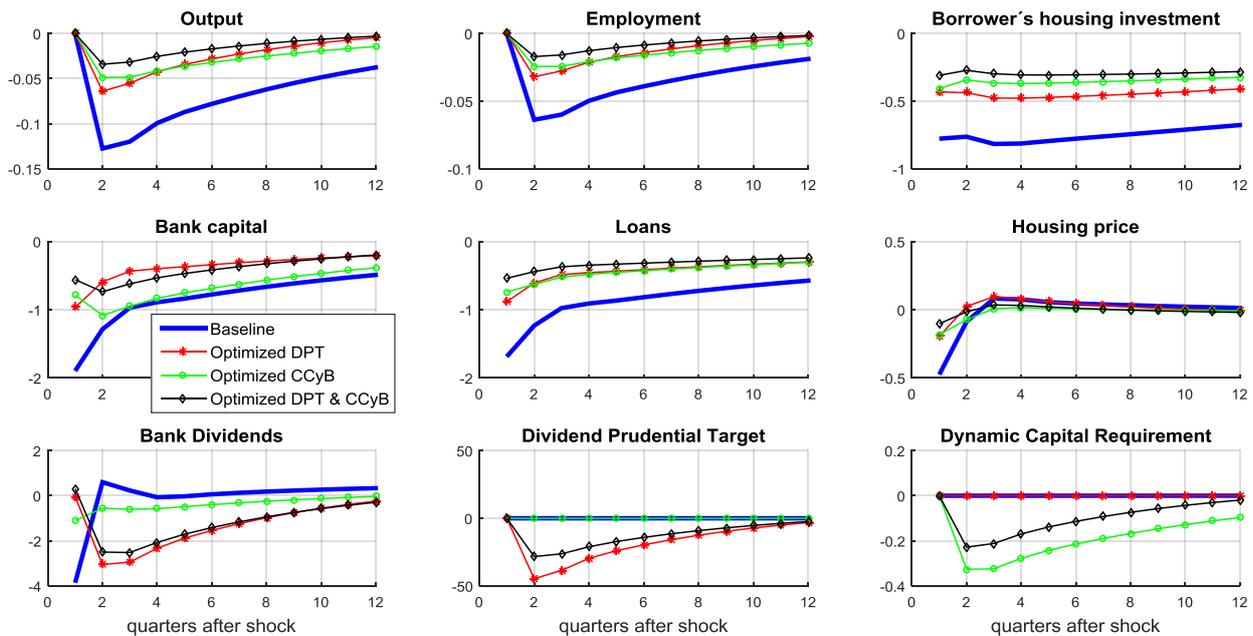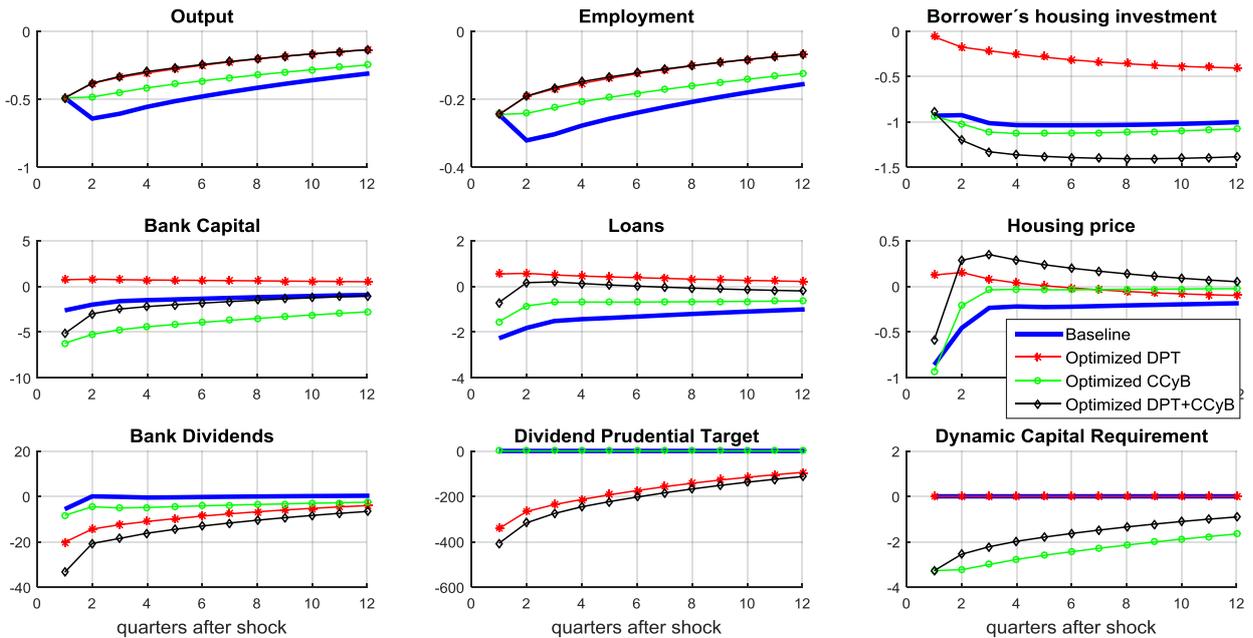

Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,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

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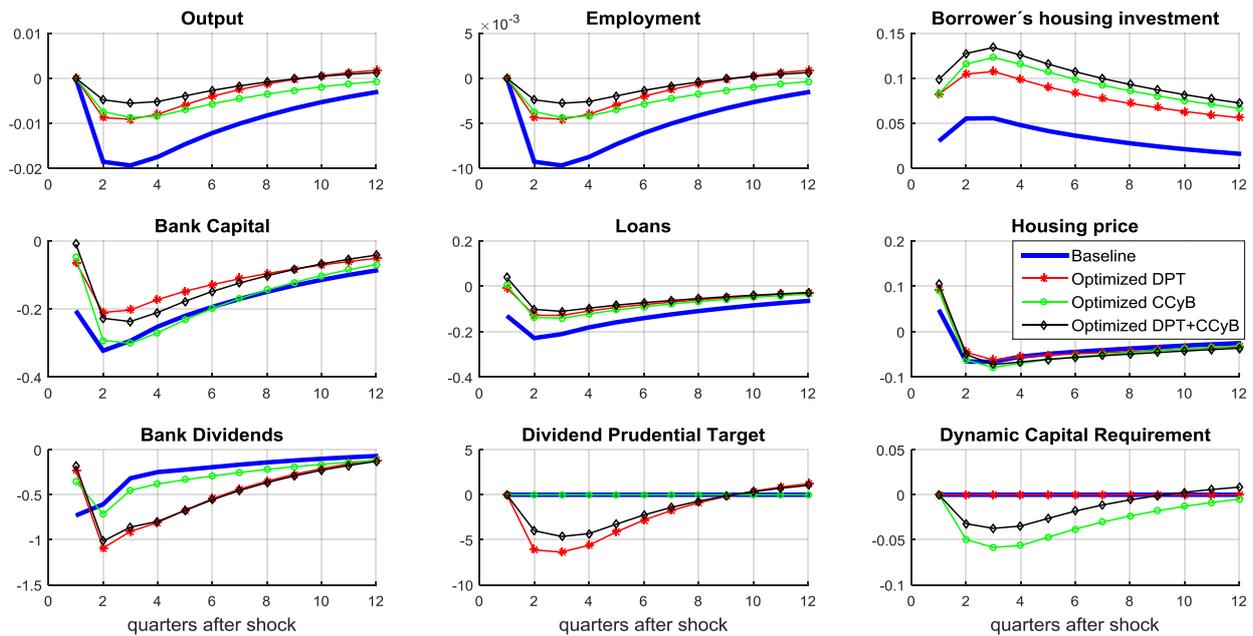

Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target,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

Figure 14: Impulse-responses to a negative bank capital shock (extended model, macroprudential policy scenarios)
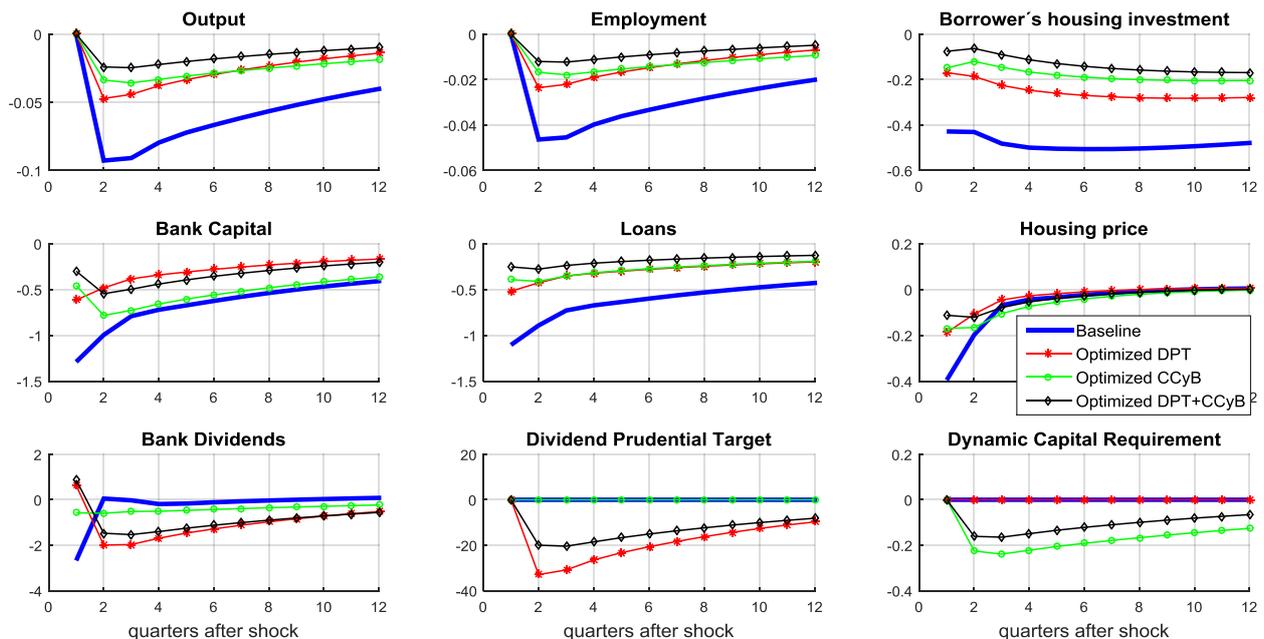
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, ρ_x. The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of dynamic capital requirements, γ_x. The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters ρ_x and γ_x.

Figure 15: Impulse-responses to a negative housing preference shock (extended model, macroprudential policy scenarios)
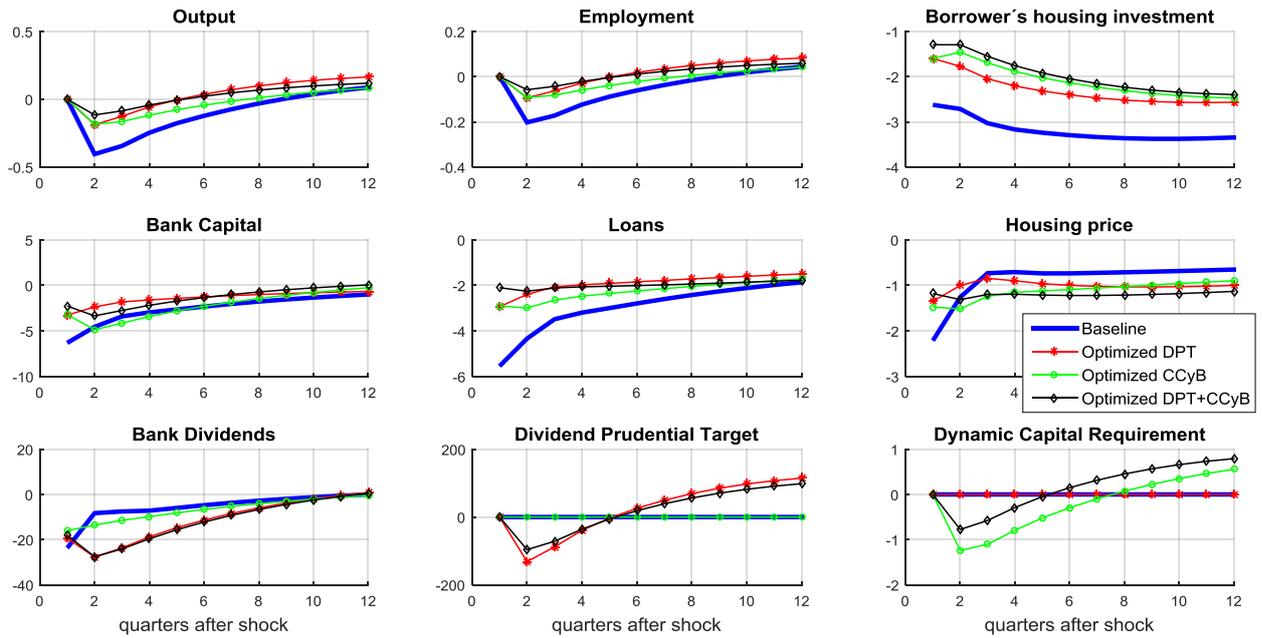
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, ρ_x. The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of dynamic capital requirements, γ_x. The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters ρ_x and γ_x.

Figure 16: 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, ρ_x. The dotted line relates to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of dynamic capital requirements, γ_x. The diamond line makes reference to an alternative (policy) scenario in which welfare has been maximized with respect to cyclical policy parameters ρ_x and γ_x.

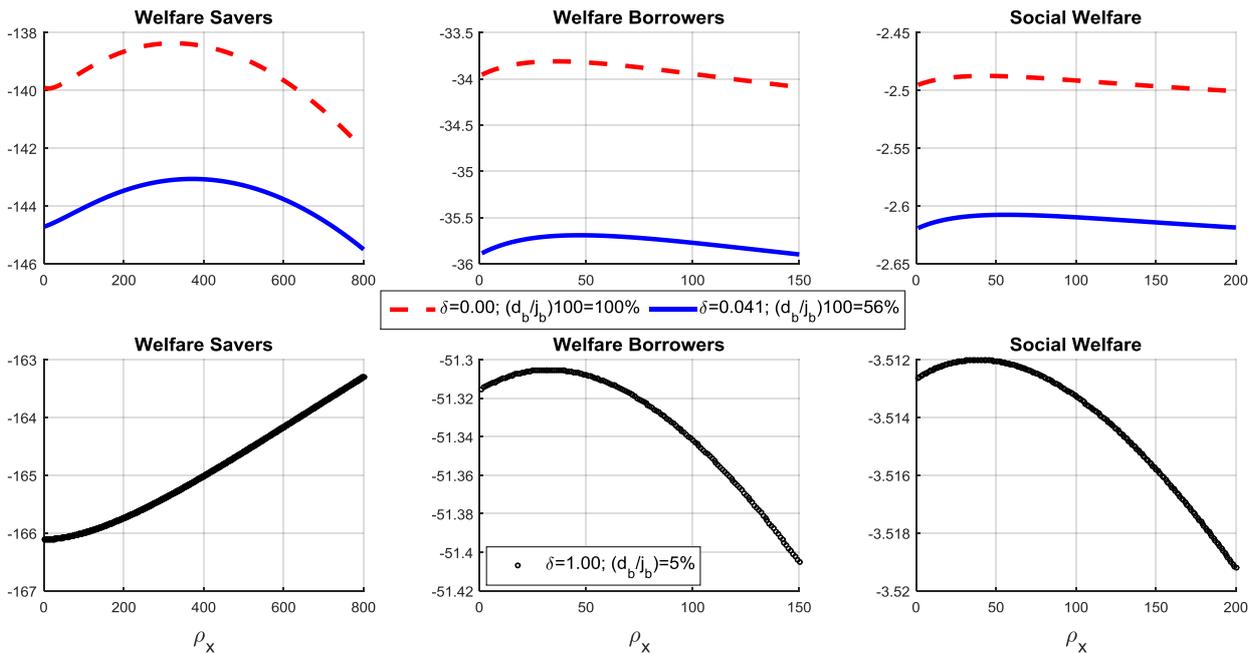Figure 17: Robustness checks: ω_b (welfare effects of ceteris paribus changes in ρ_x)
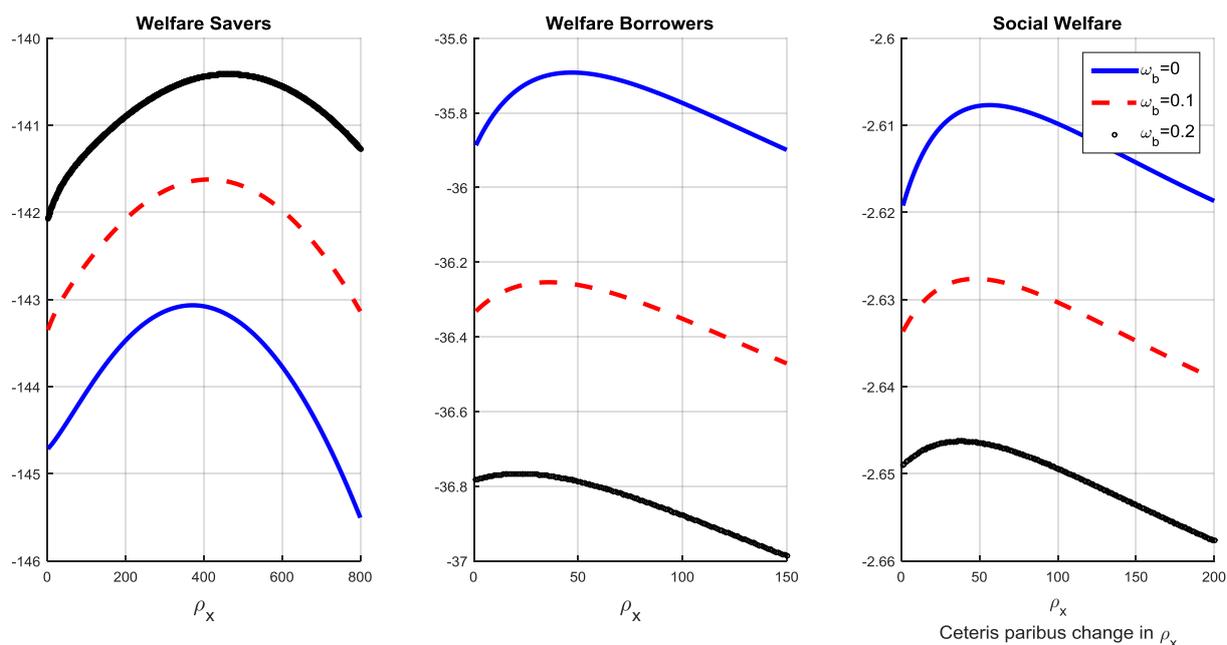
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative fractions of banks owned by savers. The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios.

Figure 18: Robustness checks: χ (welfare effects of ceteris paribus changes in ρ_x)
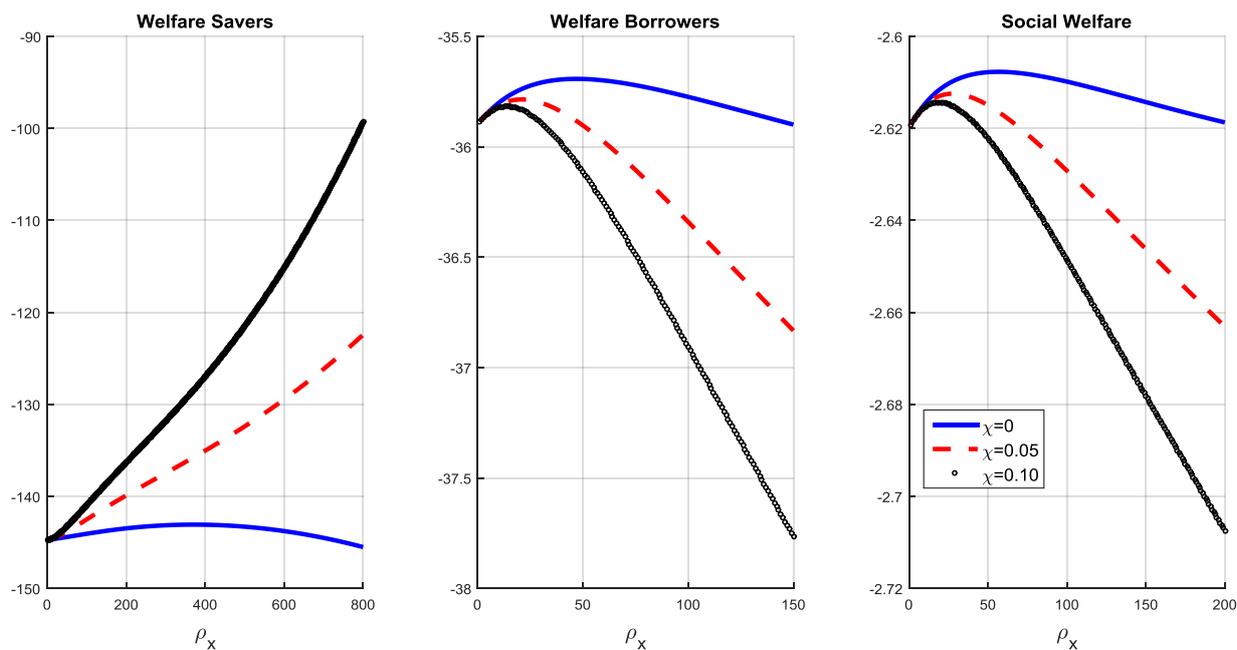
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative fractions χ of the net transfer that savers 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.

Figure 19: Robustness checks: κ (welfare effects of ceteris paribus changes in ρ_x)
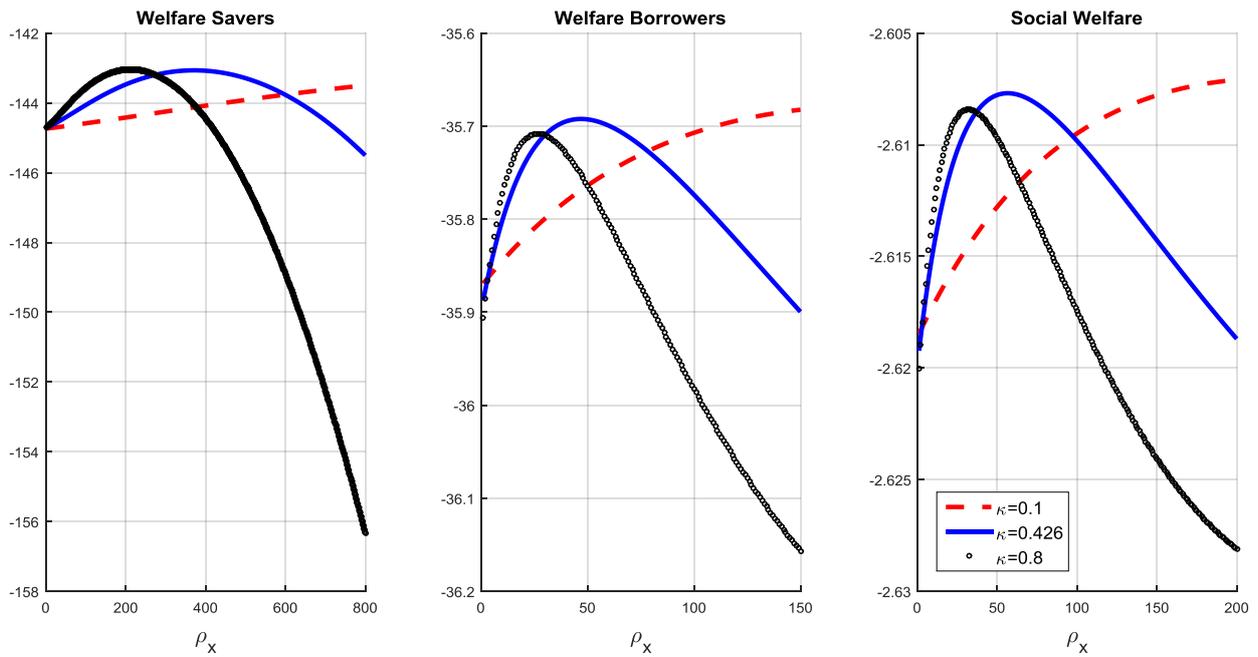
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative values of the dividend adjustment cost parameter, κ. The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios.

Figure 20: Robustness checks: δ (welfare effects of ceteris paribus changes in ρ_x)

Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative values of the depreciation rate of bank capital, δ. The solid line refers to the baseline scenario whereas the dotted and dashed lines relate to alternative parameterization scenarios. For each scenario, the associated steady state payout ratio is reported.

Figure 21: Robustness checks: Non-financial shocks and the effectiveness of optimized DPTs
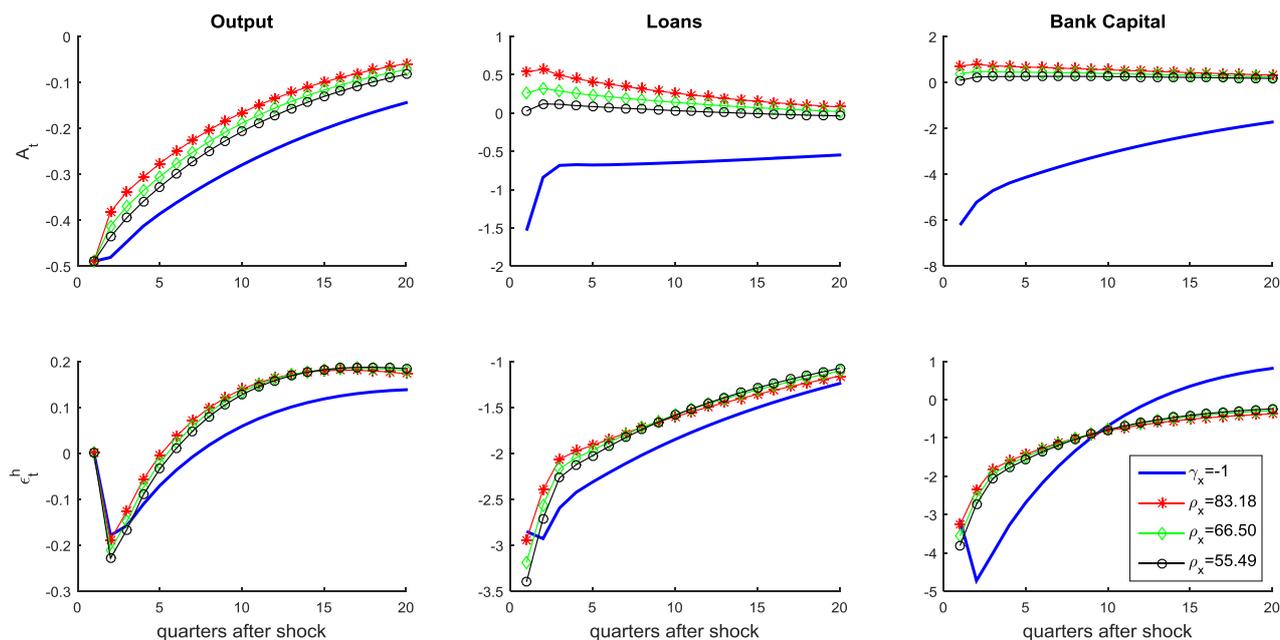
Note: Variables are expressed in percentage deviations from the steady state. Non-financial shocks refer to technology and housing preference shocks. The solid line refers to a policy scenario in which welfare has been maximized with respect to the cyclical parameter of dynamic capital requirements, γ_x (which roughly coincides with the value of γ_x for which the prudential authority minimizes the asymptotic variance of the loans-to-output ratio under full commitment). The starred, dotted and diamond lines correspond to policy scenarios in which welfare has been maximized with respect to ρ_x under the two proposed welfare criteria and the asymptotic variance of the loans-to-output ratio has been minimized under full commitment (i.e., problem 17), respectively.

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 3 and to calibrate the extended model in section 6.

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: Total Common Dividends*100 / 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.[48] 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. Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.[49]

Total Equity: Bank's total assets minus its total liabilities. Calculated as: Common Equity + Minority Interest + Preferred Equity.[50] Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.[51]

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[48]"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.

[49]Following investors and Bloomberg's convention, in figure 1c total retained earnings has been constructed as the capitalization-weighted sum of the SX7E members, after having normalized raw data by the number of total shares outstanding. In order to report its cyclical component in figure 2, retained earnings has been constructed as the simple sum of all SX7E member's retained earnings.

[50]"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.

[51]Following investors and Bloomberg's convention, in figure 1c total equity has been constructed as the capitalization-weighted sum of the SX7E members, after having normalized raw data by the number of total

Total Assets: Bank'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.

B   Equations of the Basic Model

This section presents the full set of equilibrium conditions of the basic model.

B.1   Households

Households seek to maximize their objective function subject to the following budget constraint:

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

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

$$\lambda_t^h = \frac{1}{C_{h,t}}, \tag{B.2}$$

$$\lambda_t^p = \beta_h R_{h,t} E_t \lambda_{t+1}^p, \tag{B.3}$$

$$q_t \lambda_t^p = \frac{j}{H_{h,t}} + \beta_h E_t \left(q_{t+1} \lambda_{t+1}^p \right), \tag{B.4}$$

$$\frac{W_{h,t}}{C_{h,t}} = N_{h,t}^\phi, \tag{B.5}$$

where λ_t^h is the Lagrange multiplier on the budget constraint of the representative patient household.

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shares outstanding. In order to report its cyclical component in figure 2 and for calibration purposes, total equity has been constructed as the simple sum of all SX7E member's total equity.

B.1.1 Entrepreneurs (net borrowers)

Entrepreneurs seek to maximize their objective fundtion subject to a budget constraint, the available technology and the corresponding borrowing limit

$$C_{e,t} + R_{e,t}B_{e,t-1} + q_t(H_{e,t} - H_{e,t-1}) + W_{h,t}N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t}, \qquad (B.6)$$

$$Y_t = H_{e,t-1}^v N_t^{1-v}, \qquad (B.7)$$

$$B_{e,t} \le m_{e,t}^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_t N_t. \qquad (B.8)$$

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

$$\lambda_t^e = \frac{1}{C_{e,t}}, \qquad (B.9)$$

$$\lambda_t^e \left[q_t - \left(1 - \frac{\partial \Phi_e(B_{e,t})}{\partial B_{e,t}} \right) m_t^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} \right) \right] = \beta_e E_t \left\{ \lambda_{t+1}^e \left[q_{t+1}(1 - m_t^H) + v \left(\frac{Y_{t+1}}{H_{e,t}} \right) \right] \right\}, \qquad (B.10)$$

$$\lambda_t^e \left[W_{h,t} + m^N W_{h,t} \left(1 - \frac{\partial \Phi_e(B_{e,t})}{\partial B_{e,t}} \right) - (1 - v)\frac{Y_t}{N_t} \right] = \beta_e E_t \left[\lambda_{t+1}^e m^N W_{h,t} R_{e,t} \right], \qquad (B.11)$$

where λ_t^e is the Lagrange multiplier on the budget constraint of the representative patient household.

The way m_t^H and m^N enter equations (B.10) and (B.11) shows that collateral constraint (B.8) introduces a wedge between the marginal productivity of each input and its price, and generates inefficiencies not only over the cycle but also in the steady state. To have a clear account of this phenomenon, the steady state expressions of (B.10) and (B.11) are presented:

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

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

where $\eta = \frac{1}{\beta_e} \left[1 - \frac{m^H}{R_e} - \beta_e(1 - m^H) \right]$, and $\psi = \left\{ 1 + m^N \left[1 - \beta_e R_e \right] \right\}$.

B.1.2 Bankers

The representative banker chooses the trajectories of dividend payouts $d_{b,t}$, loans to entrepreneurs B_t, and deposits $D_{b,t}$ that maximize her objective function subject to a cash flow restriction and a borrowing limit (capital adequacy constraint)

$$d_{b,t} + B_t - D_{b,t} - (1-\delta_t)\left(B_{t-1} - D_{b,t-1}\right) = r_{e,t}B_{t-1} - r_{h,t-1}D_{b,t-1} - \Phi_b(B_t) - T(d_{b,t}, d_t^*), \quad \text{(B.12)}$$

$$D_{b,t} \leq \gamma_t B_t. \quad \text{(B.13)}$$

The law of motion for bank equity reads

$$K_{b,t} = J_{b,t} - d_{b,t} + (1-\delta_t)K_{b,t-1}. \quad \text{(B.14)}$$

The resulting optimality condition reads

$$\frac{(1-\gamma_t) + \dfrac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t}\left[1 + \kappa(d_{b,t} - d_t^*)\right]} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma_t\left(R_{h,t} - \delta\right)}{d_{b,t+1}\left[1 + \kappa\left(d_{b,t+1} - d_{t+1}^*\right)\right]} \right\}. \quad \text{(B.15)}$$

B.2 Macroprudential Authority

The dividend prudetial target is specified as follows

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

Such policy rule is associated to a sanctions regime that penalizes deviations from the dividend prudential target. The DPT enters a penalty function of the form

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2}(d_{b,t} - d_t^*)^2.\tag{B.17}$$

The macroprudential authority has full control over the regulatory capital ratio, $(1 - \gamma_t)$. The debt-to-assets ratio associated to such capital requirement reads

$$\gamma_t = \gamma + \gamma_x(\frac{x_t}{x^{ss}} - 1).\tag{B.18}$$

B.3 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:

$$Y_t = C_t + \delta K_{b,t-1} + Adj_t,\tag{B.19}$$

where C_t denotes the aggregate consumption of the three agent types. Formally, $C_t = C_{h,t} + C_{e,t} + d_{b,t}$ and the term Adj_t corresdonds to the sum of all resources dedicated in the economy to adjust bank loans in period t. Similarly, in equilibrium labor demand equals total labor supply,

$$N_t = N_{h,t}.\tag{B.20}$$

Similarly, in equilibrium demand for loans of impatient households and entrepreneurs equals aggregate credit supply

$$B_t = B_{e,t}.\tag{B.21}$$

The stock of bank deposits held by patient households must be equal to aggregate debt issued by bankers

$$D_t = D_{b,t}.\tag{B.22}$$

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

$$\overline{H} = H_{h,t} + H_{e,t}. \tag{B.23}$$

B.4 Shocks

There is a zero-mean, AR(1) collateral shock that hits the economy in the basic model:

$$\log \varepsilon_t^{mh} = \rho_{mh} \log \varepsilon_{t-1}^{mh} + e_{mh,t}, \ e_{mh,t} \sim N(0, \sigma_{mh}). \tag{B.24}$$

C Equations of the Extended Model

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

C.1 Patient Households

Patient households seek to maximize their objective function subject to the following buget constraint:

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

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

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

$$\lambda_t^p = \beta_p R_{d,t} E_t \lambda_{t+1}^p, \tag{C.3}$$

$$q_t \lambda_t^p = \frac{j\varepsilon_t^h}{H_{p,t}} + \beta_p E_t \left(q_{t+1} q_t \lambda_{t+1}^p \right), \tag{C.4}$$

$$W_t = N_{p,t}^\phi, \tag{C.5}$$

where λ_t^p is the Lagrange multiplier on the budget constraint of the representative patient household.

C.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 their objective function subject to a budget constraint and a borrowing limit:

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

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

The resulting optimality conditions are

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

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

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

where λ_t^i is the Lagrange multiplier on the budget constraint of the representative patient household.

C.3 Entrepreneurs

Entrepreneurs seek to maximize their objective function subject to a budget constraint, the available technology and the corresponding borrowing limit

$$d_{e,t} + R_{b,t}B_{e,t-1} + q_t^k \left[K_{e,t} - (1 - \delta_t^k)K_{e,t-1} \right] + q_t(H_{e,t} - H_{e,t-1}) + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t}, \tag{C.11}$$

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

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

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

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

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

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

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

C.4 Bank Managers

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 $D_{b,t}$ that maximize her objective function subject to a cash flow restriction and a borrowing limit (capital adequacy constraint)

$$d_{b,t} + B_{it} + B_{e,t} - D_{b,t} - (1 - \delta_t)\left(B_{i,t-1} + B_{e,t-1} - D_{b,t-1}\right)$$
$$= r_{e,t}B_{e,t-1} + r_{i,t-1}B_{i,t-1} - r_{d,t-1}D_{b,t-1} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - T(d_{b,t}, d_t^*), \quad \text{(C.18)}$$

$$D_{b,t} = \gamma_{i,t}B_{i,t} + \gamma_{e,t}B_{e,t}, \tag{C.19}$$

The law of motion for bank equity reads

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

The resulting optimality conditions read

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

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

C.5 Capital Goods Producers

Capital-good-producing firms seek to maximize their objective function with respect to net investment in physical capital, I_t. The resulting optimal condition is

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

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

$$K_t = (1 - \delta_t^k)K_{t-1} + I_t \left[1 - \frac{\psi_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right]. \tag{C.24}$$

C.6 Macroprudential Authority

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

$$d_t^* = \rho_d + \rho_\chi \left(\frac{x_t}{x^{ss}} - 1 \right). \tag{C.25}$$

Such policy rule is associated to a sanctions regime that penalizes deviations from the prudential target. The DPT enters a penalty function of the form

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2} \left(d_{b,t} - d_t^* \right)^2. \tag{C.26}$$

The prudential authority has full control over regulatory capital ratios, $\left(1 - \gamma_{i,t} \right)$ and $\left(1 - \gamma_{e,t} \right)$. The sectorial debt-to-asset ratios associated to such capital regulatory scheme read

$$\gamma_{i,t} = \gamma_i + \gamma_x \left(\frac{x_t}{x^{ss}} - 1 \right), \tag{C.27}$$

$$\gamma_{e,t} = \gamma_e + \gamma_x \left(\frac{x_t}{x^{ss}} - 1 \right). \tag{C.28}$$

C.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:

$$Y_t = C_{p,t} + C_{i,t} + q_t^k I_t + \delta_t K_{b,t-1} + Adj_t, \tag{C.29}$$

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

supply,

$$N_t = N_{p,t} + N_{i,t}. \tag{C.30}$$

The stock of physical capital produced by capital goods producers must equal the demand for this good coming from entrepreneurs

$$K_t = K_{e,t}. \tag{C.31}$$

Similarly, in equilibrium demand for loans of impatient households and entrepreneurs equals aggregate credit supply

$$B_t = B_{i,t} + B_{e,t}. \tag{C.32}$$

The stock of bank deposits held by patient households must be equal to aggregate debt issued by bankers

$$D_t = D_{b,t}. \tag{C.33}$$

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

$$\overline{H} = H_{p,t} + H_{i,t} + H_{e,t}. \tag{C.34}$$

C.8   Shocks

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

$$\log \varepsilon_t^{mh} = \rho_{mh} \log \varepsilon_{t-1}^{mh} + e_{mh,t}, \ e_{mh,t} \sim N(0, \sigma_{mh}), \tag{C.35}$$

$$\log \varepsilon_t^{mk} = \rho_{mk} \log \varepsilon_{t-1}^{mk} + e_{mk,t}, \ e_{mk,t} \sim N(0, \sigma_{mk}), \tag{C.36}$$

$$\log \varepsilon_t^{kb} = \rho_{mk} \log \varepsilon_{t-1}^{kb} + e_{kb,t}, \ e_{kb,t} \sim N(0, \sigma_{kb}), \tag{C.37}$$

$$\log \varepsilon_t^h = \rho_h \log \varepsilon_{t-1}^h + e_{h,t}, \ e_{h,t} \sim N(0, \sigma_h), \tag{C.38}$$

$$\log A_t = \rho_A \log A_{t-1} + e_{A,t}, \ e_{A,t} \sim N(0, \sigma_A). \tag{C.39}$$

D Policy Discussion

The DPT vs the CCyB   The wide acceptance of the CCyB as a fundamental macro-prudential tool, deserves the comparative analysis between such policy instrument and the countercyclical DPT to be extended without limiting to the proposed analytical framework. As presented in this paper, the countercyclical DPT is a two-sided target that gives bankers incentives to distribute earnings in a more procyclical and volatile fashion even if they are compliant with their capital requirements. By way of contrast, the CCyB operates as a dynamic one-sided restriction that gives bankers "full discretion" to distribute equity provided that they meet their corresponding capital requirements. Interestingly, the DPT and the CCyB seem to operate in opposite directions. During the downturn (when the probability of bank default tends to be higher), the DPT encourages bank managers to cut back on dividends, whereas the CCyB calls on banks to release the capital buffer they have built up during the upturn (arguably, by restricting their dividend payouts during the credit expansion in order to retain more earnings).

In particular, and as reflected in the proposed DSGE model, both macroprudential tools smooth loans supply, but operate through very different transmission channels: Under the CCyB, bank capital readjusts in the face of shocks, permitting debt (which now represents a larger proportion of assets) to evolve in a smoother fashion. By way of contrast, the DPT gives incentives for bank managers to optimally tolerate a higher degree of dividend volatility, thereby allowing for smoother retained earnings.

These differences have two important policy implications. First, the countercyclical DPT is more effective (than the CCyB) in smoothing the credit cycle since it directly attacks the root of the "problem" by discouraging bank dividend smoothing.[52] Second, arguably, the DPT should be more effective than the CCyB in reducing the probability of bank default

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[52]This is is one of the findings of this paper, which is presented and discussed in section 6.

over the cycle, since it discourages equity distributions when the likelihood of bank failure is relatively high (i.e., during the downturn).[53]

Yet, the quantitative analysis proposed in this paper suggests the DPT and the CCyB are important complements for at least two reasons. First, while households who do not own banks have a strict preference for the DPT (since they are more effective than the CCyB in smoothing bank debt and loans supply), bank owners have a stronger preference for the CCyB (as this tool favours smoother dividend payouts). Second, the complementarities of the different mechanisms through which each of these instruments operate translates into optimized DPTs reinforcing the effectiveness of the CCyB in smoothing the credit and the business cycle and the optimal DPT performing particularly better than the optimized, highly responsive, CCyB under non-financial shocks.

Importantly, there are other key aspects the proposed model omits and which may reinforce the complementarities between the two instruments in practice. In reality, the CCyB plays a key role in preventing and mitigating the build up of endogenous systemic risk during credit expansions, whereas the role of the DPT would be more focused on effectively enhancing bank soundness and sustained lending during economic downturns. In this regard, the DPT could be interpreted as a dynamic dividend restriction, in which case parameter κ could be regarded as the binding degree of the policy rule or recommendation.

The DPT and the Sanctions Regime The proposed regulatory scheme incorporates a sanctions regime that plays an important role during the lower phase of the cycle. It gives incentives for banks to cut back on dividends and imposes a sanction to those who deviate from the DPT. For simplicity, the model assumes the collected public revenues are transferred to households within the same period. Such transfer system acts as a insurance scheme for the real economy as it provides households with a positive payoff when they need it the most (i.e., when the marginal utility of their consumption is relatively high). A more comprehensive set-up in which bank default is considered, would permit to set an insurance fund built on such public revenues and aimed at reducing the probability of bank failure in bad times.

Although required penalties for this regulatory scheme to give the right incentives seem to be quantitatively small, the supervisor could alternatively use the dividend prudential target

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[53]Confirming that this is the case would require to extend the proposed model by allowing for risk of bank default.

as a mere indicator to give recommendations on prudent payout policies to banks.

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