UNIVERSIDAD COMPLUTENSE DE MADRID
FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES

TESIS DOCTORAL

Essays on Macroprudential Regulation and Financial Stability

(Ensayos sobre Regulación Macroprudencial y Estabilidad Financiera)

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Manuel Álvaro Muñoz García

Directores

Javier Ángel Andrés Domingo
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Madrid

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Tesis Doctoral

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To my family

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Resumen

Ensayos sobre Regulación Macroprudencial y Estabilidad Financiera

Como consecuencia de la Crisis Financiera Global, la política macroprudencial se ha erigido como el tercer pilar de las políticas macroeconómicas (los otros dos pilares son la política monetaria y la política fiscal). El objetivo de la política macroprudencial es el de suavizar el ciclo financiero y prevenir la acumulación endógena de riesgo sistémico. Si bien, algunas de las reformas financieras desarrolladas tras el estallido de la Crisis Financiera Global han supuesto importantes avances en este ámbito, la crisis de COVID-19 ha puesto de manifiesto la necesidad de reconsiderar la regulación macroprudencial existente. Los acontecimientos recientes sugieren que los Acuerdos de Basilea III no proporciona a los bancos los incentivos adecuados para que éstos utilicen sus colchones de capital cuando la situación más lo requiere (es decir, la regulación de capital contracíclica está resultando ser menos efectiva de lo que se esperaba inicialmente). Además, la crisis causada por la pandemia ha puesto de relieve la importancia de reforzar el marco de política macroprudencial para instituciones financieras no bancarias.

El objetivo último de esta tesis es el de contribuir al desarrollo de un marco de regulación macroprudencial - tanto para el sector bancario como para el sector no bancario - más efectivo y eficiente. En ella documento ciertas regularidades empíricas y hechos ocurridos recientemente en el sector financiero de la zona euro e identifico ciertos patrones que podrían representar riesgos para la estabilidad financiera. Con estas premisas, propongo una serie de reformas de regulación financiera y evalúo sus efectos macroeconómicos y de bienestar mediante el uso de modelos dinámicos, estocásticos y de equilibrio general. Los principales resultados del análisis cuantitativo sugieren que la adopción de las reglas de política macroprudencial correspondientes contribuiría positivamente a la estabilidad financiera y la estabilización económica. La tesis se estructura en una introducción, tres capítulos principales y una conclusión.

El primero de los tres capítulos principales se hace eco de dos tendencias mostradas por los bancos de la zona euro tras la Gran Recesión: (i) su tendencia a mejorar sus ratios de capital mediante la reducción en el total de activos (contracción en la oferta de crédito), y (ii) su reticencia a reducir el pago de dividendos (caída en beneficios retenidos). En primer lugar, se proporciona evidencia en favor de un vínculo potencial entre ambos patrones. Ante el advenimiento de shocks que golpean a sus beneficios, los bancos tienden a hacer el ajuste vía beneficios retenidos con el fin de suavizar el pago de dividendos. Esto genera volatilidad en el capital bancario y en la oferta de crédito. Seguidamente, el capítulo desarrolla un modelo cuantitativo, dinámico, estocástico y de equilibrio general que incorpora este mecanismo para estudiar la transmisión y efectos de una novedosa regla de política macroprudencial - denominada objetivo prudencial de dividendos (DPT, por sus siglas en inglés) - orientada a complementar la regulación de capital (bancario) existente al combatir este problema. Los DPTs que maximizan el bienestar son eficaces (más que el colchón de capital contracíclico o CCyB, por sus siglas en inglés) a la hora de suavizar el ciclo financiero y económico (mediante unos beneficios retenidos menos volátiles) e inducen ganancias de bienestar significativas asociadas a una regulación de capital de tipo Basilea III mediante varios canales.

El segundo capítulo argumenta que el marco regulatorio de Basilea III - el cual impone restricciones a la distribución de dividendos de forma automática cuando los bancos se sitúan por debajo de un cierto umbral de capital (en un contexto de fuerte reticencia a la reducción en el pago de dividendos de los bancos) - no proporciona a las entidades de crédito con los incentivos adecuados para que éstas utilicen sus colchones de capital en la fase bajista del ciclo. En efecto, acontecimientos recientes desencadenados por la crisis de COVID-19 sugieren que la regulación de capital contracíclica no ha sido tan efectiva como se preveía. Ante esta situación, bancos centrales de todo el mundo han solicitado a las entidades de crédito que se abstengan de distribuir dividendos (aunque cumplan con sus requerimientos de capital) con el fin de mantener la provisión de crédito durante la crisis causada por la pandemia. Este capítulo incorpora rigideces nominales y una regla de Taylor simple en el modelo presentado en el capítulo anterior para evaluar los efectos e interacciones entre este tipo de regulación (macroprudencial) de dividendos y política monetaria, con y sin una regulación de capital contracíclica efectiva. Primero, la regulación macroprudencial de dividendos es más eficaz a la hora de suavizar el ciclo económico que la regla de Taylor simple óptima o el CCyB óptimo. Segundo, coordinar perfectamente la política monetaria y la regulación contracíclica de capital y de dividendos supone ganancias de bienestar. Tercero, cuando la política monetaria se ve restringida por el límite inferior igual a cero (ZLB, por sus siglas en inglés), la regulación contracíclica de dividendos y el CCyB son particularmente eficaces y la necesidad de combinar medidas de conservación de capital con aquellas de utilización de capital (en la fase bajista del ciclo) se hace más evidente.

El tercer capítulo pone de relieve la creciente presencia de inversores institucionales en el mercado inmobiliario desde el estallido de la Crisis Financiera Global. Fondos de inversión inmobiliaria y otras empresas de inversión inmobiliaria se apalancan para llevar a cabo grandes inversiones en inmuebles (con fines de alquiler) que les permiten fijar precios en el mercado de alquiler. Una proporción relevante de esta financiación es proporcionada en forma de crédito no -bancario (el cual no está sujeto a límites regulatorios de LTV). Este capítulo desarrolla un modelo dinámico, estocástico y de equilibrio general, que incorpora las principales características de la industria de fondos de inversión inmobiliaria en el contexto actual con el fin de estudiar la efectividad de los ratios LTV dinámicos como herramienta macroprudencial. A pesar de que la proporción relativa de inmuebles y de deuda mantenida por los fondos de inversión inmobiliaria es muy baja, las reglas LTV optimizadas que afectan a la capacidad de endeudamiento de estos fondos som más eficaces a la hora de suavizar el ciclo crediticio e inmobiliario que aquellas que modifican el límite de endeudamiento de los hogares. Este resultado es muy robusto para distintas calibraciones (de parámetros clave) y para distintas especificaciones del modelo. La razón que subyace a tan importante y robusto resultado se asocia a las interconexiones de estos fondos con varios sectores de la economía.

En conclusión, esta tesis doctoral desarrolla una variedad de modelos cuantitativos dinámicos, estocásticos y de equilibrio general con sector financiero con el objeto de evaluar los principales mecanismos de transmisión y efectos macroeconómicos de ciertas reglas de *policy* que tienen el potencial de poder pasar a formar parte del conjunto de herramientas macroprudenciales en el futuro. Los resultados fundamentales del análisis cuantitativo sugieren que las reglas de política prudencial propuestas son particularmente eficaces (más que algunas de las herramientas de política macroprudencial ya existentes) a la hora de suavizar ciclos financieros y económicos.

Abstract

Essays on Macroprudential Regulation and Financial Stability

As a consequence of the Global Financial Crisis (GFC), macroprudential policy emerged as the third pillar of macroeconomic policies (the other two pillars are monetary policy and fiscal policy). The aim of macroprudential policy is to smooth the financial cycle and to prevent the endogenous build-up of systemic risk. While some of the financial reforms undertaken in the aftermath of the GFC have represented important steps on this front, the COVID-19 crisis has highlighted the need for rethinking macroprudential regulation. Recent developments suggest that the Basel III Accord does not provide banks with the right incentives for them to draw on their capital buffers when such action is needed the most (i.e., bank capital countercyclical regulation is proving to be less effective than initially expected). In addition, the pandemic crisis has underscored the importance of strengthening the macroprudential policy framework for non-banks.

The final goal of this thesis is to contribute to the development of a more effective and efficient macroprudential regulatory framework for both, banks and non-banks. I document certain regularities and recent developments in the euro area financial sector and identify certain patterns that could potentially constitute risks to financial stability. Against this background, I propose certain financial regulatory reforms and assess their welfare and macroeconomic effects from a DSGE perspective. The main findings of the quantitative analysis suggest that the adoption of the corresponding macroprudential policy rules would positively contribute to financial stability and economic stabilization. The thesis is structured in an introduction, three main chapters and a conclusion.

The first of these three main chapters takes note of 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, some evidence of a potential link between

these two trends is provided. When shocks hit their profits, banks tend to adjust retained earnings to smooth dividends. This generates bank equity and credit supply volatility. Then, the chapter develops a quantitative 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 counter-cyclical capital buffer or 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.

The second chapter argues that existing (Basel III) capital regulation - which imposes automatic dividend restrictions when banks breach a specific capital threshold (in a context of strong reluctance to cut back on bank dividends) - does not provide credit institutions with adequate incentives to draw on their capital buffers in bad times. Indeed, recent developments triggered by the COVID-19 crisis suggest that countercyclical capital regulation has not been as effective as intended. Against this background, central banks around the world have requested credit institutions to refrain from distributing dividends (even if they would meet their capital requirements) to maintain credit provision amid the pandemic crisis. This chapter incorporates nominal rigidities and a simple Taylor-type policy rule in the model presented in the previous chapter to assess the effects and interactions between this type of (macroprudential) dividend regulation and monetary policy, with and without having effective countercyclical capital regulation in place. First, optimal macroprudential dividend regulation is more effective (in smoothing the business cycle) than the optimal simple Taylor rules or the optimal CCyB. Second, perfect coordination between monetary policy, the CCyB, and macroprudential dividend regulation induces significant welfare gains. Third, when monetary policy hits the zero lower bound, countercyclical dividend regulation and the CCyB become particularly effective and the need for combining measures of capital conservation with those of capital usability (in bad times) is underscored.

The third chapter highlights the steady increase in the presence of institutional investors in housing markets since the onset of the Global Financial Crisis. Real estate funds (REIFs) and other housing investment firms leverage large-scale buy-to-rent investments in real estate assets that enable them to set prices in rental housing markets. A significant fraction of this funding is being provided in the form of non-bank lending (i.e., lending that is not subject to regulatory LTV limits). This chapter develops a quantitative two-sector DSGE model that incorporates the main features of the real estate fund industry in the current context to study the effectiveness of dynamic LTV ratios as a macroprudential tool. Despite the comparatively low fraction of total property and debt held by REIFs, optimized LTV rules limiting the borrowing capacity of such funds are more effective in smoothing property prices, credit and business cycles than those affecting (indebted) households' borrowing limit. This finding is remarkably robust across alternative calibrations (of key parameters) and specifications of the model. The underlying reason behind such an important and unexpectedly robust finding relates to the strong interconnectedness of REIFs with various sectors of the economy.

In conclusion, this doctoral thesis develops a variety of quantitative DSGE models with financial sector in order to evaluate the main transmission mechanisms and macroeconomic effects of selected policy rules that could potentially become part of the macroprudential toolkit in the future. The main findings of the quantitative analysis suggest that the proposed prudential policy rules are particularly effective (more than some of the already existing key macroprudential tools) in smoothing financial and business cycles.

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[1] This chapter is based on joint work with Carlos Montes-Galdón (European Central Bank).

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Chapter 1

Introduction

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 low profitability environment) 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 deleveraging 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, chapter 2 develops 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 Prudential 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 procyclical and 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 (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 chapter 1 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).

The COVID-19 crisis has highlighted certain deficiencies in the existing macroprudential regulatory framework. Prudential authorities all over the world adopted an array of relief measures to ensure that the sanitary crisis would not turn into a financial crisis. Among others, central banks encouraged credit institutions to make full use of all releasable capital buffers. However, banks have so far remained hesitant to draw on their buffers, among other reasons, due to the fear of potential stigma effects in financial markets. The Basel III Accords impose automatic (institution-specific) dividend restrictions when banks breach a specific capital requirement threshold. Given the strong reluctance of bankers for cutting back on dividends during the economic downturn and the related risk of releasing capital buffers during such phase of the cycle (i.e., in terms of an increased probability of breaching the mentioned capital threshold), existing capital regulation does not seem to be providing banks with the adequate incentives to draw on their buffers when such action is needed the most.

In this context, central banks around the world have requested credit institutions to temporarily refrain from distributing dividends (even if they would meet their capital requirements) in order to keep funding households and firms amid the COVID-19 crisis. That is, they have de facto switched from a microprudential (institution-specific) and capital-contingent dividend regulation to a macroprudential and state-contingent dividend regulation similar to the one that is proposed in chapter 1. These measures have been adopted in a context of significant monetary accommodation and low-interest rates.

Chapter 3, which is based on joint work with Carlos Montes-Galdón (European Central Bank), extends the previous DSGE macro-banking model to incorporate nominal rigidities and a simple Taylor-type rule with the ultimate goal of studying the welfare effects, interactions and cooperative options between monetary policy and macroprudential dividend regulation in the current Basel III regulatory environment.

Several conclusions that can be drawn from the quantitative analysis stand out. First, and regardless of the nature of the exogenous shock, the optimal dividend prudential target is more effective in smoothing the business cycle than the optimal simple Taylor rule or the optimal CCyB. Second, there are significant welfare gains from combining an optimal simple Taylor rule with macroprudential dividend regulation, even if a an optimal (and highly responsive) CCyB is in place. Furthermore, under perfect cooperation, additional welfare gains are attained through a stronger specialization of monetary and macroprudential policies on their respective traditional objectives (i.e., price stability and financial stability). Third, the proposed prudential policy rules become particularly effective when the short term nominal interest rate hits the zero lower bound. In a low interest rate environment, the different transmission mechanisms through which the DPT and the CCyB operate (as well as the conflictive effect they have on bank capital) become more evident, thereby highlighting the importance of combining measures of capital conservation (i.e., dividend limits) with measures of capital usability (capital buffers) in bad times.

Recent developments have also underscored the need to strengthen the macroprudential policy framework for non-banks, in general, and for investment funds, in particular. Total assets of the euro area non-banking sector have doubled over the last decade, with the size of the investment fund industry expanding at a relatively higher pace and its interconnectedness with other segments of the financial sector and the real economy being well documented. Moreover, the short-term impact of the COVID-19 shock on the financial sector has highlighted the potential of the investment fund sector to trigger episodes of severe market volatility and price dislocations.

More specifically, Since 2013, institutional investment in euro area real estate assets has more than quadrupled in absolute terms and as a share of total housing investment. According to recent empirical studies, real estate funds (REIFs) and other housing investment firms have been leveraging large-scale buy-to-rent investments in real estate assets, a pattern that has arguably enabled them to set prices in rental housing markets. Importantly, a significant proportion of this funding is being provided in the form of non-bank lending (i.e., lending that is not subject to regulatory LTV limits). Moreover, real estate funds are generally not subject to leverage limits in the EU and there is significant uncertainty surrounding their actual leverage measures, among other reasons, due to the fact that investment funds often lever up synthetically through the use of derivatives.

Based on the findings of recent empirical studies, chapter 4 develops a two-sector DSGE model that incorporates the main features of the real estate fund industry in the current context and calibrates it to quarterly euro area data in order to assess the potential effectiveness of countercyclical LTV ratios that limit their borrowing capacity (i.e., LTV limits on commercial mortgages) in smoothing housing price and credit cycles.

Despite the comparatively low fraction of property and debt held by REIFs, optimized countercyclical LTV rules directly affecting their borrowing limit are more effective in smoothing property prices, credit and business cycles than the well investigated optimized LTV limits restricting the borrowing capacity of (indebted) households. Moreover, if the sole objective of the macroprudential authority is to tame the housing price and credit cycle, the best option is to have an LTV rule affecting REIFs' borrowing limit in place (i.e., the LTV rule limiting households' borrowing capacity seems to be redundant in this case). Such findings are impressively robust across key alternative specifications and calibrations of the model.

These results shed light on some of the potential avenues for strengthening the macroprudential policy framework for non-banks. There are at least two policy instruments that could be considered to tackle the issue of funds' leverage-induced procyclicality in practice and which are still not in place: (dynamic) limits on REIFs' leverage and countercyclical LTV limits on non-bank lending. Moreover, the quantitative analysis notes that such (quantity) regulation would allow for reference prices in rental housing markets to increase less abruptly during the boom, an issue that policymakers in several countries of the euro area have attempted to handle via price regulation (an alternative that could generate price distortions).

Chapter 2

Rethinking Capital Regulation: The Case for a Dividend Prudential Target

2.1 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 84^{th} 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 chapter is to define a very simple framework that incorporates this mechanism to study the transmission channel 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.

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

[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.

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

[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.

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 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 chapter is organized as follows. Section 2.2 discusses how the contents of this chapter fit into the existing literature. Section 2.3 presents empirical evidence on bank dividends and earnings in the euro area. Section 2.4 describes the basic model and identifies the transmission mechanism through which a dividend prudential target smooths the credit cycle. Section 2.5 presents the extended model to improve the matching of the model to the data. Section 2.6 develops a quantitative exercise to assess the welfare effects of the DPT and its interactions with regulatory capital ratios. Section 2.7 concludes.

2.2 Related Literature

This chapter 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 chapter 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

[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 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).

plays such 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 chapter 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.

2.3 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 2.1 and 2.2 is from the Euro Stoxx Banks Index, SX7E.[8] All time series are at quarterly frequency and have been seasonally adjusted.[9] Figure 2.1a 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 2.1b), 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] 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 2.1c).[11]

[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 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 2.1a have been constructed as a simple sum of the SX7E members whereas those in figures 2.1b and 2.1c have been reported as the index itself (i.e., as a capitalization-weighted sum of the same group of banks).

Figure 2.2 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 2.2a 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 2.2b). The bottom line is that there is a high degree of comovement among bank retained earnings, lending and real GDP (see figures 2.2c and 2.2d).

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.

2.4 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 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.

[12] Financial data plotted in figure 2.2 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 2.6.

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.

2.4.1 Main Features

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

$$E_0 \sum_{t=0}^{\infty} \beta_h^t \left[\log C_{h,t} + j \log H_{h,t} - \frac{N_{h,t}^{1+\phi}}{(1+\phi)} \right], \tag{2.1}$$

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.

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

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \log C_{e,t} \tag{2.2}$$

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 $\Phi_e(B_{e,t}) = \frac{\phi_e}{2} \frac{(B_{e,t} - B_{e,t-1})^2}{B_e^{ss}}$ 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]

$$Y_t = H_{e,t-1}^{v} N_t^{1-v}. \tag{2.3}$$

In addition, entrepreneurs are subject to:

$$B_{e,t} \leq m_t^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_{h,t} N_t. \tag{2.4}$$

Expression (2.4) 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 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]

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

$$E_0 \sum_{t=0}^{\infty} \beta_b^t \log d_{b,t}, \tag{2.5}$$

subject to

[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).

[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.

$$B_t = K_{b,t} + D_{b,t}, \tag{2.6}$$

$$d_{b,t} + K_{b,t} - (1-\delta)K_{b,t-1} = r_{e,t}B_{t-1} - r_{h,t-1}D_{b,t-1} - \Phi_b(B_t), \tag{2.7}$$

$$D_{b,t} \leq \gamma B_t, \tag{2.8}$$

where equations (2.6), (2.7) and (2.8) denote the balance sheet identity, the sequence of cash flow restrictions, and the borrowing constraint of the banker, respectively.

According to (2.6), 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]

$$K_{b,t} = J_{b,t} - \ d_{b,t} + \ (1-\delta)K_{b,t-1}, \tag{2.9}$$

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

$$J_{b,t} = \underbrace{\underbrace{(K_{b,t} - K_{b,t-1})}_{\text{reinvested profits}} + \underbrace{\delta K_{b,t-1}}_{\text{eroded equity}}}_{\text{retained earnings}} + \underbrace{d_{b,t}}_{\text{distributed earnings}}, \tag{2.10}$$

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 re-

[16] Expression (2.9) 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).

tained 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 2.1c). Second, expression (2.9) 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 (2.9) allows to map the model to first and second moments of data on bank dividends and earnings (see section 6).

Equation (2.7) 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.

Expression (2.8) 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:

$$\frac{(1-\gamma) + \dfrac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t}} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma (R_{h,t} - \delta)}{d_{b,t+1}} \right\}. \tag{2.11}$$

Expression (2.11) 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 2.11) and that dedicated to the financial intermediation activity (numerator on each side of equation 2.11). 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

[17] As in the case of the entrepreneur, $\Phi_b(B_t) = \dfrac{\phi_b}{2} \dfrac{(B_t - B_{t-1})^2}{B^{ss}}$ 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.

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 (2.11) 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 (2.11) 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 (2.11) synthesizes the information of a powerful mechanism for transmission and amplification of shocks that hit bank profits. The preference for dividend smoothing (expression 2.5) implies that the bulk of the adjustment to shocks that hit profits is going to be made via retained earnings. Due to the strong link between equity and loans (equations 2.6 and 2.8), such fluctuations in retained earnings are going to translate into loans supply volatility.

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):

$$Y_t = C_t + \delta K_{b,t-1} + \Phi_b(B_t) + \Phi_e(B_t), \tag{2.12}$$

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

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

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

[18] By equations (2.6) and (2.8), such decision automatically involves borrowing additional γ units of deposits and lending an extra unit of assets.

$$d_t^* = \rho_d + \rho_\chi(\frac{x_t}{x^{ss}} - 1), \tag{2.13}$$

and

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2}\left(d_{b,t} - d_t^*\right)^2, \tag{2.14}$$

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 (2.13), 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 (2.14). $\kappa \geqslant 0$ 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 (2.14) 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 (2.13) (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

$$\frac{(1-\gamma) + \dfrac{\partial \Phi_b(B_t)}{\partial B_t}}{d_{b,t}\left[1 + \kappa(d_{b,t} - d_t^*)\right]} = \beta_b E_t \left\{ \frac{(R_{e,t+1} - \delta) - \gamma\left(R_{h,t} - \delta\right)}{d_{b,t+1}\left[1 + \kappa\left(d_{b,t+1} - d_{t+1}^*\right)\right]} \right\}. \tag{2.15}$$

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 2.11). Under a dividend prudential target within the class (2.13), 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 2.15).

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

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

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

$$\gamma_t = \gamma + \gamma_x(\frac{x_t}{x^{ss}} - 1), \tag{2.16}$$

where γ_x is the macroprudential policy parameter associated to the regulatory capital ratio implied by equation (2.16), $(1-\gamma_t)$. Note that equations (2.8) and (2.11) are directly affected by this new policy environment.

There is a strand of literature on macro-banking models that attempts to evaluate the effects of the so-called countercyclical capital buffer (CCyB) by specifying a dynamic regulatory capital ratio similar to the one associated to policy rule (2.16) (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 (2.9) and (2.16) 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).

2.4.2 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]

[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.

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%.

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.

The Transmission Mechanism of Dividend Prudential Targets

Figure 2.3 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 (2.13), and (2.16) respectively

[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.

$$\arg\min_{\Theta} L^{mp} = \omega_z \sigma_z^2, \qquad \omega_z > 0 \ , \tag{2.17}$$

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 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 (2.14), κ, are set to 1 and 0.426, respectively.[23]

In order to identify the optimal simple rule within the class (2.13) that solves (2.17), 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 (2.13) that solves (2.17) 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 (2.17) with respect to parameter γ_x of policy rule (2.16) 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 (2.16) that solves (2.17) 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

[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 (2.14), 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.

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 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 2.1 reports the prudential losses and optimized policy parameters related to the solution to problem (2.17), 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 (2.14) can be interpreted as a sanctions regime that acts as an insurance scheme for the real economy. As noted in figure 2.3, 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.

[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 (2.13) and (2.16) 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 (2.17).

[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.

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

[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).

2.5.1 Overview of the Model

Households

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

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t \left[\frac{1}{1-\sigma_h} \left(C_{\varkappa,t} - \frac{N_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} + \varepsilon_t^h j \log H_{\varkappa,t} \right], \tag{2.18}$$

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 (2.18) is restricted to the sequence of budget constraints:

$$C_{p,t} + D_t + q_t(H_{p,t} - H_{p,t-1}) = R_{d,t-1}D_{t-1} + W_t N_{p,t} + \omega_b d_{b,t} + \chi T(d_{b,t}, d_t^*) + \omega_e d_{e,t}, \tag{2.19}$$

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

$$\begin{aligned} C_{i,t} + R_{i,t-1}B_{i,t-1} + q_t(H_{i,t} - H_{i,t-1}) + \Phi_i(B_{i,t}) \\ = B_{i,t} + W_t N_{i,t} + (1-\omega_b)d_{b,t} + (1-\chi)T(d_{b,t}, d_t^*) + (1-\omega_e)d_{e,t}, \end{aligned} \tag{2.20}$$

$$B_{i,t} \leq m_{i,t}^H E_t \left[\frac{q_{t+1}}{R_{i,t}} H_{i,t} \right]. \tag{2.21}$$

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. $m^H_{i,t}$ captures exogenous shocks to such collateral.

Entrepreneurs

Let $\Lambda^e_{0,t} = \left[\omega_e \beta_p \frac{\lambda^p_{t+1}}{\lambda^p_t} + (1-\omega_e)\beta_i \frac{\lambda^i_{t+1}}{\lambda^i_t}\right]$ be the stochastic discount factor of entrepreneurs (managers), with λ^p_t and λ^i_t being the Lagrange multipliers of the patient and impatient households' optimization problems, respectively. Then, the representative entrepreneur maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda^e_{0,t} \quad \frac{1}{(1-\frac{1}{\sigma})} d_{e,t}^{\left(1-\frac{1}{\sigma}\right)}, \tag{2.22}$$

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

$$d_{e,t} + R_{b,t}B_{e,t-1} + q^k_t \left[K_{e,t} - (1-\delta^k_t)K_{e,t-1}\right] + q_t(H_{e,t} - H_{e,t-1}) + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t}, \tag{2.23}$$

$$Y_t = A_t(u_t k_{e,t-1})^{\alpha} H^{\eta}_{e,t-1} N_t^{(1-\alpha-\eta)}, \tag{2.24}$$

$$B_t \leq m^H_{e,t} E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t}\right) - m^N W_{h,t} N_t. \tag{2.25}$$

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:

$$\delta^k_t\left(u_t\right) = \delta^k_0 + \delta^k_1(u_t - 1) + \frac{\delta^k_2}{2}\left(u_t - 1\right)^2. \tag{2.26}$$

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

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{b} \frac{1}{(1-\frac{1}{\sigma})} d_{b,t}^{\left(1-\frac{1}{\sigma}\right)}, \tag{2.27}$$

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

$$B_{it} + B_{e,t} = K_{b,t} + D_{b,t}, \tag{2.28}$$

$$d_{b,t}+K_{b,t}-(1-\delta_t)K_{b,t-1} = r_{e,t}B_{e,t-1}+r_{i,t-1}B_{i,t-1}-r_{d,t-1}D_{b,t-1}-\Phi_{be}(B_{e,t})-\Phi_{bi}(B_{i,t})-T(d_{b,t}, d_t^{*}), \tag{2.29}$$

$$D_{b,t} = \gamma_{i,t}B_{i,t} + \gamma_{e,t}B_{e,t}. \tag{2.30}$$

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 (2.11), one for each asset class.

[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 (2.24) 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".

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

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{e} \left(q_{k,t} \Delta x_{k,t} - I_t \right), \tag{2.31}$$

subject to

$$x_{k,t} = x_{k,t-1} + I_t \left[1 - \frac{\psi_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right], \tag{2.32}$$

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.

2.6 Quantitative Analysis

2.6.1 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 2.2A). 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).

[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.

Second, another group of parameters is calibrated by using steady state targets (tables 2.2B and 2.3). 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 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 2.3.[34] Note that after having rearranged in the steady state expression of equation (2.9)

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

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

[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%.

γ_i and corporate loans γ_e are obtained by solving a system of two linear equations:

$$0.895 = \gamma_i \frac{B_i^{ss}}{B^{ss}} + \gamma_e \frac{B_e^{ss}}{B^{ss}}, \tag{2.33}$$

$$(1 - \gamma_e) = 2.1176(1 - \gamma_i). \tag{2.34}$$

Equation (2.33) is the result of equating the steady state leverage ratio to 0.895 after having normalized expression (2.30) to total loans. Its interpretation is straightforward. The equilibrium capital requirement is a weighted average of the two sectorial capital requirements, $(1 - \gamma_e)$ and $(1 - \gamma_i)$, and it has been set to 0.105. Such value has been chosen for empirical and regulatory reasons. (i) It is similar to the pre-crisis historical average of regulatory capital ratios. (ii) According to existing capital legislation, in general terms, the authority cannot impose any restriction on dividend payouts as long as the bank meets the minimum capital requirement (0.08) plus a conservation buffer of 0.025.

Expression (2.34) 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 2.2C and 2.4). 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

[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 %.

function (in the baseline scenario) of the type (2.14) (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 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).

2.6.2 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:

$$\arg\max_{\Theta} V_0 = \zeta_p V_0^p + \zeta_i V_0^i, \tag{2.35}$$

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 (2.35) 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:

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U\left(C_{\varkappa,t}^a, H_{\varkappa,t}^a, N_{\varkappa,t}^a\right) = E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U\left[\left(1+\lambda_{\varkappa}\right) C_{\varkappa,t}^b, H_{\varkappa,t}^b, N_{\varkappa,t}^b\right], \tag{2.36}$$

[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).

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 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 (2.35) 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 (2.35) 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 2.4 plots the individual and social welfare effects of changing the value of parameter ρ_x in a policy rule of the type (2.13), 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 2.4 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 (2.35) for the two proposed welfare criteria by searching over the following grid of parameter values: ρ_x $\{0 - 200\}$.[38] Table 2.5 reports the corresponding optimized parameter values and the welfare gains.

[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 (2.13) has been 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.

Interactions with Capital Requirements and Welfare Effects

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 2.5b). The same applies to the effect of ceteris paribus changes of γ_i on borrowers' welfare (see figure 2.5c).

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 2.5a and 2.5b) and a negative effect on borrowers' welfare (see figures 2.5c and 2.5d).[39]

Note, however, that figures 2.5c and 2.5d 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 2.5e and 2.5f, 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, γ_i^* =0.9418 and γ_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.

[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").

Figure 2.6 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 requirements (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 2.34 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 2.7, 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 2.6 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 γ =0.885), with respect to the baseline scenario (γ =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 2.7 describes the welfare effects of introducing an optimal DPT under the three capital scenarios already considered in figure 2.6. As already mentioned, hikes in capital requirements exacerbate the "problem" of dividend smoothing and enhance the potential of DPTs to tackle such issue. For each of the two proposed welfare criteria, the higher capital

[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.

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 2.8, 2.9 and 2.10 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 2.11 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 2.11b and 2.11d plot the welfare 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 2.11a and 2.11b display the corresponding optimized ρ_x values

[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.

[42] Social welfare gains of the CCyB without an optimal DPT cannot be computed under welfare criterion

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 2.8). 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 2.10), 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 2.9).

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 2.12 to 2.16 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 (2.35) 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 2.12 to 2.14). Under non-financial shocks, the optimal DPT performs better than the optimal CCyB (figures 2.15 and 2.16).[44]

In order to further explore the effectiveness of the three alternative macroprudential policy scenarios in taming the credit cycle, table 2.8 reports the main results of solving problem (2.17) in the extended model, for the three considered policy parameter vectors,

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 2.9). 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 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.

$\Theta \equiv \{\rho_x; \gamma_x; (\rho_x, \gamma_x)\}$, 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.

2.6.3 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 2.17 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]

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 2.18). 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 2.19, this is

[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.

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 2.4.1 and 2.6.1, expression (2.9) 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 2.20 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 2.21 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 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.

2.7 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

[47] Interestingly, figure 2.20 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 (2.9), it follows that if $\delta = 0$, in the steady state bank profits are fully distributed. As in subsection 2.6.2, for the alternative parameterization scenarios considered in figure 2.20, I have assumed that $\rho_d = d_b$.

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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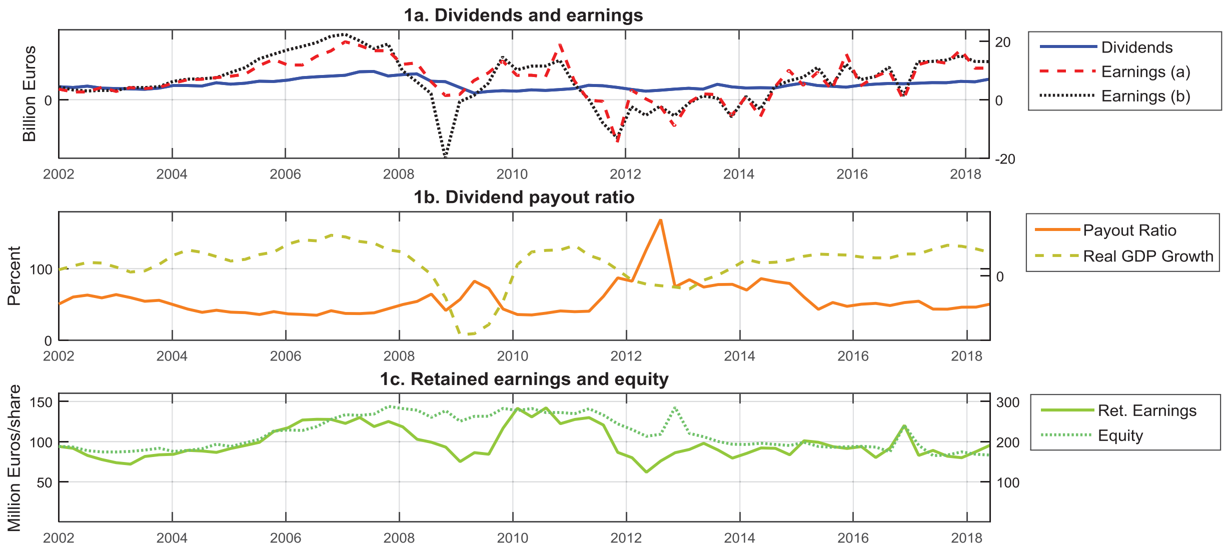
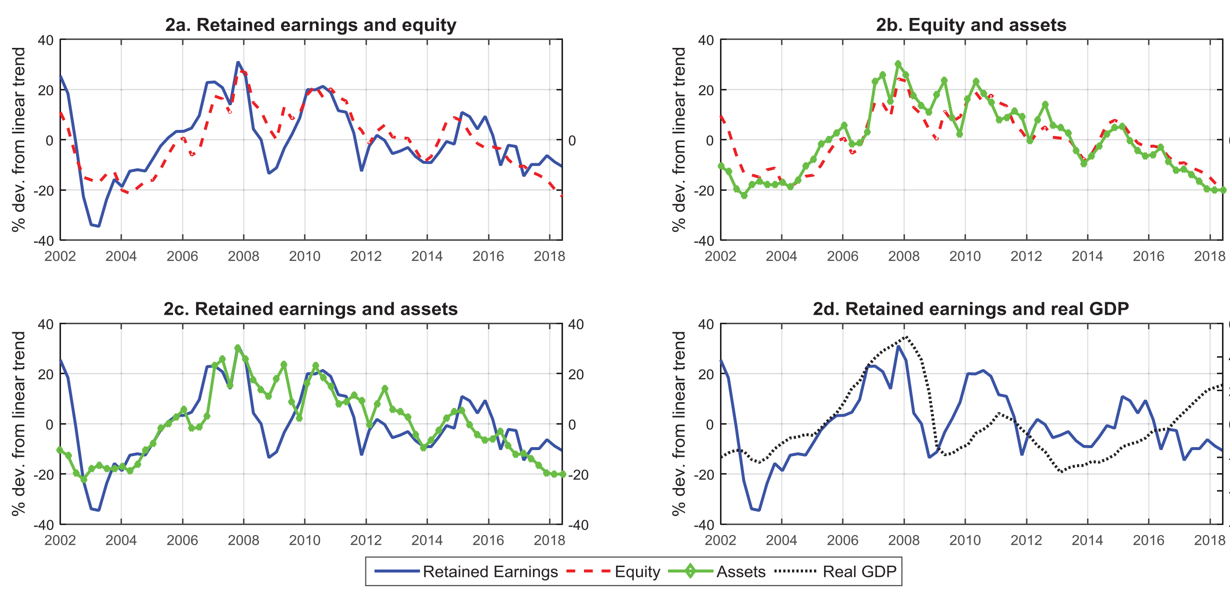
Figure 2.1: Bank dividends and earnings in the euro area (SX7E). 2002:I - 2018:II



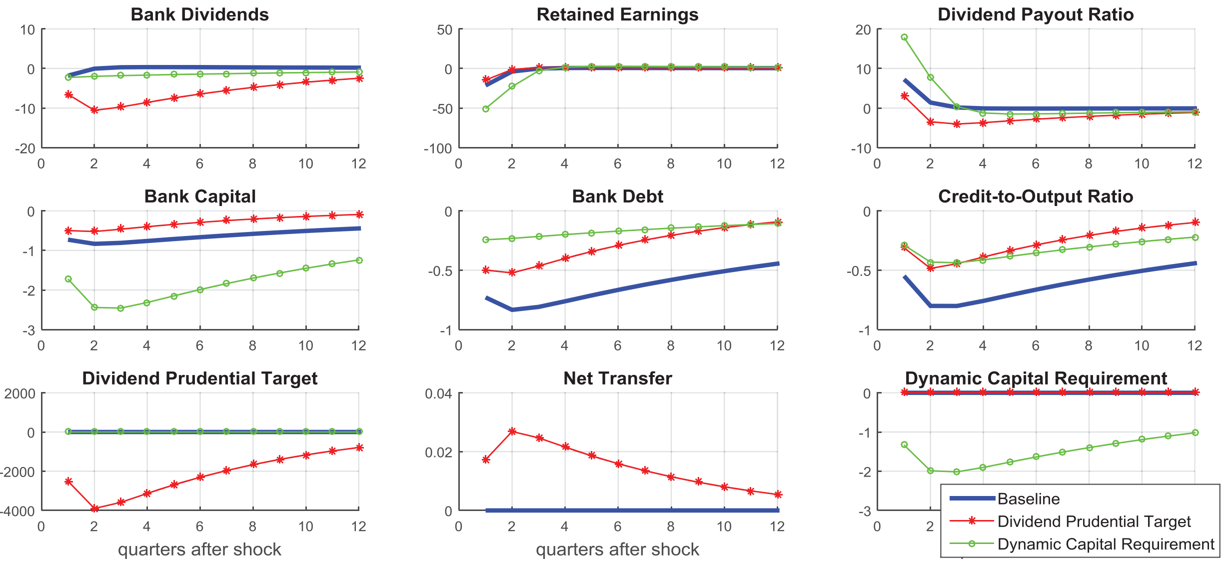
Note: SX7E refers to the Euro Stoxx Banks Index. Time series plotted in figure 1a have been constructed as a simple sum of the SX7E members whereas those in figures 1b and 1c have been reported as the index itself (i.e., as a capitalization-weighted sum of the same group of banks). See the online appendix 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 2.2: Co-movements among bank retained earnings, equity, assets and real GDP



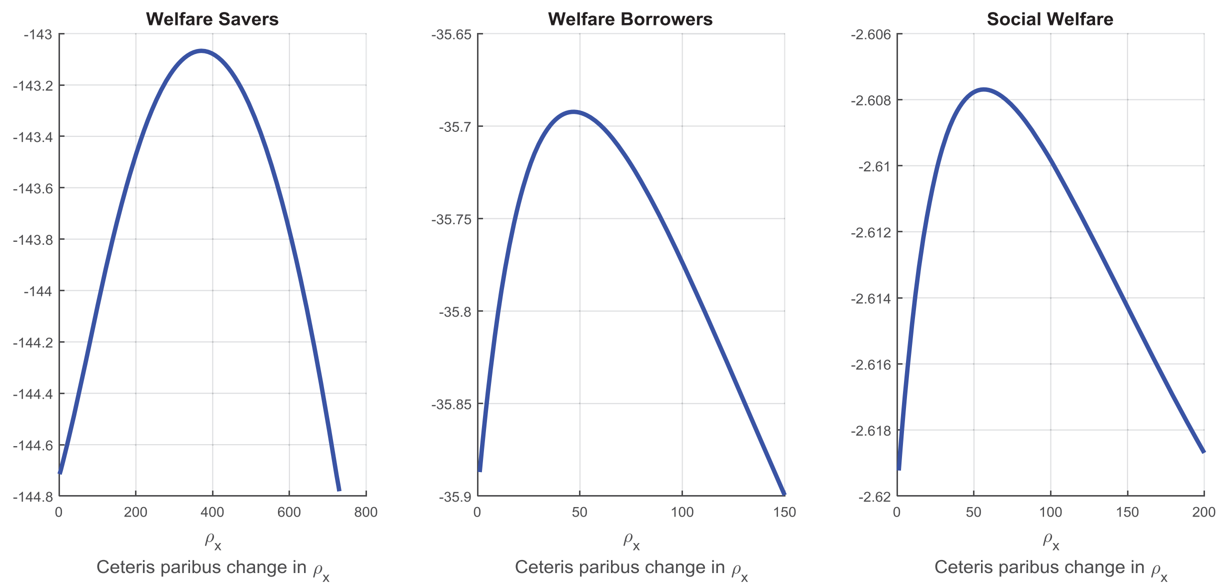
Note: This figure reports the cyclical component of euro area real GDP as well as of aggregate (cumulative) retained earnings, equity and assets of the SX7E members. In order to compute their cyclical component, the log value of seasonally adjusted and deflated time series has been linearly detrended. 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 2.3: The transmission mechanism. IRFs to a negative financial shock (basic model)



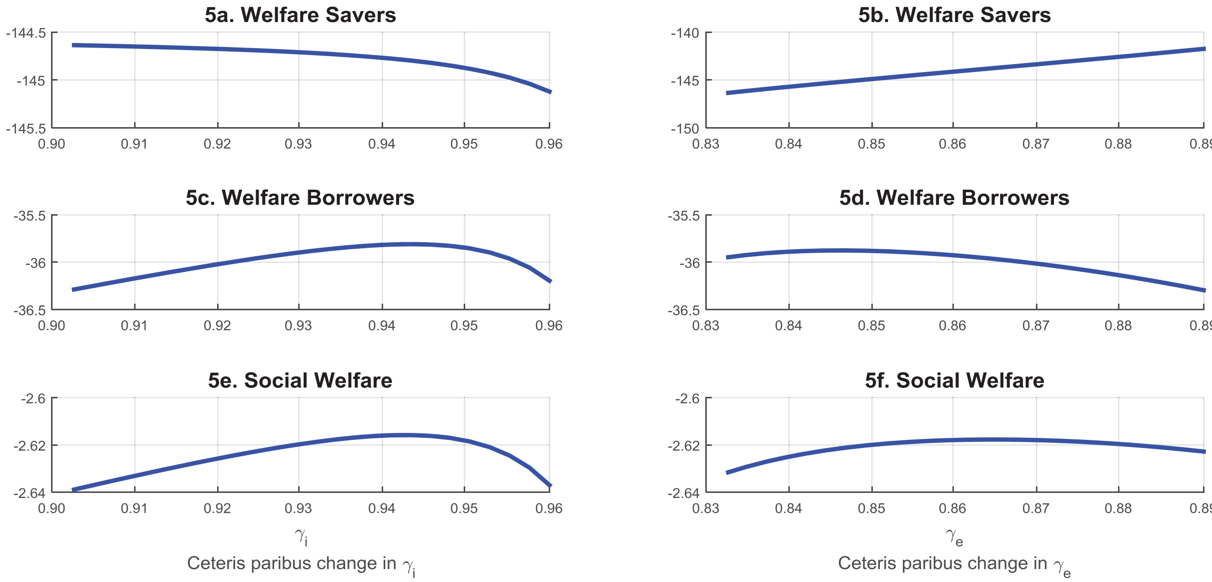
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which the optimized prudential rule is a dividend prudential target. The dotted line relates to an alternative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

Figure 2.4: Welfare effects of DPTs (welfare effects of ceteris paribus changes in ρ_x)



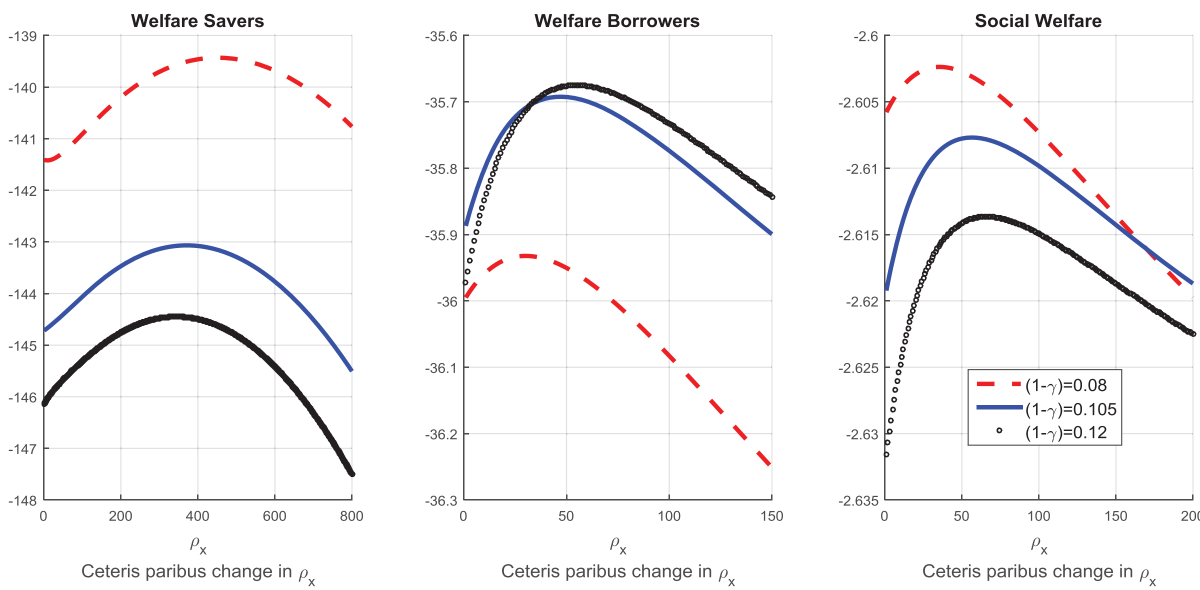
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, while keeping the other policy parameter, ρ_d, to its baseline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

Figure 2.5: Welfare effects of capital ratios (welfare effects of ceteris paribus changes in γ_i and γ_e)



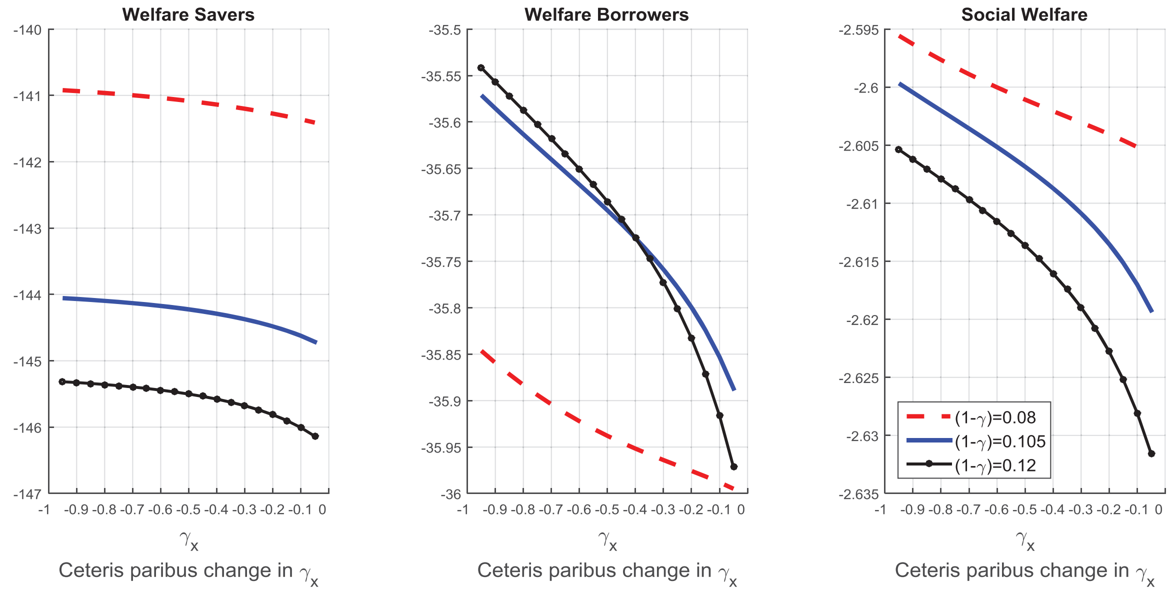
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of capital adequacy parameters γ_i and γ_e. Note that the static capital requirement on NFC loans is (1- γ_e) whereas the static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

Figure 2.6: Welfare effects of DPTs under alternative capital scenarios



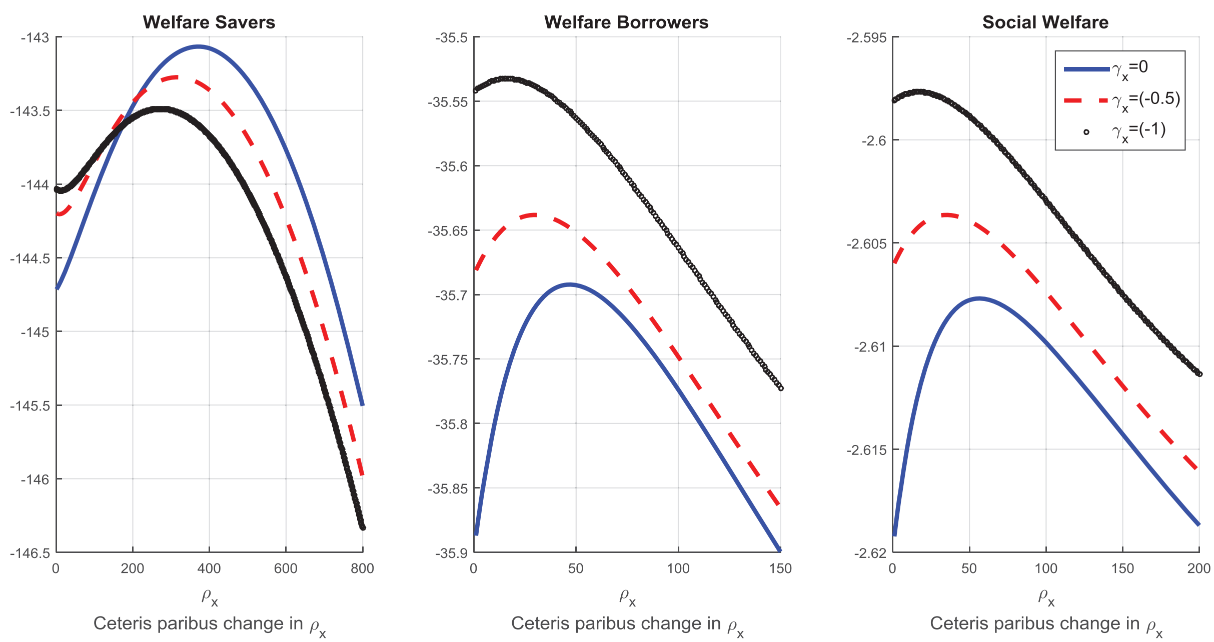
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for three alternative capital scenarios (1-γ).

Figure 2.7: Welfare effects of the CCyB for alternative capital scenarios



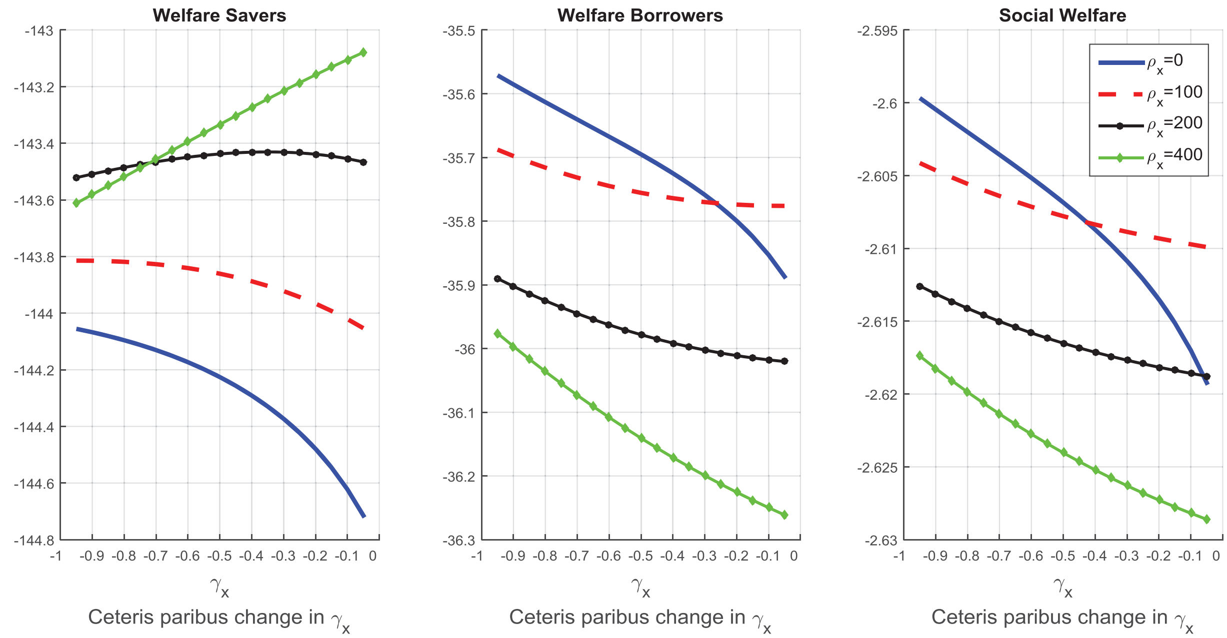
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of dynamic capital requirements, γ_x, for three alternative capital scenarios (1-γ).

Figure 2.8: Welfare effects of DPTs for alternative CCyBs



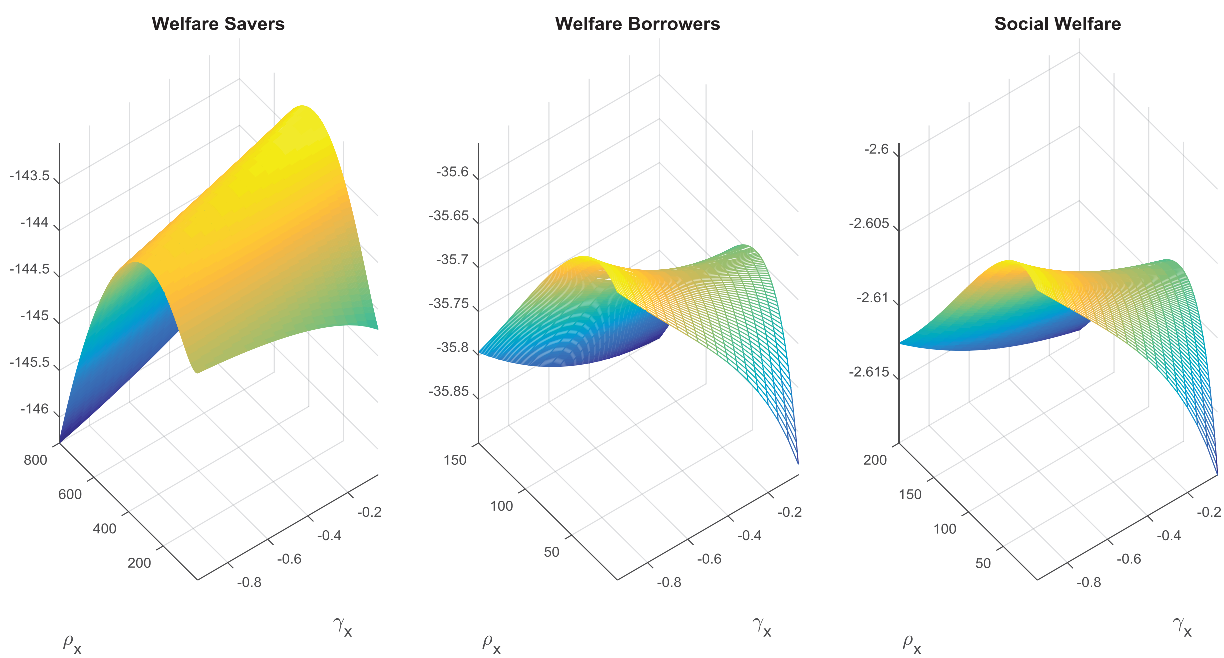
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the of the dividend prudential target, ρ_x, for alternative values of the cyclical parameter of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

Figure 2.9: Welfare effects of the CCyB for alternative DPTs



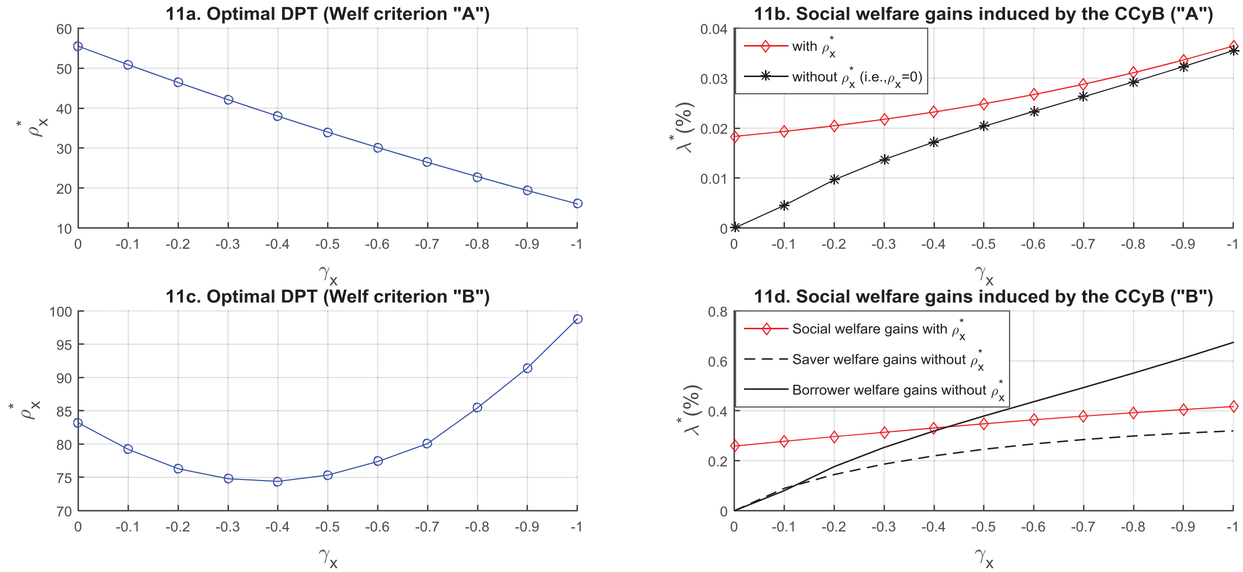
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of dynamic capital requirements, γ_x, for alternative values of the cyclical parameter of the dividend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

Figure 2.10: Interactions between the DPT and the CCyB (welfare effects of ceteris paribus changes in ρ_x - γ_x)



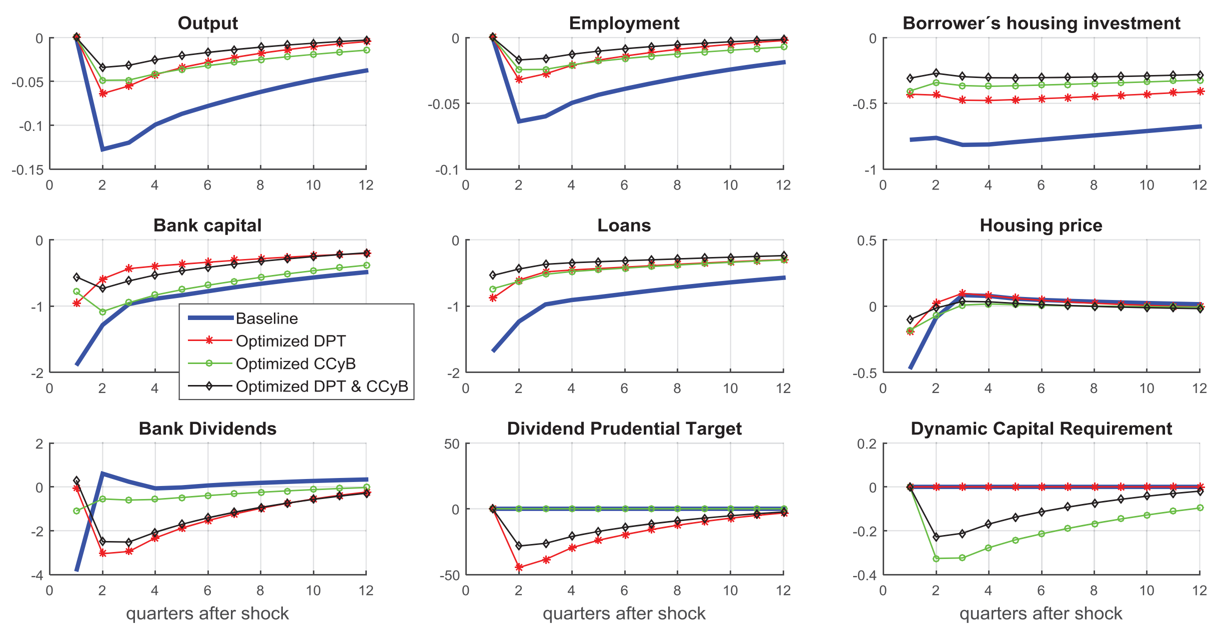
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameters of dynamic capital requirements and the dividend prudential target, γ_x and ρ_x.

Figure 2.11: Optimal DPT and welfare gains for alternative calibrations of the CCyB



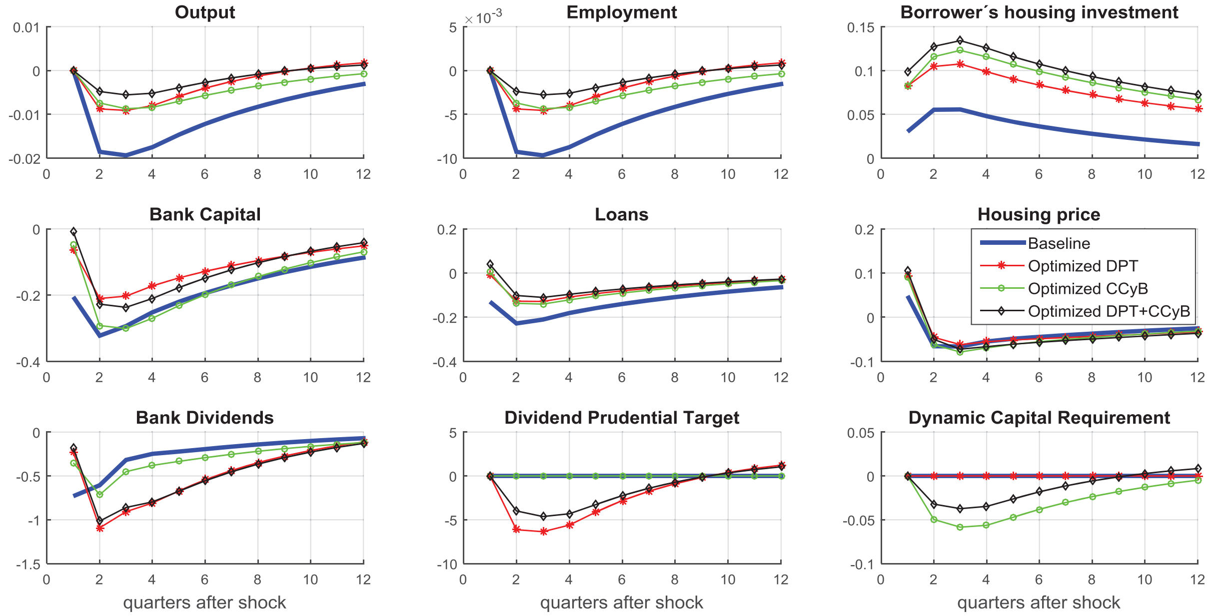
Note: Panels 11b and 11d report the second-order approximation to the unconditional social welfare gains induced by the CCyB, for different values of $\gamma_x \in [-1,0]$ - with and without introducing an optimal DPT (diamond line and starred line, respectively) in the alternative policy scenario (i.e., 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 2.12: Impulse-responses to a negative HH collateral shock (extended model, macroprudential policy scenarios)



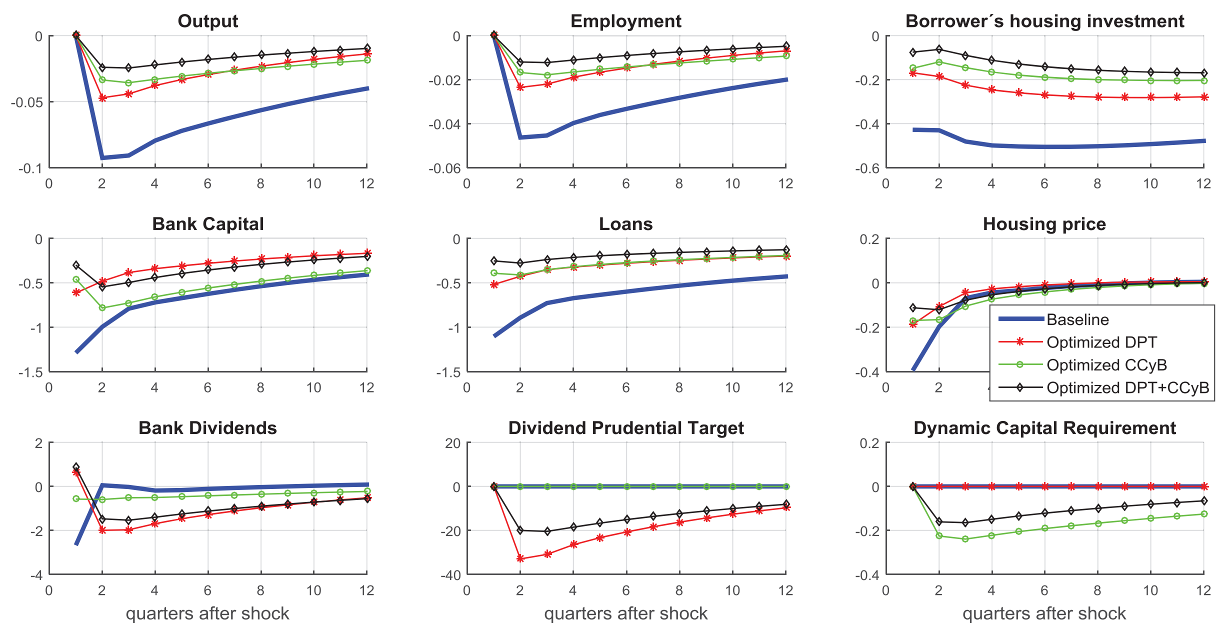
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, 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 2.13: Impulse-responses to a negative NFC collateral shock (extended model, macroprudential policy scenarios)



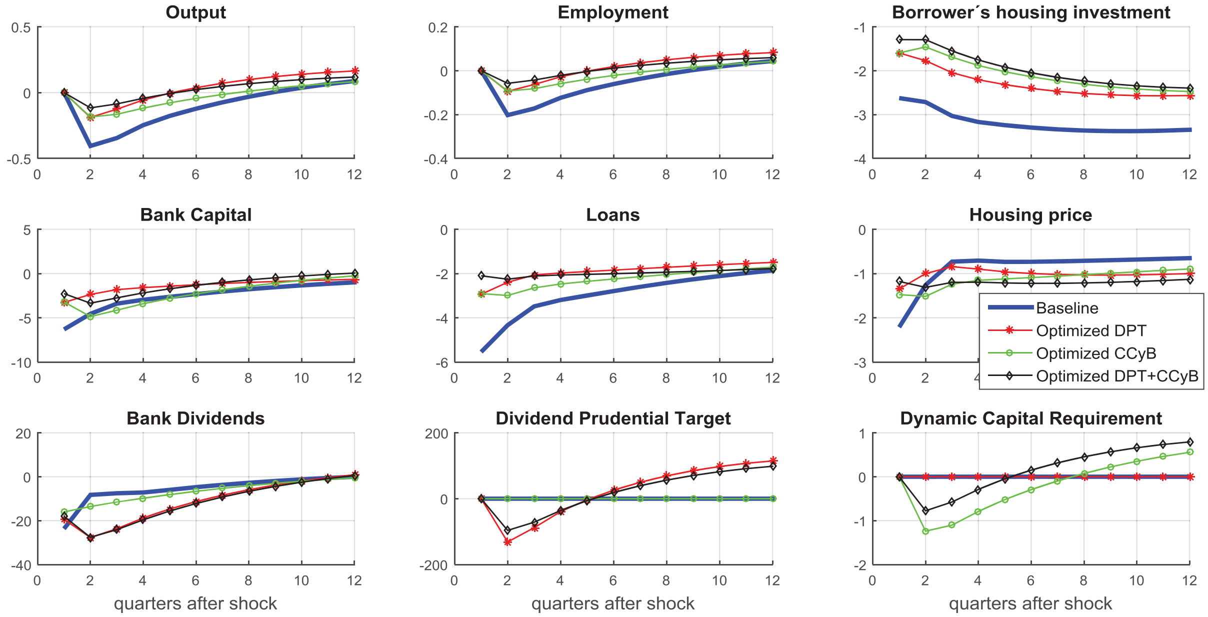
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, 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 2.14: Impulse-responses to a negative bank capital shock (extended model, macroprudential policy scenarios)



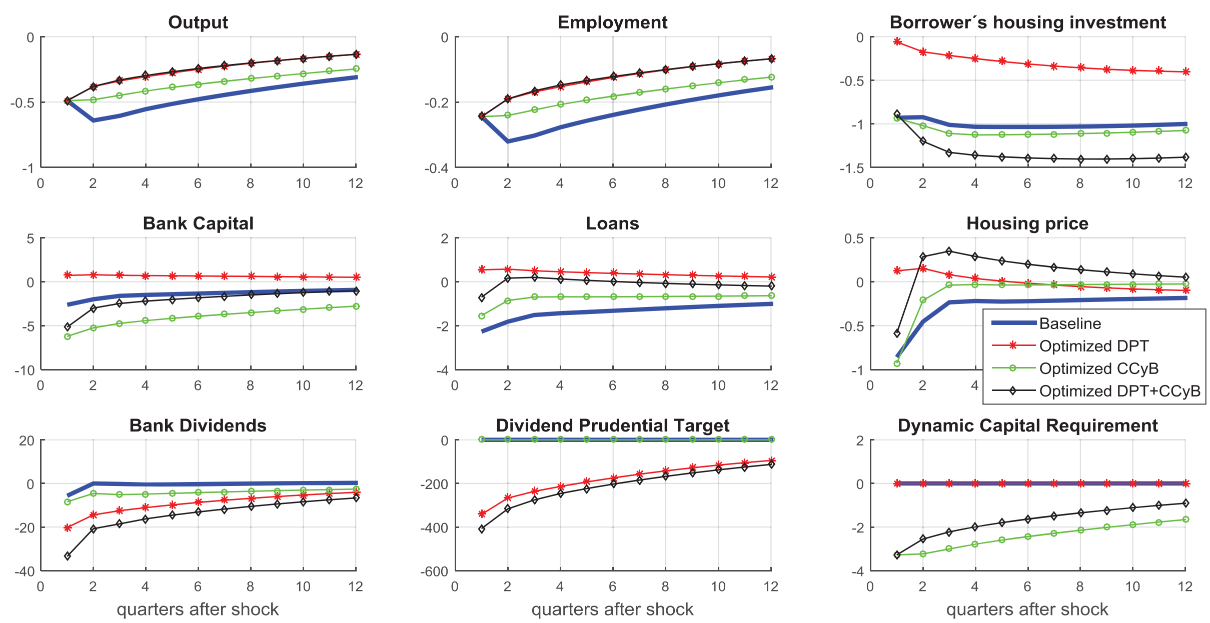
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, 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 2.15: Impulse-responses to a negative housing preference shock (extended model, macroprudential policy scenarios)



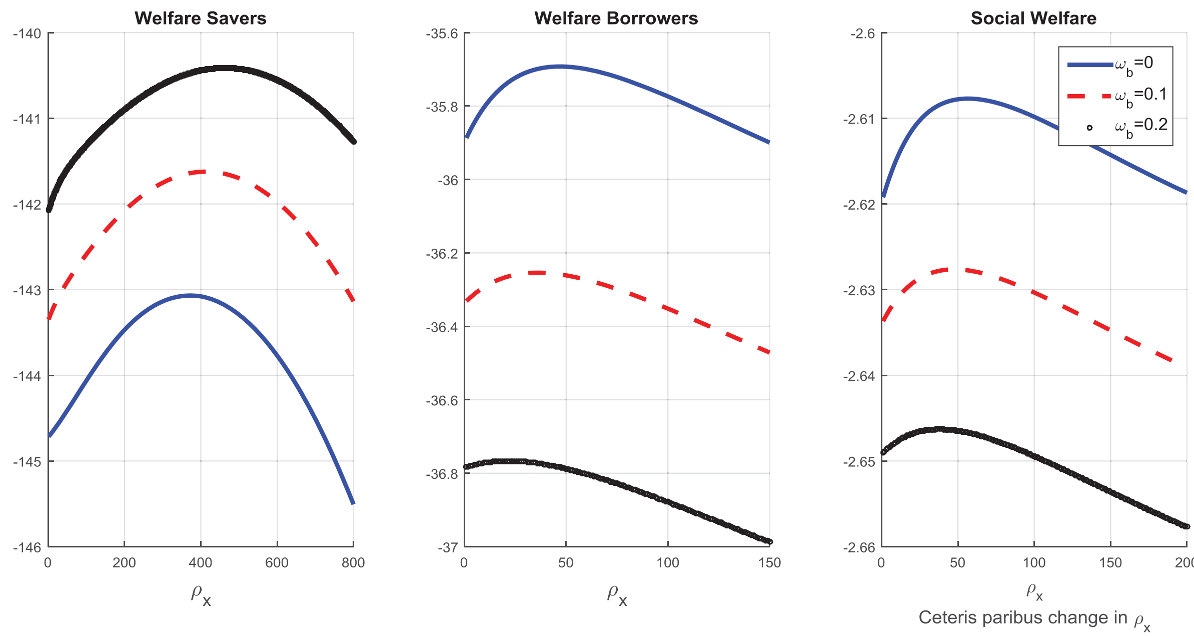
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, 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 2.16: Impulse-responses to a negative technology shock (extended model, macroprudential policy scenarios)



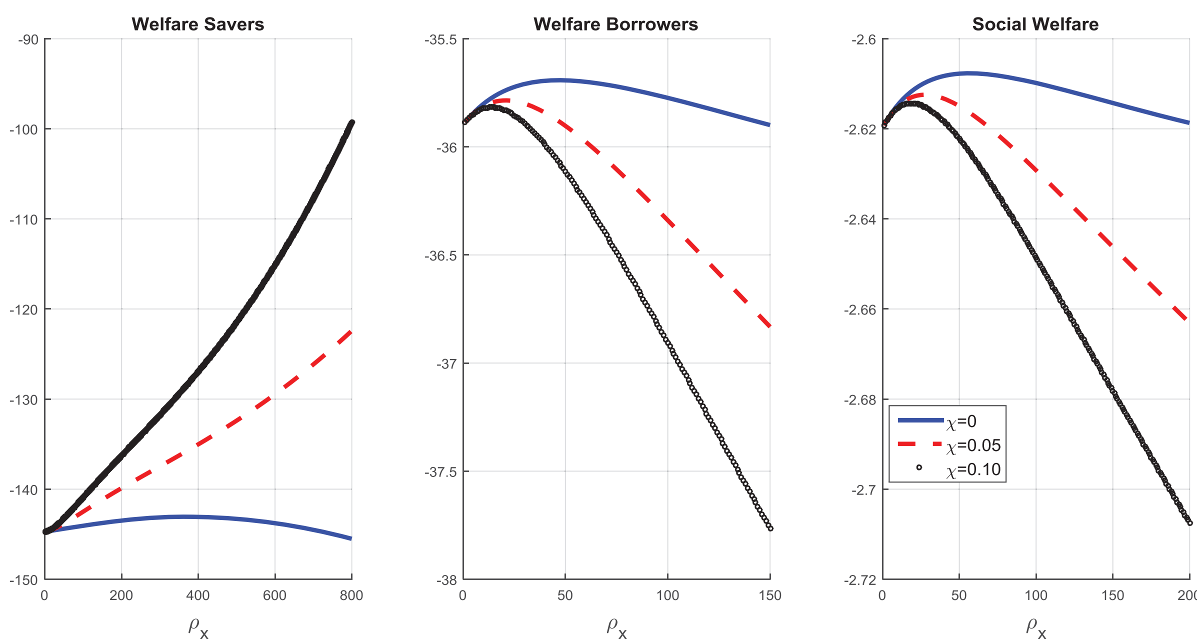
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to an alternative (policy) scenario in which welfare has been maximized with respect to the cyclical parameter of the dividend prudential target, 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 2.17: Robustness checks: ω_b (welfare effects of ceteris paribus changes in ρ_x)



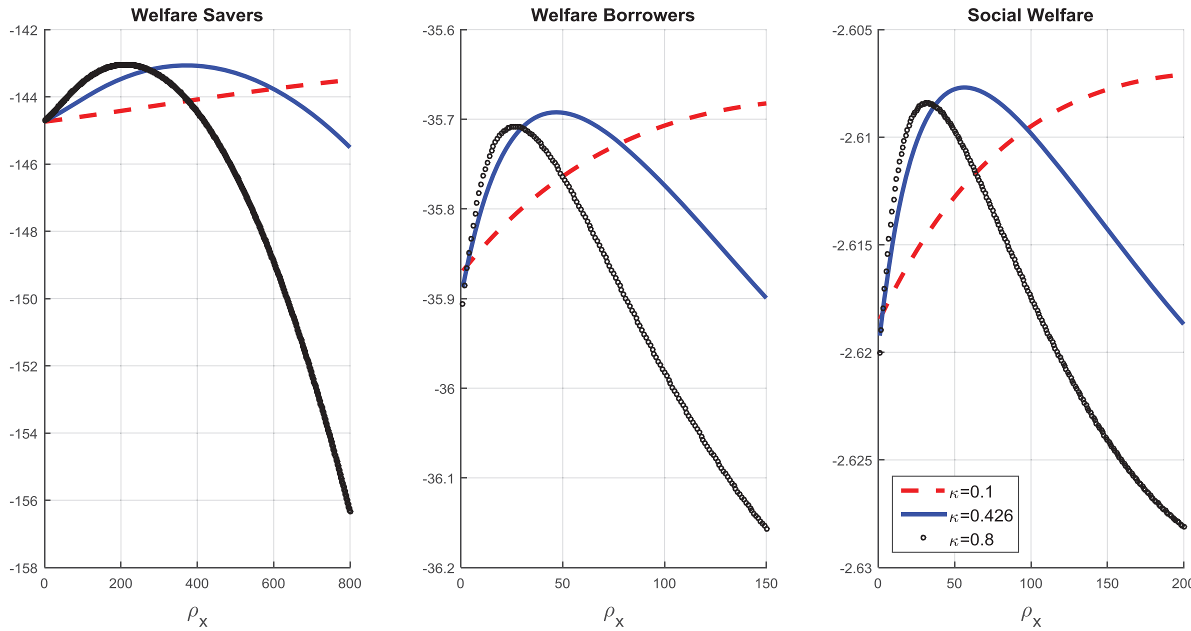
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative fractions of banks owned by savers. The solid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

Figure 2.18: Robustness checks: χ (welfare effects of ceteris paribus changes in ρ_x)



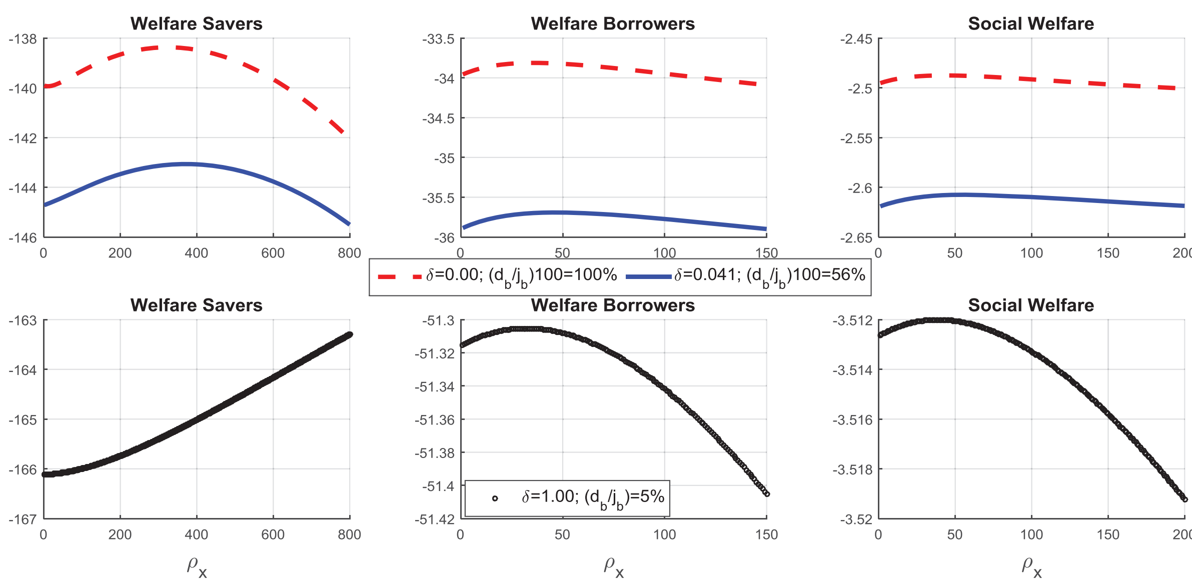
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative fractions χ of the net transfer that savers 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 2.19: Robustness checks: κ (welfare effects of ceteris paribus changes in ρ_x)



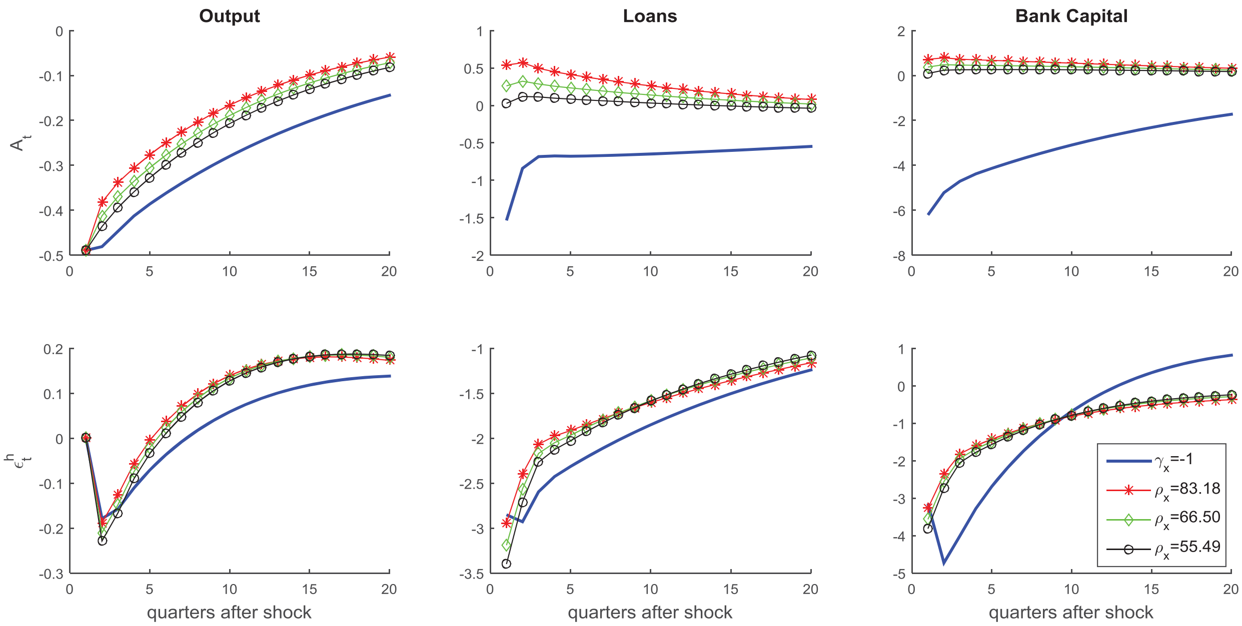
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare (under welfare criterion "A") as a function of the cyclical parameter of the dividend prudential target, ρ_x, for alternative values of the dividend adjustment cost parameter,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

Figure 2.20: 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 2.21: 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.

Table 2.1: 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

Table 2.2: 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	$r_{k_e}^{ss}$;0.1*$r_{k_e}^{ss}$	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	$\sigma_Y = 2.138$

Table 2.3: 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

Table 2.4: 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

Table 2.5: 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

Table 2.6: Welfare Gains to a 1 p.p. hike in capital requirements

1.0 p.p. increase in $(1-\gamma)$	ρ_x	Savers	Borrowers	Social
(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)

Table 2.7: 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

Table 2.8: 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

Chapter 3

Prudential Dividend Regulation, Capital Requirements and Monetary Policy[1]

3.1 Introduction

Since the outbreak of the COVID-19 crisis, central banks around the world have encouraged credit institutions to make full use of all releasable capital buffers to maintain credit provision. However, banks have so far remained hesitant to release them, among other reasons, due to the fear of potential stigma effects in financial markets. The Basel III Accords impose automatic (institution-specific) dividend restrictions when banks breach a specific capital requirement threshold.[2] Given the strong reluctance of bankers to cut back on dividends during the economic downturn and the related risk of releasing capital buffers during such phase of the cycle (i.e., in terms of an increased probability of breaching the mentioned capital threshold), existing capital regulation does not seem to be providing banks with the adequate incentives to draw on their buffers when such action is needed the most.

In this context, central banks around the world have requested banks to temporarily refrain from distributing dividends (even if they would meet their capital requirements) in order to keep funding households and firms amid the COVID-19 crisis. That is, they have de facto switched from a microprudential (institution-specific) and capital-contingent dividend regulation to a macroprudential and state-contingent dividend regulation similar to the one

[1] This chapter is based on joint work with Carlos Montes-Galdón (European Central Bank).

[2] 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 is shown to be optimal in Muñoz (2020a).[3]

These actions have been undertaken by public authorities in a context of significant monetary stimulus and low-interest rates. While significant efforts have been made in the recent past to shed light on how to coordinate monetary policy and countercyclical capital requirements, little attention has been paid to the interdependencies between monetary policy and prudential dividend restrictions. The main contribution of this chapter is to study the welfare effects, interactions and cooperative options between monetary policy and dynamic dividend regulation in the current Basel III regulatory environment.

In order to do so, we extend the quantitative macro-banking DSGE model proposed in Muñoz (2020a) along two dimensions: (i) we endogenize housing supply by assuming that real estate investment is generated by combining physical capital and labor (i.e., there are two production sectors in the economy; housing and non-housing), and (ii) we assume that entrepreneurs (i.e., intermediate non-housing good producers) operate under monopolistic competition in the market of their own variety and set prices a la Calvo (1983). Thus, the model features nominal rigidities, with the non-housing production sector being the only one that is subject to price stickiness (as in Iacoviello and Neri 2010); households' heterogeneity in discount rates, with borrowing limits as in Kiyotaki and Moore (1997) and Iacoviello (2005 and 2015); and a banking sector in which the strong preference for distributing high and stable amounts of dividends over time conflicts with the obligation of credit institutions to meet their capital requirements by retaining earnings (on a period-by-period basis), and ultimately amplifies fluctuations in aggregate lending through bank capital volatility.[4]

This environment opens up the possibility of having welfare-improving macroprudential and monetary policies. The central bank sets the short-term nominal interest rate according to a Taylor-type policy rule whereas the prudential authority has two policy instruments at hand: a countercyclical capital buffer (henceforth CCyB) and a dividend prudential target (henceforth DPT). While the central bank has to optimally balance the incentive to offset the price stickiness distortion with the one of marginally affecting borrowers' collateral constraints, the prudential authority has to calibrate the DPT by trading-off the main benefits of this instrument (in terms of credit smoothing) with its costs (in terms of increased bank dividend volatility). In addition, such welfare trade-off has important implications for the joint calibration of the CCyB and the DPT. While the DPT is comparatively more effec-

[3] The key difference between the type of macroprudential, state-contingent, dividend regulation proposed in Muñoz (2020) and the recent formal request (from central banks) for banks to refrain from distributing capital is that the former is based on a policy rule whereas the latter is a discretionary measure.

[4] The assumptions by which banks are constrained by a balance sheet identity (as in Gertler and Karadi 2011 and Gertler and Kiyotaki 2010) and bank capital acummulates out of retained earnings (as in Gerali et al. 2010) are crucial for banks' dividend smoothing to amplify credit fluctuations through "volatile" bank capital.

tive in smoothing aggregates of the real economy, the CCyB does not induce any type of significant welfare cost to bank owners.

In order to carry out a meaningful quantitative analysis on the welfare effects and interactions of monetary policy, countercyclical capital buffers and dynamic dividend regulation, we first calibrate the model to quarterly data of the euro area so as to match a number of first and second moments of macroeconomic and banking aggregates. Then, we define a measure of social welfare - specified as a weighted average of the expected life-time utility of savers and borrowers - and select a welfare weighting criterion that adequately reflects the preferences of borrowers (i.e., the type of household that tends to be underweighted due to its comparatively low subjective discount factor) and bank owners (i.e., the type of household that suffers the main cost of dividend prudential targets).[5]

The proposed quantitative analysis is carried out in three stages. First, we define three different policy scenarios to assess the welfare effects and effectiveness of each of the three (optimal) policy rules in isolation. Second, we consider three additional policy scenarios to study the welfare effects and interactions of combining an optimal simple Taylor rule with an optimal DPT and/or with an optimal CCyB, both; under perfect coordination and under no policy coordination (between monetary and prudential authorities). Third, we assess the effectiveness of the two macroprudential policy rules when monetary policy is constrained by the (occasionally binding) zero lower bound (henceforth ZLB).

The main findings of the quantitative analysis can be summarized as follows. First, while each of the three optimal policy rules induces significant welfare gains for both, savers and borrowers - when adopted in isolation - the optimal dividend prudential target is the most effective one in smoothing the business cycle. Second, there are significant welfare gains from combining an optimal simple Taylor rule with any of the two optimal prudential rules. Furthermore, under perfect cooperation, additional welfare gains are attained through a stronger specialization of monetary and macroprudential policies on their respective traditional objectives (i.e., price stability and financial stability). Importantly, if the two prudential authorities perfectly coordinate their actions, combining the three policy rules is optimal. That is, despite the very conservative assumptions (by which the analysis particularly accounts for bank owners' welfare), jointly combining a simple Taylor rule and a highly responsive CCyB with countercyclical dividend regulation is optimal.

[5] The quantitative analysis makes additional conservative assumptions that permit to reinforce the conclusion by which regulating bank dividends from a macroprudential perspective is optimal. Among others, the consideration of a range of countercyclical capital parameter values that allows for a very highly responsive CCyB (when compared to the Basel III-proposed calibration for this instrument), and bank owners accounting for half of the entire household population (a proportion that is well above the empirically relevant one).

Third, the proposed prudential policy rules become particularly effective when the short term nominal interest rate hits the zero lower bound. In a low interest rate environment, the different transmission mechanisms through which the DPT and the CCyB operate (as well as the conflictive effect they have on bank capital) become more evident, thereby highlighting the importance of combining measures of capital conservation (i.e., dividend limits) with measures of capital usability (countercyclical capital buffers) in bad times.

The chapter is organized as follows. Section 3.2 discusses how the contents of the chapter fit into the existing literature. Section 3.3 presents the DSGE macro-banking model. Section 3.4 maps the model to the data. Section 3.5 presents a welfare analysis to assess the effects and interactions between monetary policy, countercyclical capital buffers and macroprudential dividend regulation. Section 3.6 evaluates the effectiveness of macroprudential policies in a low interest rate environment. Section 3.7 concludes.

3.2 Related Literature

This chapter contributes to the strand of the literature that studies the interaction and/or coordination between monetary and prudential policies. Among others, Angelini et al. (2014), Angeloni and Faia (2013), Carrillo et al. (2017), Collard et al. (2017), Fahri and Werning (2016), De Paoli and Paustian (2017), Mendicino et al. (2020) and Van der Ghote (2020). Our quantitative analysis has some similarities to that of Angeloni and Faia (2013) to the extent that we also assess the interactions between monetary policy and countercyclical capital regulation based on the type of welfare analysis proposed in Schmitt-Grohe and Uribe (2007); the grid of policy parameter values is restricted to those consistent with implementable policy rules and welfare gains are defined as the implied differences in consumption between two different scenarios. A distinctive feature of our analysis is that we explicitly measure the welfare gains of alternative macroprudential-monetary policy options stemming from perfect policy coordination. The main novelty of our welfare and policy coordination analysis is that we explicitly consider dynamic dividend restrictions as one of the macroprudential policy rules, a prudential instrument that has recently been widely used by central banks amid the COVID-19 crisis.

The contents of the chapter also relate to recent work that highlights the importance of regulating dividend distributions under certain conditions. Based on U.S. banking data for the period 2007-2009, Acharya et al. (2012) defend 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 certain conditions. 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. Muñoz (2020a) proposes a macro-banking DSGE model in which a combination of banks'strong preference for smoothing dividends over the cycle and a Basel III-type of capital regulation exacerbates the problem of credit supply procyclicality. The chapter shows that macroprudential-based policy rules in the form of dividend prudential targets (i.e., prudential policy rules that provide bankers with incentives to tolerate a higher degree of dividend volatility) can be particularly effective in smoothing financial and business cycles through less volatile bank retained earnings. In this regard, this is our closest antecedent.

3.3 The Model

The model features two types of households (savers and borrowers), two production sectors (housing and non-housing) and a banking sector. Patient households (savers) work, consume, accumulate physical capital and housing and invest their savings in one-period bank deposits. Impatient households (borrowers) work, consume and borrow resources via one-period bank loans. On the supply side, the housing sector produces new houses (residential and commercial real estate) by combining labor and physical capital. The non-housing sector consists of final good producers, entrepreneurial firms and capital good producers. Final (non-housing) good producers combine intermediate goods to generate final output. The entrepreneurial firm industry is populated by two agent types. Entrepreneurial managers demand one-period bank loans to accumulate commercial real estate and rent it to (entrepreneurial) retailers while the latter combine such input with labor and physical capital to produce intermediate goods under monopolistic competition. Capital good producers sell their output to savers, who rent it to housing producers and entrepreneurs. Banks intermediate financial resources by borrowing from patient households and lending to impatient households and entrepreneurs. They devote the resulting net profit to both; pay dividends and meet their capital requirements by retaining earnings. For each type of agent, there is a continuum of individuals in the $[0, 1]$ interval. Households own all financial and non-financial corporations in the economy.

The presence of financial frictions and nominal rigidities opens up the possibility of having welfare-improving macroprudential and monetary policies in this model economy. In particular, impatient households, entrepreneurs and banks face borrowing constraints a la Iacoviello (2005 and 2015) and intermediate good producers are assumed to be Calvo (1983) price-setters in the market of their own variety. In what follows all variables are expressed in real terms.

3.3.1 Households: Savers and Borrowers

The representative patient (and impatient) household seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^{t} \left[\frac{1}{1-\sigma_h} \quad \left. C_{\varkappa,t} - \frac{\widetilde{N}_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} + \varepsilon_t^h j \log H_{\varkappa,t} \right], \tag{3.1}$$

where $x = p, i$ denotes the type of household the problem refers to (i.e., saver or borrower), $\beta_{\varkappa} \in (0,1)$ is the household's discount factor $\left(\beta_p < \beta_i\right)$, σ_h stands for the risk parameter of the household, $\phi > 0$ refers to the inverse of the Frisch elasticity, j is the preference parameter for housing services and ε_t^h captures exogenous housing preference shocks. $C_{\varkappa,t}$ denotes final consumption, $H_{\varkappa,t}$ refers to housing, and $\widetilde{N}_{\varkappa,t}$ is a composite index of labor supply to the consumption sector, $N_{\varkappa,t}^c$, and the housing sector, $N_{\varkappa,t}^h$:

$$\widetilde{N}_{\varkappa,t} = \left[\omega_n^{1/\varepsilon} \left(N_{\varkappa,t}^c \right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N_{\varkappa,t}^h \right)^{(1+\varepsilon)/\varepsilon} \right]^{\varepsilon/(\varepsilon+1)}, \tag{3.2}$$

where $\omega_n \in (0,1)$ is a weight parameter and ε is the elasticity of substitution between types of labor supply.[6]

Patient Households (net savers)

In the case of patient households, the maximization of (3.1) is restricted to the sequence of budget constraints:

$$\begin{aligned} C_{p,t} + D_t + q_t \left[H_{p,t} - (1-\delta_h) H_{p,t-1} \right] + \sum_{i=c,h} q_{k,t}^i \left[K_{p,t}^i - (1-\delta_t^i) K_{p,t-1}^i \right] \\ = R_{d,t-1} \frac{D_{t-1}}{\pi_t} + \sum_{i=c,h} \left[w_t^i N_{s,t}^i + r_{k,t}^i u_t^i K_{p,t-1}^i \right] + \omega_e d_{e,t} + \omega_b d_{b,t} + \chi T(d_{b,t}, d_t^*), \end{aligned} \tag{3.3}$$

where D_t denotes the stock of deposits, $R_{d,t}$ is the gross interest rate on deposits, $\pi_t \equiv P_t / P_{t-1}$ is gross inflation, q_t is the price of housing, δ_h is the depreciation rate of the housing stock. $q_{k,t}^i$, $r_{k,t}^i$, w_t^i, $K_{p,t}^i$, and $N_{s,t}^i$ refer to the price of physical capital, its rate of return, the real wage

[6] Households are assumed to have GHH preferences (see Greenwood et al. 1988). This type of preferences - under which wealth effects on labor supply are arbitrarily close to zero - has been extensively used in the business cycle literature as a useful device to match several empirical regularities. As in this chapter, 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).

rate, the stock of capital and hours worked in production sector $i = c, h$ (final consumption or housing), respectively. δ_t^i is the depreciation rate of physical capital rented by firms producing in sector i, which is an increasing and convex function of the rate of capital utilization, u_t^i:

$$\delta_t^i\,(u_t) = \delta_0^i + \delta_1^i(u_t^i - 1) + \frac{\delta_2^i}{2}\,(u_t^i - 1)^2. \tag{3.4}$$

Finally, $d_{e,t}$ and $d_{b,t}$ denote earnings distributed by entrepreneurial firms (including entrepreneurial managers and intermediate good producers) and by banks, respectively. $\omega_e \in [0,1]$ and $\omega_b \in [0,1]$ refer to the fraction of entrepreneurial firms and banks owned by patient households, respectively. As discussed below, $T(d_{b,t}, d_t^*)$ is the sanction imposed by the prudential authority to the representative bank for having deviated (when distributing earnings, $d_{b,t}$) from the dividend prudential target, d_t^*, in period t. χ is the fraction of such sanction that is transferred to the representative patient household and it is assumed to be equal to the stake of banks they own (i.e., $\chi = \omega_b$). That is, the degree of "insurance" received by net savers is assumed to be proportional to their exposure to the increased bank dividend volatility triggered by the dividend prudential target. This is relevant under policy scenarios in which the DPT operates.

Each period, the representative household allocates its resources in terms of wage earnings, properties in the housing market and gross returns on total deposits and physical capital between final consumption and investment in deposits, physical capital and housing.

Impatient Households (net borrowers)

In the case of borrowers, the maximization of (3.1) is restricted by a sequence of budget constraints and a borrowing limit,

$$\begin{aligned} C_{i,t} + R_{i,t}\frac{B_{i,t-1}}{\pi_t} &+ q_t\left[H_{i,t} - (1-\delta_h)H_{i,t-1}\right] + \Phi_i(B_{i,t}) \\ &= B_{i,t} + w_t^c N_{it}^c + w_t^h N_{i,t}^h + (1-\omega_e)d_{e,t} + (1-\omega_b)d_{b,t} + (1-\chi)T(d_{b,t}, d_t^*), \end{aligned} \tag{3.5}$$

$$B_{i,t} \leq m_{i,t}^H E_t\left[\frac{q_{t+1}}{R_{it+1}} H_{it}\pi_{t+1}\right], \tag{3.6}$$

where $B_{i,t}$ denotes bank loans extended to net borrowers, R_{it} is the gross interest rate on loans to impatient households, and $\Phi_i(B_{i,t}) = \dfrac{\phi_i}{2}\dfrac{\left(B_{i,t} - B_{i,t-1}\right)^2}{B_i^{ss}}$ is a quadratic loan portfolio adjustment cost, assumed to be external to the household, as in Iacoviello (2015).[7] B_i^{ss} is the steady-state value of $B_{i,t}$ and ϕ_i is the corresponding loans adjustment cost parameter. According to (3.5), 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 and adjust their loan portfolio.

Expression (3.6) dictates that the borrowing capacity of impatient households is tied to the value of their collateral. In particular, they cannot borrow more than a possibly time-varying fraction $m_{i,t}^H$ of the expected value of their real estate stock. More precisely, $m_{i,t}^H = m_i^H \varepsilon_t^{mh}$ is the exogenously time-varying loan-to-value ratio, where $m_i^H \in [0, 1]$ and ε_t^{mh} captures exogenous shocks to constrained households' collateral.

3.3.2 Technology and Production

Housing Producers

The representative, perfectly competitive, housing producing firm chooses the demand schedules for labor N_t^h and physical capital K_t^h that maximize:

$$IH_t - w_t^h N_{,t}^h(j) - r_{k,t}^h K_{t-1}^h, \tag{3.7}$$

where IH_t stands for net investment in real estate (or total construction) in period t and is produced by using a Cobb-Douglas technology that combines labor and physical capital as follows

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\upsilon} N_t^{h(1-\upsilon)} \tag{3.8}$$

where υ is the share of physical capital in housing production. The standard law of motion for capital accumulation applies to the stock of real estate, H_t. Formally,

$$H_t = (1 - \delta_h)H_{t-1} + IH_t. \tag{3.9}$$

Final Non-housing Good Producers

A typical perfectly competitive final (non-housing) good producer chooses the trajectory of intermediate good $Y_{c,t}(j)$ that maximizes

$$P_t Y_{c,t} - \int_0^1 P_{c,t}(j)\, Y_{c,t}(j)\, di. \tag{3.10}$$

[7] This cost discourages the impatient households from changing their credit balances too quickly, thereby contributing to match the empirical fact that bank credit varies slowly over time.

where $Y_{c,t}$ denotes final non-housing production and P_t is the aggregate price level. $Y_{c,t}(i)$ denotes demand for intermediate good j and $P_{c,t}(j)$ is the corresponding price. The homogeneous final non-housing good is produced by means of the following technology

$$Y_{c,t} = \left(\int_0^1 Y_{c,t}(j)^{(\varepsilon-1)/\varepsilon} \, di \right)^{\varepsilon/(\varepsilon-1)}, \tag{3.11}$$

where $\varepsilon > 1$ is the elasticity of substitution across varieties in the non-housing production sector. Profit maximization yields demand functions for intermediate good j:

$$Y_{c,t}(j) = \left(\frac{P_{c,t}(j)}{P_t} \right)^{-\varepsilon} Y_{c,t}, \, \forall j. \tag{3.12}$$

From the zero profit condition, $P_t Y_{c,t} = \int_0^1 P_{c,t}(j) \, Y_{c,t}(j) \, di$, it follows that P_t can be interpreted as the price index:

$$P_t \equiv \left(\int_0^1 P_{c,t}(j)^{(1-\varepsilon)} \, dj \right)^{1/(1-\varepsilon)}. \tag{3.13}$$

Entrepreneurial Firms

The entrepreneurial firm industry is populated by two types of agents. For each entrepreneurial firm, there is a manager who obtains bank lending to acquire new housing in the form of commercial real estate and a retailer who rents such input and combines it with physical capital and labor (through a Cobb-Douglas technology) to produce intermediate (non-housing) goods under monopolistic competition.[8]

Entrepreneurial Managers Let $d_{m,t}$ be earnings distributed by entrepreneurial managers and $\Lambda_{0,t}^e = \left[\omega_e \beta_p \frac{\lambda_{t+1}^p}{\lambda_t^p} + (1-\omega_e) \beta_i \frac{\lambda_{t+1}^i}{\lambda_t^i} \right]$ the stochastic discount factor of the same agent type, with λ_t^p and λ_t^i being the Lagrange multiplier of the patient an impatient households' optimization problems, respectively. Then, the representative entrepreneurial manager maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \quad \frac{1}{\left(1-\frac{1}{\sigma}\right)} d_{m,t}^{\left(1-\frac{1}{\sigma}\right)}, \tag{3.14}$$

[8] Alternatively, entrepreneurial managers and retailers could be interpreted as agent types belonging to separate corporate groups. In that case, managers could be regarded as commercial real estate suppliers whose interpretation could be analagous to a simplified version of the type of institutional investors modelled in Muñoz (2020b), whereas retailers,could be considered as standard intermediate good producers.

subject to a sequence of budget constraints and a borrowing limit:

$$d_{m,t} + R_{e,t-1}B_{e,t-1} + q_t(H^c_{e,t} - H^c_{e,t-1}) + \Phi_e(B_{e,t}) = B_{e,t} + r_{h,t}H^c_{e,t-1}, \tag{3.15}$$

$$B_{e,t} \leq m^H_{e,t}E_t\left(\frac{q_{t+1}}{R_{e,t}}H_{e,t}\pi_{t+1}\right). \tag{3.16}$$

where $B_{e,t}$ and R_{et} denote bank loans extended to entrepreneurial firms and the corresponding gross interest rate, respectively. According to (3.15), each period, entrepreneurial managers devote their available resources in terms of loans and rents to distribute earnings, repay their debt, purchase housing and adjust their loan portfolio. Expression (3.16) dictates that the borrowing capacity of entrepreneurial firms is tied to the value of their housing collateral. In particular, they cannot borrow more than a possibly time-varying fraction $m^H_{e,t}$ of the expected value of their real estate stock. In particular, $m^H_{e,t} = m^H_e\varepsilon^{me}_t$ is the exogenously time-varying loan-to-value ratio, where $m^H_e \in [0,1]$ and ε^{me}_t captures exogenous shocks to entrepreneurial firms' collateral.

Entrepreneurial Retailers There is a continuum of entrepreneurial retailers (also referred to as intermediate non-housing good producers). Each intermediate good producer i operates the following Cobb-Douglas production function:

$$Y_t(j) = A_t\left[u^c_t(j)K^c_{t-1}(j)\right]^{\alpha}H^c_{t-1}(j)^{\eta}N^c_t(j)^{(1-\alpha-\eta)}, \tag{3.17}$$

where A_t captures technology shocks in the intermediate good production sector and $K^c_{t-1}(j)$, $H^c_{t-1}(j)$, and N^c_t denote the quantity of physical capital, commercial real estate and labor rented by firm j, respectively. Intermediate good producers solve a two-stage problem. In the first stage they choose the trajectories of $K^c_{t-1}(j)$, $H^c_{t-1}(j)$, and $N^c_t(j)$ that minimize total real costs:

$$r^c_{k,t}K^c_{t-1}(j) + r_{h,t}H^c_{t-1}(j) + w^c_tN^c_t(j), \tag{3.18}$$

subject to the available technology, represented by (3.17). Assuming Calvo (1983) price-setting, in the second stage intermediate good producers choose the price, $P_{c,t}(j)$, that maximizes discounted real profits:

$$E_t \sum_{s=0}^{\infty} \left[\left(\beta_p \theta\right)^s \frac{\lambda^p_{t+s}}{\lambda^p_t} + \left(\beta_i \theta\right)^s \frac{\lambda^i_{t+s}}{\lambda^i_t} \right] \left\{ \left[\prod_{\tau=1}^{s} \pi^{\chi}_{t+\tau-1} \frac{P_{c,t}(j)}{P_{t+s}} - mc_{t+s} \right] Y_{c,t+s}(j) \right\}, \tag{3.19}$$

where θ is the probability of not adjusting the price, $\chi \in [0,1]$ is the indexation parameter, and mc_t denotes the real marginal cost of the intermediate good producer. In each period, a fraction θ of firms reoptimize their prices. All other firms can only index their prices by past inflation, with $\chi = 0$ and $\chi = 1$ referring to the particular cases of no indexation and total indexation, respectively. The first-order condition is standard (see Appendix B), with all time-t price setters choosing a common optimal price $P^*_{c,t}$.

Capital Goods Producers

At the beginning of each period, capital producers oriented to production sector $i = c, h$ demand an amount I^i_t of final good from patient households, 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^i_t, that maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda^e_{0,t} \left(q^i_{k,t} \Delta x^i_{k,t} - I^i_t \right), \tag{3.20}$$

subject to

$$x^i_{k,t} = x^i_{k,t-1} + I^i_t \left[1 - \frac{{}^{i}_{I}}{2} \left(\frac{I^i_t}{I^i_{t-1}} - 1 \right)^2 \right], \tag{3.21}$$

where $\Delta x^i_{k,t} = K^i_{e,t} - (1 - \delta^k_t) K^i_{e,t-1}$ is the flow output and $S\left(\frac{I^i_t}{I^i_{t-1}}\right) = \frac{{}^{i}_{I}}{2} \left(\frac{I^i_t}{I^i_{t-1}} - 1 \right)^2$ denotes investment adjustment costs.

3.3.3 Banks

Let $\Lambda^b_{0,t} = \left[\omega_p \beta_p \frac{\lambda^p_{t+1}}{\lambda^p_t} + (1 - \omega_p) \beta_i \frac{\lambda^i_{t+1}}{\lambda^i_t} \right]$ represent the stochastic discount factor of bankers and $d_{b,t}$ bank dividends. The representative bank manager seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda^b_{0,t} \frac{1}{(1 - \frac{1}{\sigma})} d_{b,t}^{\left(1 - \frac{1}{\sigma}\right)}, \tag{3.22}$$

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

$$B_{it} + B_{e,t} = K_{b,t} + D_{b,t}, \tag{3.23}$$

$$d_{b,t}+K_{b,t}-(1-\delta_t)\frac{K_{b,t-1}}{\pi_t} = \frac{(r_{i,t}B_{i,t-1} + r_{e,t-1}B_{e,t-1} - r_{d,t-1}D_{b,t-1})}{\pi_t} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - T(d_{b,t}, d_t^*), \tag{3.24}$$

$$D_{b,t} \leq \gamma_{i,t}B_{i,t} + \gamma_{e,t}B_{e,t}. \tag{3.25}$$

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.

According to (3.23), bank assets are financed by the sum of bank equity $K_{b,t}$ (also referred to as bank capital) and debt. There are two types of bank assets; one-period loans which are extended to impatient households and one-period loans extended to commercial real estate suppliers. 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):[9]

$$K_{b,t} = J_{b,t} - \ d_{b,t} + \ (1 - \delta_t)K_{b,t-1}/\pi_t, \tag{3.26}$$

where $J_{b,t}$ stands for bank net profits. Rearranging in expression (3.26), bank net profits can be decomposed into three terms:

[9] Expression (2.9) 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).

$$J_{b,t} = \underbrace{\underbrace{(K_{b,t} - K_{b,t-1}/\pi_t)}_{\text{reinvested profits}} + \underbrace{(\delta_t K_{b,t-1}/\pi_t)}_{\text{eroded equity}}}_{\text{retained earnings}} + \underbrace{d_{b,t}}_{\text{distributed earnings}}, \tag{3.27}$$

where the term $(K_{b,t} - K_{b,t-1}/\pi_t)$ refers to the part of profits made in period t which are reinvested in the financial intermediation business, and $\delta K_{b,t-1}/\pi_t$ 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 $\delta K_{b,t-1}/\pi_t$ 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.

Equation (3.24) 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 model, bank net profits are defined as the difference between net interest income, $(r_{i,t}B_{i,t-1} + r_{e,t-1}B_{e,t-1} - r_{d,t-1}D_{b,t-1})/\pi_t$, and other costs banks incur when readjusting their loan portfolio - $\Phi_{be}(B_{e,t})$ and $\Phi_{bi}(B_{i,t})$ - and when deviating from the dividend prudential target, $T(d_{b,t}, d_t^*)$.[10] $r_{i,t}$, $r_{e,t}$ and $r_{d,t}$ denote the net interest rates on residential mortgages, commercial mortgages and deposits, respectively.

Expression (3.25) stipulates that bankers are constrained in their ability to issue liabilities. For a given period t, deposits cannot exceed total risk-weighted assets, where $\gamma_{i,t}$ and $\gamma_{e,t}$ denote the proportions of residential mortgages and commercial mortgages that can be financed with debt and whose specification will be explained in detail in the policy block. Given this expression is binding in a neighborhood of the steady state, $(1-\gamma_{i,t})$ and $(1-\gamma_{e,t})$ can be interpreted as the corresponding dynamic sectoral capital requirements.

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

$$\frac{(1-\gamma_{i,t}) + \dfrac{\partial \Phi_{bi}(B_{i,t})}{\partial B_{i,t}}}{d_{b,t}\left[1+\kappa(d_{b,t}-d_t^*)\right]} = \Lambda^b E_t \left\{ \frac{\left[\left(r_{i,t+1} - \gamma_{i,t} r_{d,t}\right) + (1-\gamma_{i,t})(1-\delta_{t+1})\right]/\pi_{t+1}}{d_{b,t+1}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]} \right\}, \tag{3.28}$$

[10] As in the case of the impatient households and entrepreneurial managers, $\Phi_{bi}(B_{et}) = \dfrac{\phi_{bi}}{2}\dfrac{(B_{it}-B_{it-1})^2}{B_i^{ss}}$ and $\Phi_{be}(B_t) = \dfrac{\phi_{be}}{2}\dfrac{(B_{et}-B_{et-1})^2}{B_e^{ss}}$ are quadratic loan portfolio adjustment costs that are assumed to be external to the banker. $\phi_{bi} \geq 0$ and $\phi_{be} \geq 0$ are the corresponding credit adjustment cost parameters.

$$\frac{(1-\gamma_{e,t}) + \dfrac{\partial \Phi_{be}(B_{e,t})}{\partial B_{e,t}}}{d_{b,t}\left[1+\kappa(d_{b,t}-d_t^*)\right]} = \Lambda^b E_t \left\{ \frac{\left[\left(r_{e,t}-\gamma_{e,t} r_{d,t}\right) + \left(1-\gamma_{e,t}\right)\left(1-\delta_{t+1}\right)\right]/\pi_{t+1}}{d_{b,t+1}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]} \right\}. \quad (3.29)$$

Expressions (3.28) and (3.29) stand for the optimality conditions for intertemporal substitution between the part of net income devoted to the dividend payout policy (denominator on each side of equations 3.28 and 3.29) and that dedicated to the financial intermediation activity in each sector (numerator on each side of equations 3.28 and 3.29). Bank managers find optimal to invest in residential and commercial mortgages (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 each of the two types of investment.

3.3.4 Public Authorities

Monetary Policy

The central bank sets the policy rate (also referred to as the short-term nominal interest rate) r_t according to a Taylor-type policy rule:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left(r^{ss} + \alpha_\pi \tilde{\pi}_t + \alpha_Y \tilde{y}_t\right) + e_{r,t}, \quad (3.30)$$

where ρ_r is the interest rate smoothing parameter, r^{ss} is the steady-state policy rate, $\alpha_\pi > 1$ determines the response of the short-term nominal interest rate to inflation deviations from the target $\tilde{\pi}_t = \log(\pi_t/\bar{\pi})$, $\alpha_Y \geq 0$ measures the degree of responsiveness of the policy rate to output growth $\tilde{y}_t = \log(Y_t/Y_{t-t})$, and $e_{r,t}$ is a white noise shock to the policy rate.

Prudential Policy

The prudential authority has two types of policy instruments at hand: dynamic sectoral capital requirements and dividend prudential targets. Dynamic capital requirements on residential mortgage loans $(1-\gamma_{i,t})$ and on commercial mortgage loans $(1-\gamma_{e,t})$ are set according to the following policy rules:

$$\gamma_{i,t} = \gamma_i + \gamma_x\left(\frac{x_t}{x^{ss}} - 1\right), \quad (3.31)$$

and

$$\gamma_{e,t} = \gamma_e + \gamma_x\left(\frac{x_t}{x^{ss}} - 1\right), \quad (3.32)$$

where the complementary of γ_i and γ_e refer to the structural (i.e., steady-state) capital requirements on residential mortgage loans $(1-\gamma_i)$ and on commercial mortgage loans $(1-\gamma_e)$, and γ_x determines the response of capital requirements to deviations of x_t from its steady state level x^{ss}.[11] Note that, for simplicity, the cyclical parameter of capital regulation γ_x is assumed to be identical across (the two) sectors of specialization. The complementary of the term $\gamma_x(\frac{x_t}{x^{ss}}-1)$ can be interpreted as the countercyclical capital buffer (henceforth CCyB). When $\gamma_x<0$ dynamic capital requirements are countercyclical.

Similarly, the dividend prudential target d_t^* is set according to the following regulatory scheme:

$$d_t^* = \rho_d + \rho_\chi(\frac{x_t}{x^{ss}} - 1), \tag{3.33}$$

and

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2}\left(d_{b,t} - d_t^*\right)^2, \tag{3.34}$$

where ρ_d is the bank dividend payout targeted by the prudential authority in the steady state and ρ_χ measures the degree of responsiveness of the dividend prudential target d_t^* to deviations of a particular macroeconomic indicator x_t from its steady state level x^{ss}. According to expression (3.34), the dividend prudential target enters a quadratic penalty function, with $\kappa \geq 0$ being the corresponding penalty parameter. When $\kappa > 0$ and $\rho_\chi > 0$, deviating from the DPT d_t^* is costly to bankers and the policy rule is countercyclical, respectively. All resources paid by the representative banker as a sanction for having deviated, $T(d_{b,t}, d_t^*)$, are transferred by the prudential authority to households within the same period.

3.3.5 Aggregation and Market Clearing

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

$$Y_t = Y_{c,t} + q_t IH_t, \tag{3.35}$$

$$Y_t = C_{p,t} + C_{i,t} + q_t^c I_t^c + q_t^h I_t^h + q_t IH_t + \delta_t \frac{K_{b,t-1}}{\pi_t} + \Phi_b(B_t) + \Phi_e(B_t). \tag{3.36}$$

where expressions (3.35) and (3.36) refer to the GDP of the economy from the output and the expenditure approach perspectives, respectively. The income generated in the production

[11] x_t is a macroeconomic indicator of the choice of the regulator.

process is fully spent in the form of final private consumption, business and housing investment, resources devoted to manage the capital position of the bank, $\delta_t K_{b,t-1}/\pi_t$ (also interpretable as eroded equity), and all credit adjustment costs incurred by impatient households, entrepreneurial firms and banks. Similarly, the labor market, the physical capital markets, the housing market, and the credit and deposit markets, all clear in equilibrium (see Appendix B for the full set of equilibrium conditions).

3.4 Calibration

We follow a three-stage strategy in order to calibrate the model to quarterly euro area data for the period 2002:I-2018:II.[12] First, several parameters are set following convention (table 3.1A). Some of them are standard in the literature. Some others are based on papers in the field of macro-finance. The risk aversion parameter of household preferences, the inverse of the Frisch elasticity of labor, the elasticity of substitution between labor types, and the capital share in housing production are set to standard values of 2, 1, 1 and 0.33, respectively. Loan-to-value ratios (on both, residential and commercial mortgage loans) 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. The depreciation rate of housing is set to a standard value of 0.01 (see, e.g., Mendicino et al. 2018 and Muñoz 2020b). 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 parameterization of credit adjustment costs is based on Iacoviello (2015), whereas that of investment adjustment costs and managers' preferences (i.e., the elasticity of intertemporal substitution of bank and entrepreneurial managers) is identical to the one proposed in Muñoz (2020a). Relying on the calibration of the New Area-Wide Model II for the euro area economy (see Coenen et al. 2018), the elasticity of substitution between intermediate goods, the Calvo parameter, and the inflation indexation parameter are fixed to values of 6, 0.82 and 0.23, respectively. The three parameters of the Taylor rule (i.e., ρ_r, α_Y, and α_π) are fixed to 0.75, 0.1 and 1,5, in line with values used in the literature (see, e.g., Mendicino et al. 2020).

Second, another group of parameters is calibrated by using steady state targets (tables 3.1B and 3.2A). The patient households' discount factor, $\beta_p = 0.9943$, is chosen such that the annual risk-free rate equals 2.3%. The impatient households' discount factor is set to 0.95, in

[12] 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.

order to generate an annualized weighted interest rate on loans of 5.6%. Household weights on housing utility, j_p and j_i, have been calibrated to match a consumption-to-GDP ratio of 76% and a household loans-to-GDP ratio of 215%, respectively. The weight parameter of hours worked in the non-housing production sector that enters' the households' labor supply aggregator ω_n is set to 0.51 to match a construction-to-GDP ratio of 11.8%. As in Muñoz (2020a), 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, $\omega_p = 0$. These values 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; and they are particularly helpful to separate (by agent types) and more clearly identify the key welfare effects and trade-offs triggered by the proposed monetary and prudential policy rules.[13] 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 21.2% and a housing wealth-to-annual GDP ratio of 280.2%, respectively. As in Muñoz (2020a), sectoral capital requirement parameters γ_i and γ_e are fixed to values of 0.8501 and 0.9295, consistent with weighted capital requirements of 0.105 and with a capital requirements on commercial mortgage loans-to-capital requirements on residential mortgage loans ratio of 2.1176. The depreciation rate of bank capital δ is set to 0.0366, which is consistent with a bank payout ratio of 0.563. The annualized inflation target is fixed to 1.9%, consistent with the quantitative price stability objective of the ECB.

Third, the size of the six different types of shocks that hit this model economy have been calibrated to match the second moment (in terms of relative standard deviations) of GDP, total consumption, total investment, household loans, corporate loans, and bank dividends (tables 3.1C and 3.2B). The autoregressive parameter values associated to all shocks other than interest rate shocks are identical to those proposed in Gerali et al. (2010) and in Muñoz (2020a). In the baseline calibration scenario, macroprudential policy parameter γ_x is set to 0 and the dividend prudential target is inactive (i.e., $\kappa = 0$, $\rho_\chi = 0$, and $\rho_d = d_b^{ss}$).

3.5 Welfare Analysis

This section studies the welfare effects and interactions between conventional monetary policy, the countercyclical capital regulation and dynamic dividend restrictions. 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:

[13] See Muñoz (2020a) for a more detailed discussion on the technical, empirical and theoretical reasons underlying this calibration of ownership parameters ω_e and ω_b.

$$\arg\max_{\Theta} V_0 = \zeta_p V_0^p + \zeta_i V_0^i, \tag{3.37}$$

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 (3.37) is subject to all the equilibrium conditions of the 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:

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U\left(C_{\varkappa,t}^p, H_{\varkappa,t}^p, N_{\varkappa,t}^p\right) = E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U\left[\left(1+\lambda_{\varkappa}\right) C_{\varkappa,t}^b, H_{\varkappa,t}^b, N_{\varkappa,t}^b\right], \tag{3.38}$$

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

Without prejudice of the normative merit of the proposed welfare criterion, we assume that $\zeta_{\varkappa} = (1 - \beta_{\varkappa})$, with $\varkappa = p, i$. That ensures the same utility weights across households discounting future utility at different rates and prevents an overweight of savers' welfare related to a higher discount factor. Adequately weighting impatient households' expected life-time utility in the measure of social welfare is particularly important, given the baseline calibration and the type of analysis under consideration. As it will become more evident below, impatient households are the agent type that is more directly affected by the policy trade-offs that monetary and prudential authorities need to optimally strike in this model economy. As borrowers they particularly benefit from the lending smoothing effect triggered by macroprudential policies. As bank owners, they are negatively affected by increased bank dividend volatility (triggered by countercyclical DPTs). While they benefit from price stability, they optimally tolerate a certain degree of inflation volatility due to the smoothing effect it has on the real value of their debt.

3.5.1 Optimal Policy Rules

In this subsection, we study the welfare effects and effectiveness of the proposed policies by considering each of the three optimal policy rules in isolation.

Consider three policy scenarios $p = (A^S)$, (B^S) and (C^S) to be compared with the baseline scenario. Under scenario (A^S), the central bank solves problem (3.37), with respect to $\Theta = (\rho_r, \alpha_Y, \alpha_\pi)$. In order to identify the optimal simple rule within the class (3.30) that solves (3.37), it has been searched over a multidimensional grid of standard parameter values which can be defined as follows. $\rho_r\{0.5-0.95\}, \alpha_Y\{0.00-0.50\}, \alpha_\pi\{1.50-3.00\}$. Table 3.3(A^S) reports the parameter values that solve the problem and the corresponding welfare gains expressed in percentage permanent consumption. The optimal simple Taylor-type policy rule entails a high response to output growth $\alpha_Y^* = 0.50$ (i.e., the optimized parameter value is constrained by the upper bound of the selected grid of parameter values) and a relatively mild response to inflation deviations from the target $\alpha_\pi^* = 2.13$ (i.e., the optimized parameter value is not constrained by the upper bound of the selected grid of parameter values).

Under the selected welfare criterion, borrowers benefit comparatively more (than savers) from the optimal simple Taylor rule (TR). As shown in the literature (see, e.g., Monacelli 2008), in the presence of impatient households and collateral constraints, optimal inflation volatility is increasing in the borrower's utility weight (in the measure of social welfare) and in the borrower's impatience rate (relative to the saver). The central bank has to optimally balance the incentive to offset the price stickiness distortion with the one of marginally affecting borrowers' collateral constraints.[14] The first row of figure 3.1 plots the welfare effects of ceteris paribus changes in α_π under policy scenario (A^S). While savers are comparatively more concerned with price stability (and only indirectly affected by policy effects on collateral constraints through their ownership of entrepreneurial firms), borrowers optimally tolerate a relatively higher inflation volatility (note that, under scenario (A^S), borrowers' welfare is maximized for $\alpha_\pi < 2$) and advocate a policy that can effectively stabilize real debt (in the case of a Taylor-type rule within the class 3.30 , a strong response to output growth contributes to the attainment of that goal).

Under scenarios (B^S) and (C^S) the prudential authority solves problem (3.37), with respect to $\Theta = \rho_x$ and $\Theta = \gamma_x$, respectively. The optimization problem of the prudential authority under scenario (B^S) has been solved for the following grid of parameter values: $\rho_x\{0.00-45.00\}$,with $x_t = Y_t$, $\rho_d = d_b^{ss}$, and $\kappa = 10$.[15] The same problem under scenario (C^S) has been solved for a grid of parameter values that can be defined as follows: $\gamma_x\{(-1.00)-0.00\}$,with $x_t = Y_t$.[16] Table 3.3 (parts B and C) reports the parameter values

[14] Note that, in this environment, monetary policy can affect borrowers' net worth by altering the real value of the outstanding debt service.

[15] The value of κ has been set to a sufficiently high value in order to avoid certain regions of indeterminacy when combining the DPT with other optimized policy rules. Higher values of κ relate to a less responsive optimal dividend prudential target (i.e., lower ρ_r^*) but do not significantly affect welfare gains induced by the optimal DPT.

[16] See Muñoz (2020a) for a thorough discussion on the considered criteria to select the grids of parameter values for the macroprudential parameters associated to policy rules within the class (3.31; 3.32) and (3.33; 3.34).

that solve each of the problem and the associated welfare gains, whereas the second and third rows of figure 3.1 plots the welfare effect of ceteris paribus changes in ρ_x and γ_x respectively. The main welfare effects and trade-offs of the DPT and the CCyB in this model economy are analogous to those obtained for the case of a real economy in Muñoz (2020a). Importantly, the main benefit of DPTs in terms of credit smoothing needs to be traded-off with its main welfare cost in terms of increased bank dividend volatility.

Figures 3.2 to 3.7 plot the impulse-responses of key economic aggregates to the 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 (3.37) has been solved with respect to $\{\rho_r, \alpha_Y, \alpha_\pi\}$, ρ_x, and γ_x, respectively. To the extent that they are more targeted to smoothing bank lending, macroprudential policy rules within the class (3.31; 3.32) and (3.33; 3.34) are more effective in taming the business cycle than the optimal simple Taylor-type rule of the type (3.30). Furthermore, and regardless of the shock under consideration, the optimal DPT is more effective in stabilizing the economy than the optimal CCyB (and than the optimal Taylor rule). As discussed in Muñoz (2020a), the key underlying reason behind such an important finding relates to the different transmission mechanisms through which each of the two types of macroprudential tools operate. The DPT is more effective than the CCyB as it directly attacks the root of the "problem"; namely bankers' preference for smoothing dividends.

3.5.2 Optimal Policy Coordination

This subsection explores the interactions and welfare effects of different coordinated and uncoordinated monetary-macroprudential policy options. Consider another three policy scenarios $p = (A^C)$, (B^C) and (C^C) alternative to the baseline case. Given the three policy rules under consideration, each of the three scenarios considers a different combination of monetary-macroprudential policy rules. In particular, the policy rules that can be set by the corresponding public authorities in scenarios (A^C), (B^C) and (C^C) are the Taylor rule and the DPT; the TR and the CCyB; and the TR, the DPT and the CCyB, respectively. For each given scenario, two cases are considered; one in which the central bank an the prudential authority maximize social welfare independently and without taking into account the action of the other public authority (i.e, uncoordinated macroeconomic policy) and another one in which both public authorities coordinate their actions and social welfare is jointly maximized with respect to all relevant policy parameters of the policy rules under consideration (i.e, coordinated macroeconomic policy).

Table 3.4 reports the optimized policy parameter values and the corresponding welfare gains for each of the three policy scenarios, with and without coordination. Figures 3.8, 3.9 and 3.10 compare, for each of the three already considered key macroeconomic policy parameters (i.e., α_π, ρ_x and γ_x), the ceteris paribus welfare effects of each policy rule in the absence of other policy rules (solid line) - as already shown in figure 3.1 - with those of the corresponding multiple policy rule scenarios under coordination (dashed and dotted lines).

The main findings of the analysis can be summarized as follows: (i) Even if monetary and prudential authorities do not coordinate their actions, significant welfare gains can be attained by combining an optimal simple Taylor rule with any of the two optimal prudential rules, due to the different transmission mechanisms through which each of the policy rules operate (i.e., comparison between scenarios (A^C), and (B^C) and scenarios (A^S), (B^S) and (C^S)) . (ii) Under perfect cooperation, additional welfare gains are attained through a stronger specialization of monetary and macroprudential policies on their respective traditional objectives (i.e., price stability and financial stability). (iii) if the two prudential authorities perfectly coordinate their actions and the three policy instruments are available, combining the three policy rules is optimal. That is, despite the very conservative assumptions (by which the welfare analysis particularly considers bank owners' preferences), jointly combining a simple Taylor rule and a highly responsive CCyB with countercyclical dividend regulation is optimal.

A closer inspection of the welfare effects attained under scenario C^C make clear that the chosen welfare criterion notably reflects impatient households' preferences. Note that the optimal responsiveness of the DPT under perfect coordination is notably lower than under the non-cooperative case. As in Muñoz (2020a), there is an significant multidimensional grid of $\rho_x \{\rho_x > 0; \gamma_x < 0\}$ values for which the degree of responsiveness of the DPT and that of the CCyB are self-reinforcing, in the case of savers. This is the case due to the fact that each instrument operates through a different transmission channel. By way of contrast, impatient households' preferences show a relationship of substitutability between the optimal responsiveness of the DPT and that of the CCyB; even if the optimal DPT is more effective in stabilizing aggregates of the real economy than the CCyB, the latter does not generate any relevant welfare cost to bank owners.

The bottom line is that, even under a set of very conservative assumptions by which the selected measure of social welfare largely reflects bank owners preferences, it is optimal to regulate bank dividends from a macroprudential perspective and to coordinate such regulation with conventional monetary policy and countercyclical capital regulation. As already mentioned, such set of assumptions includes: (i) a range of macroprudential capital parameter values that allows for a very highly responsive CCyB (when compared to the Basel III-proposed calibration for this instrument), (ii) bank owners accounting for half of the entire household population (a proportion that is well above the empirically relevant one), and (iii) a welfare weighting criterion that largely reflects the preferences of those households who own banks.

3.6 Macroprudential Policies in a Low Interest Rate Environment

In this section we study the effects of the DPT and the CCyB when monetary policy is constrained by the (occasionally binding) ZLB on nominal interest rates. In order to do so, we apply the solution method proposed by Guerrieri and Iacoviello (2015). Figure 3.11 plots the impulse-responses of key economic aggregates to a negative housing preference shock that hits the economy in the sixth quarter under four different scenarios. The blue and red solid lines refer to the baseline and the optimal DPT scenarios when the ZLB does not bind, respectively. The dashed blue and red lines correspond to the same scenarios when the ZLB binds. When the policy rate hits the ZLB, the central bank cannot further adjust the nominal interest rate in response to the fall in inflation and output. Hence, inflation declines relatively more causing the short-term real interest rate to increase. Such effect further depresses aggregate expenditure and demand for lending. Bank profits decline, but dividends barely differ from those distributed when the ZLB does not bind, thereby amplifying the fall in bank capital, lending and economic activity. For this reason, when the ZLB on nominal interest rates binds and a negative shock hits the economy, the optimal DPT is particularly effective in sustaining lending and economic activity through bank capital conservation.

Figure 3.12 plots the impulse-responses of the same key economic aggregates when the economy is hit by the same type of shock in the sixth quarter under four different scenarios. However, in this case the solid and dashed green lines relate to optimal CCyB scenarios in which the ZLB does not bind and in which such constraint is binding, respectively. Note that the effectiveness of the CCyB also improves substantially when monetary policy is constrained by the ZLB although the mechanism through which it operates is quite different than the one of the DPT. Allowing banks to use their capital buffers in bad times is particularly effective in preventing deleveraging to take place. Nonetheless, that comes at the "cost" of bank equity experiencing a more pronounced fall than under the baseline scenario. While this set-up does not explicitly model such cost (in terms of increased probability of bank default), it highlights the importance of combining measures of capital conservation (through the use of dynamic dividend restrictions) with measures of capital usability (through the release of countercyclical capital buffers) to ensure that the banking sector keeps funding households and firms during the lower phase of the cycle.

3.7 Conclusion

Given the strong preference of bankers for smoothing dividends over the cycle, the current capital regulatory framework does not seem to be well suited to provide credit institutions with the right incentives to release their capital buffers when such action is needed the most. Against this background, central banks around the world have de facto switched from a microprudential, institution-specific, and capital-contingent dividend regulation (i.e., the type of dividend regulation that is incorporated in the Basel III Accords) to a macroprudential, state-contingent, dividend regulation (i.e., the type of prudential dividend regulation that is shown to be optimal in Muñoz 2020a).

We propose a two-sector model that features nominal rigidities and borrowing limits to assess the macroeconomic and welfare effects, interactions and cooperative options between prudential dividend regulation and monetary policy in the current Basel III regulatory environment. The proposed quantitative analysis suggests that optimal dividend regulation is particularly effective in taming the business cycle and that induces significant welfare gains when being combined with an optimal simple Taylor rule. There are welfare gains from perfect coordination between monetary policy and this type of prudential regulation as cooperation allows for each policy to focus more specifically on their traditional objectives. Importantly, even in the presence of an optimal simple Taylor rule and a highly (and optimal) CCyB, regulating bank dividends from a macroprudential perspective is welfare-improving.

From an empirical perspective, there are various potential extensions of the model that should provide the analysis with a greater deal of realism while reinforcing the policy prescriptions in favour of macroprudential dividend regulation. Among others, assuming a positive probability of bank failure, as in Clerc et al. (2015) and Mendicino et al. (2018); adopting a full heterogeneous agents model perspective to account for the specific fraction of households who hold bank shares in practice (and for the concrete weight of such shares in their asset portfolios); and constraining the CCyB by the empirically and regulatory relevant 0% lower bound on countercylical buffers. Finally, a more realistic exercise of the different policies that have attempted to be coordinated in the wake of the Coronavirus crisis would require to include fiscal policy, unconventional monetary policy and other types of supervisory measures affecting the treatment of non-performing loans and the application of accounting standards, among others.

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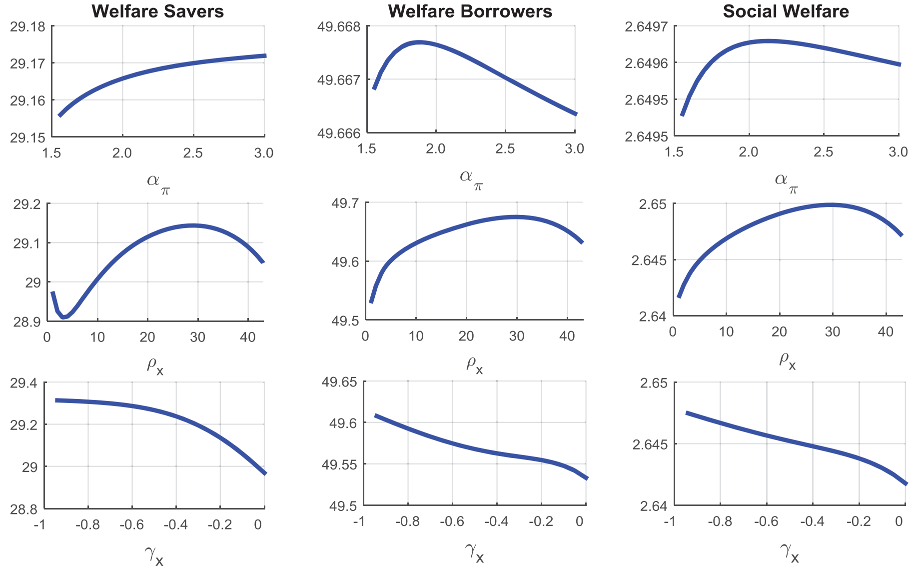
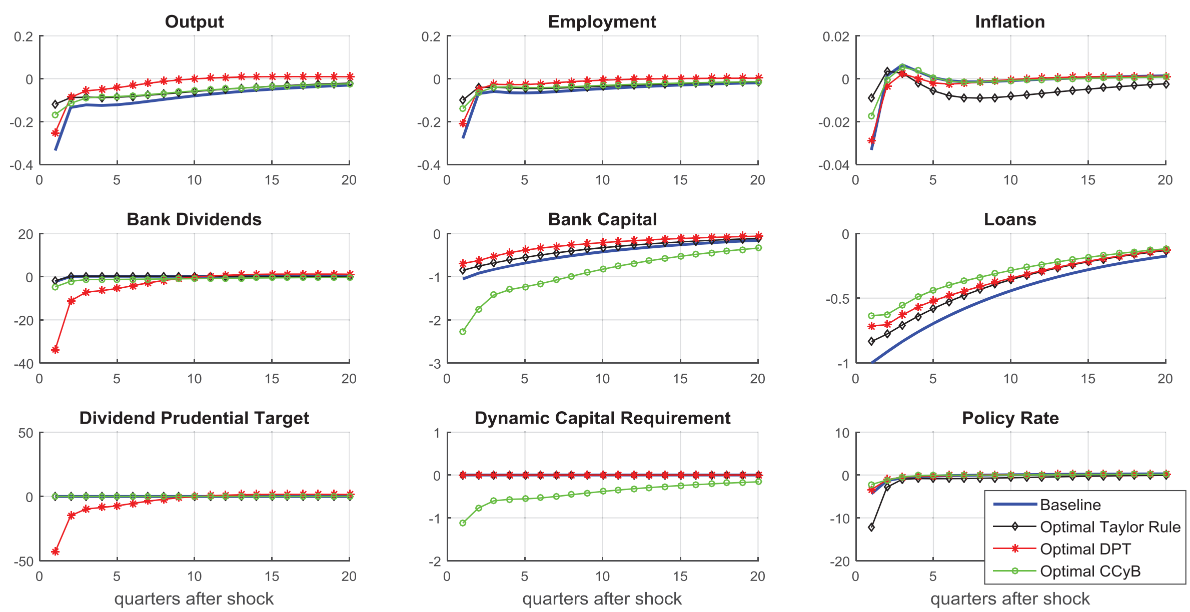
Figure 3.1: Welfare effects of selected macroeconomic policy parameters



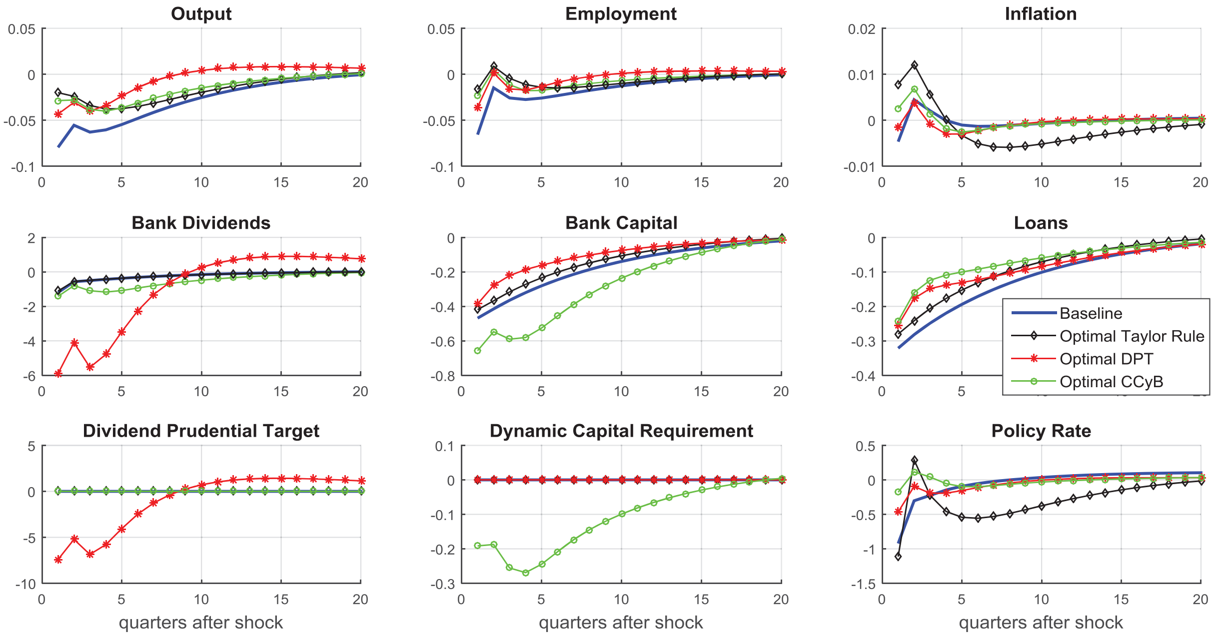
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare as a function of: (i) the inflation coefficient of the Taylor rule while keeping ρ_r and α_Y at their optimal simple Taylor rule values; (ii) the cyclical parameter of the dividend prudential target, ρ_x; and (iii) the cyclical parameter of the dynamic capital requirements, γ_x.

Figure 3.2: Impulse-responses to a negative HH collateral shock



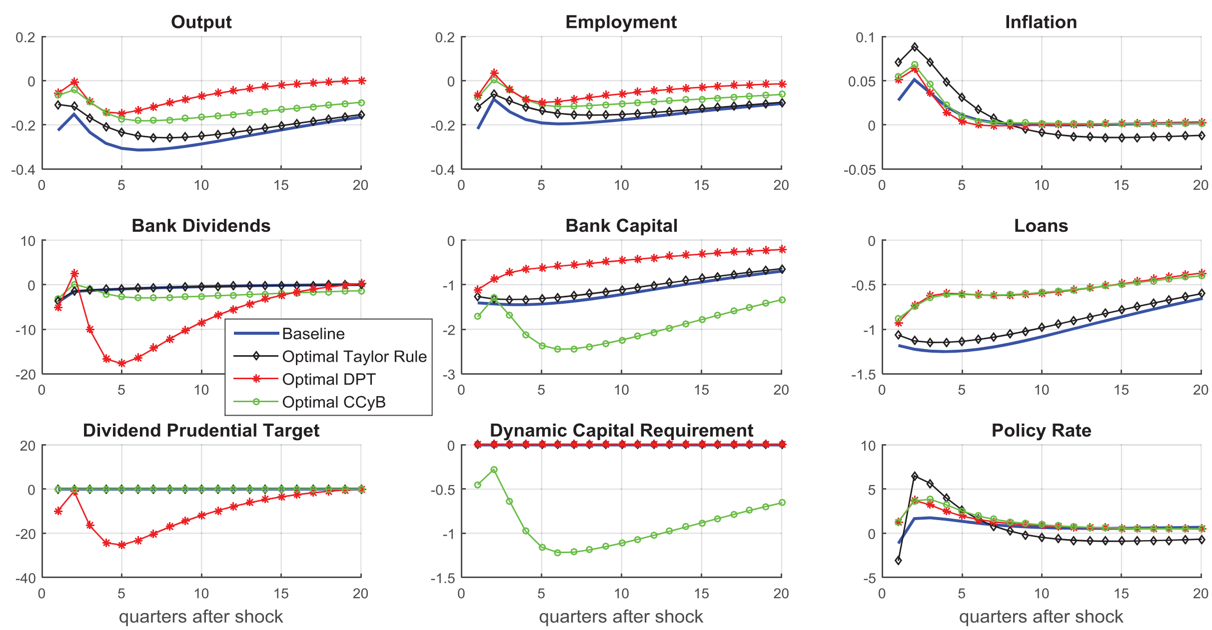
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.3: Impulse-responses to a negative NFC collateral shock



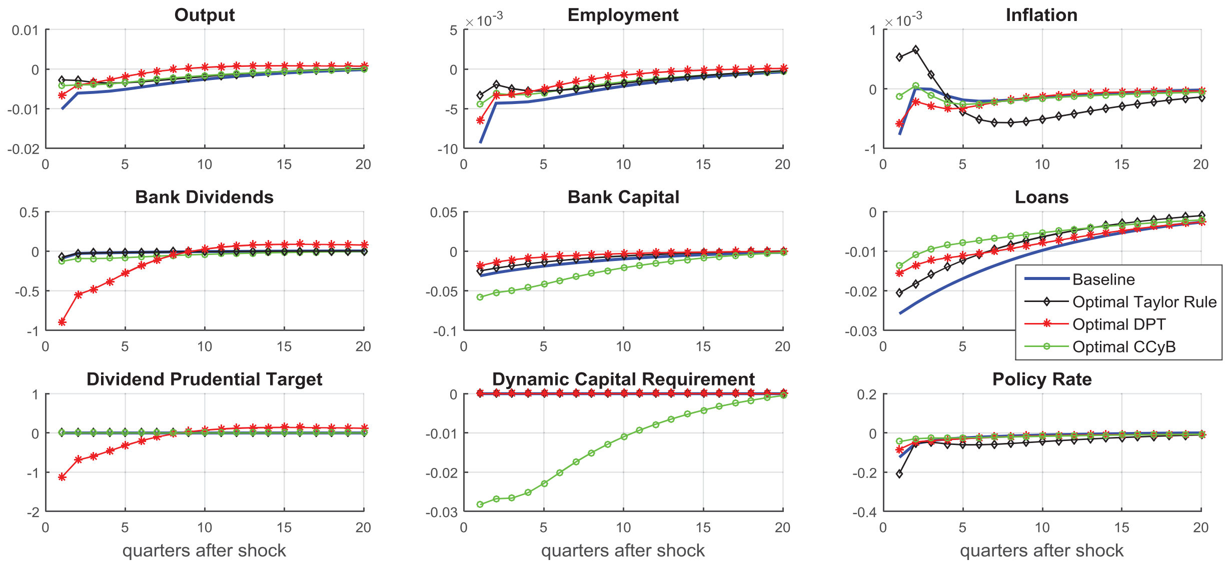
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.4: Impulse-responses to a negative bank capital shock



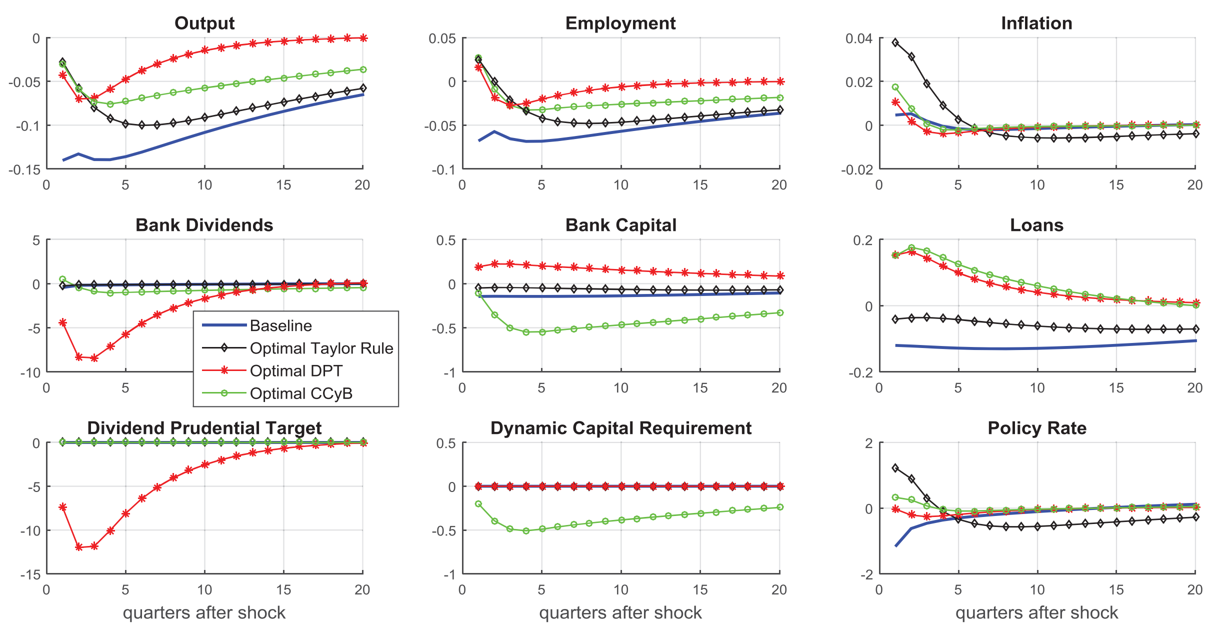
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.5: Impulse-responses to a negative housing preference shock



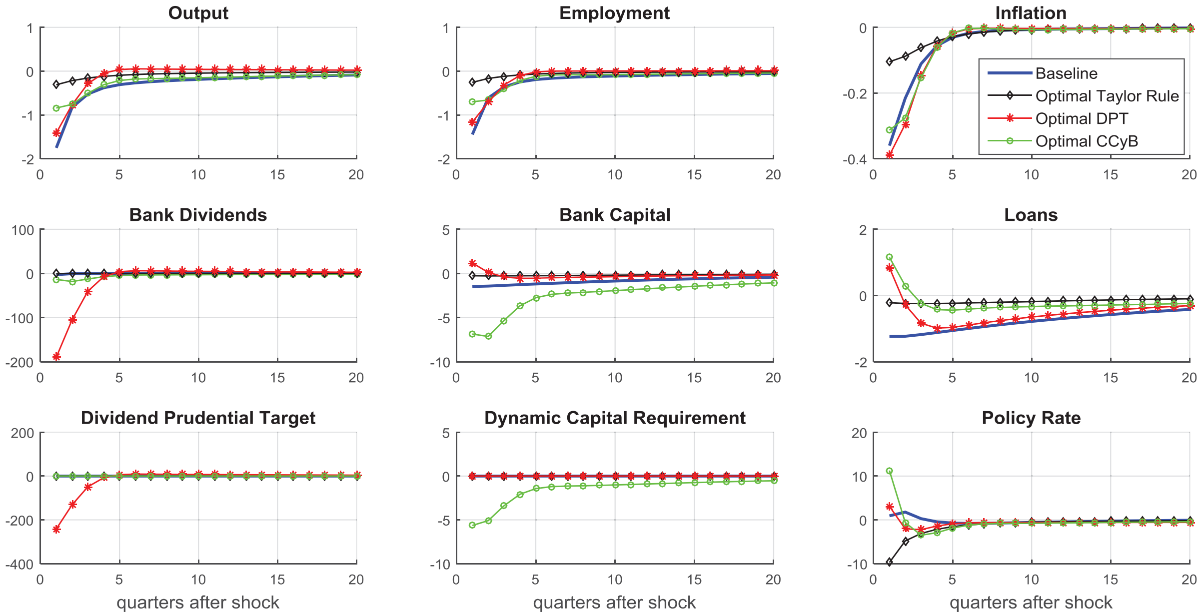
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.6: Impulse-responses to a negative technology shock



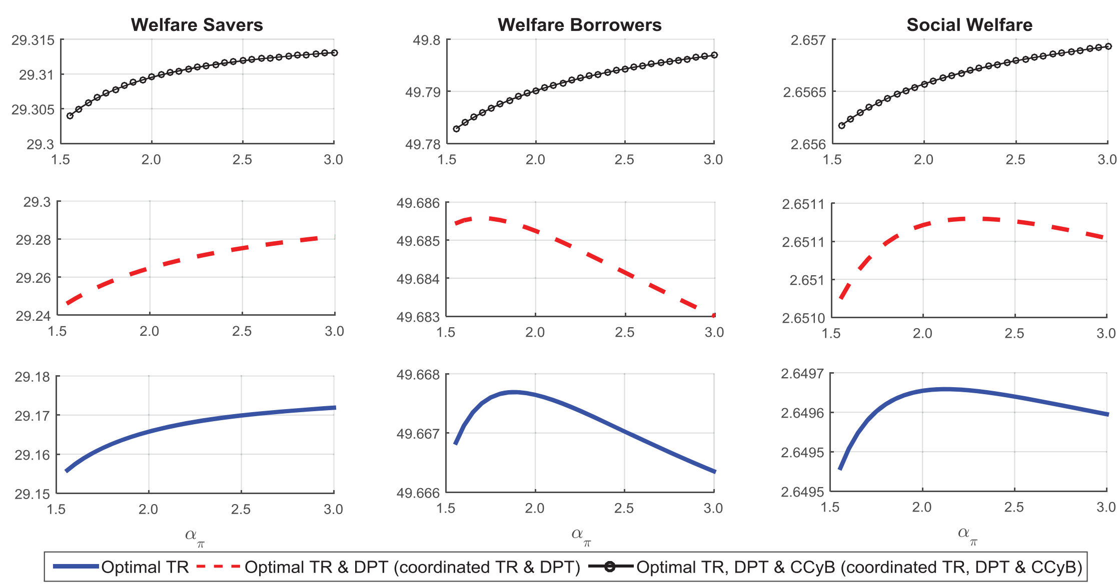
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.7: Impulse-responses to a contractionary monetary policy shock



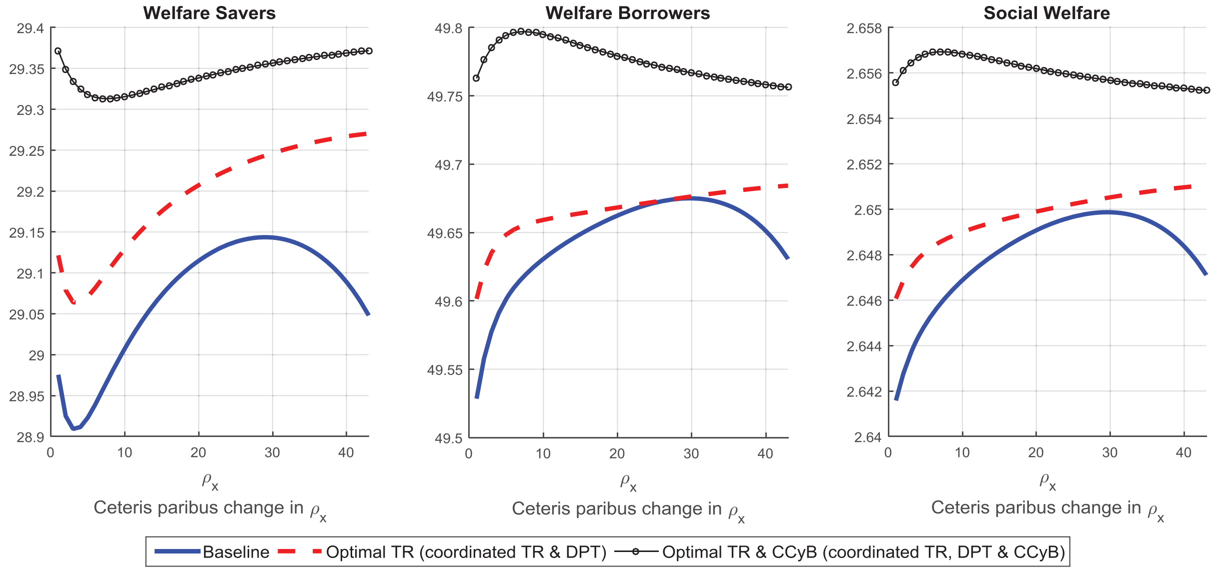
Note: Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid line refers to the baseline case. The diamond line makes reference to the optimal simple Taylor rule scenario. The starred line corresponds to the optimal DPT scenario. The dotted line relates to the optimal CCyB scenario.

Figure 3.8: Welfare effects of TR inflation targeting for alternative coordinated policy options



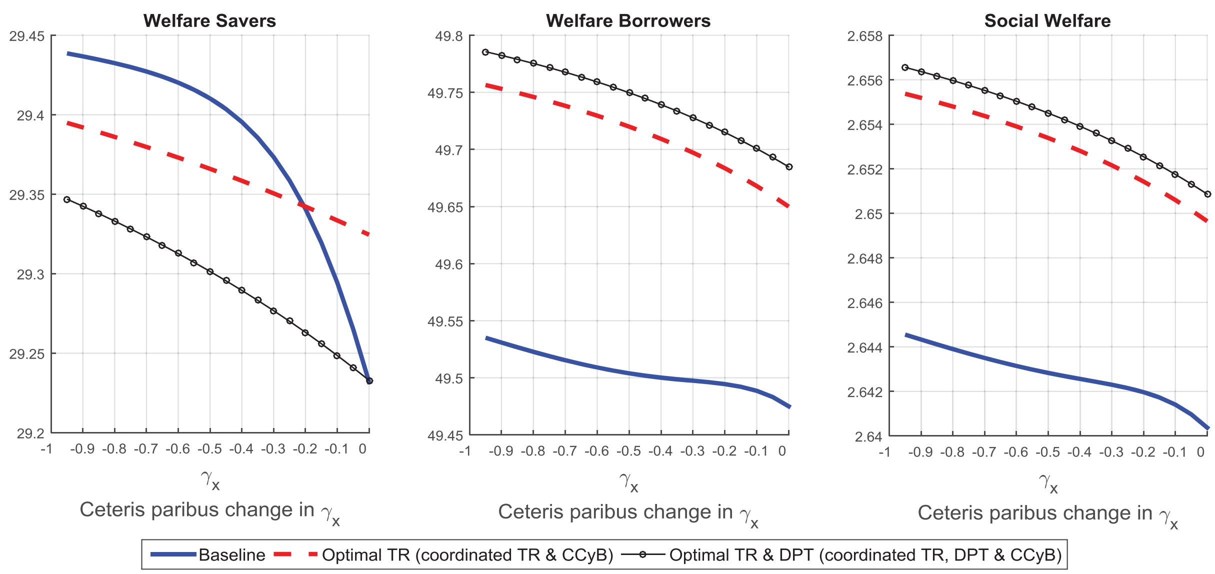
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare as a function of the inflation coefficient of the Taylor rule while keeping ρ_r and α_Y at their optimal simple Taylor rule values for: (i) the no macroprudential policies scenario; (ii) the optimal TR&CCyB - perfect coordination scenario; and (iii) the optimal TR&DPT&CCyB – perfect coordination scenario.

Figure 3.9: Welfare effects of DPTs for alternative coordinated policy options



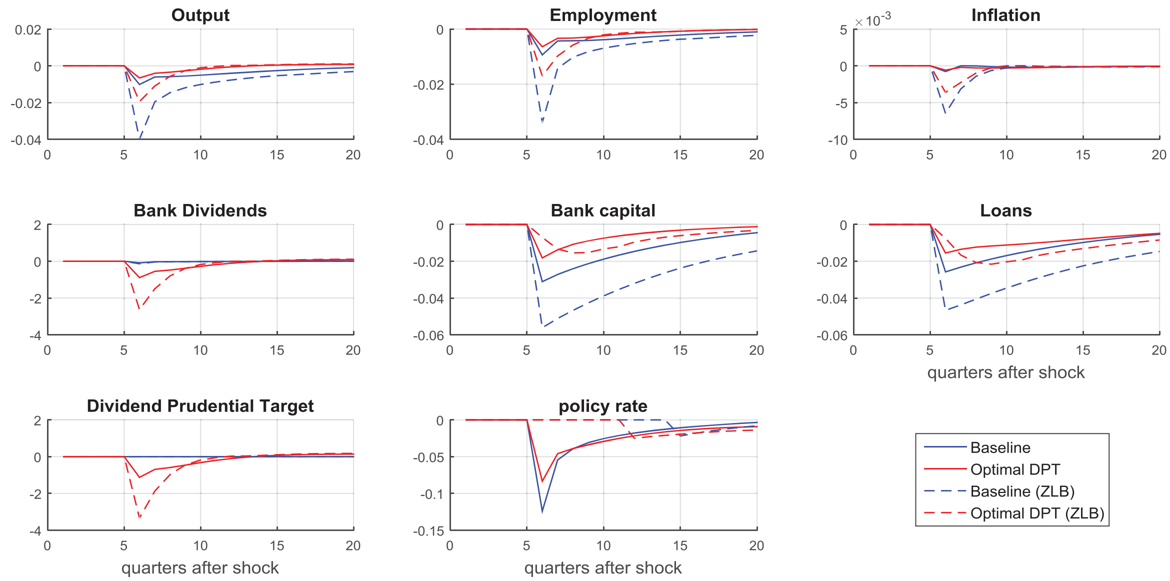
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare as a function of the cyclical parameter of the DPT for: (i) the baseline scenario; (ii) the optimal TR&DPT - perfect coordination scenario; and (iii) the optimal TR&DPT&CCyB – perfect coordination scenario.

Figure 3.10: Welfare effects of the CCyB for alternative coordinated policy options



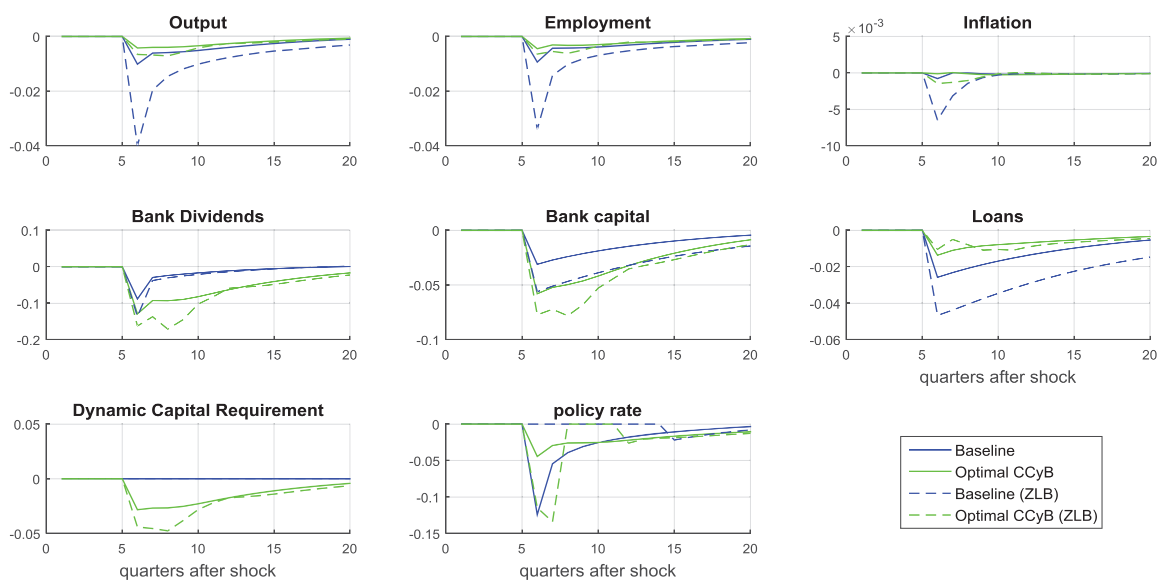
Note: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare as a function of the cyclical parameter of dynamic capital requirements for: (i) the baseline scenario; (ii) the optimal TR&CCyB - perfect coordination scenario; and (iii) the optimal TR&DPT&CCyB – perfect coordination scenario.

Figure 3.11: Effectiveness of the DPT with the ZLB



Note: Impulse-responses to a negative housing preference shock. Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid blue and red lines refer to the baseline case and the optimal DPT scenario when the ZLB on nominal interest rates is not binding, respectively. The dashed blue and red lines relate to the baseline case and the optimal DPT scenario when the ZLB is binding, respectively.

Figure 3.12: Effectiveness of the CCyB with the ZLB



Note: Impulse-responses to a negative housing preference shock. Rates are shown as absolute deviations from the steady state and are expressed in percentage points. All other variables are percentage deviations from the steady state. The solid blue and green lines refer to the baseline case and the optimal CCyB scenario when the ZLB on nominal interest rates is not binding, respectively. The dashed blue and green lines relate to the baseline case and the optimal CCyB scenario when the ZLB is binding, respectively.

Table 3.1: Baseline parameter values

Parameter					
(A) Pre-set parameters					
Inverse of the Frisch elasticity	φ	1	Credit adj. cost parameters	$\phi_i; \phi_e$	0.37; 0.06
Elast. of subst. labor types	ε_n	1	Investment adj. cost param	ψ_I^i	0.092
HH Risk aversion param	σ_h	2	Banks and Entrepreneurs EIS	σ	2.40
LTV ratio on HH and NFC housing	$m_i^H; m_e^H$	0.7; 0.7	Elast. of subst. interm. goods	ε	6
Depreciation rate of housing	δ^h	0.01	Calvo probability	θ	0.82
Depreciation rates of physical capital	δ^{kc}, δ^{kh}	0.025	Inflation indexation param	χ	0.23
Endogenous depr. rate params	$\delta_1^k; \delta_2^k$	r_k^{ss};0.1 x r_k^{ss}	Smoothing parameter (TR)	ρ_R	0.75
Capital share in housing production	υ	0.33	Response params (TR)	$\alpha_Y; \alpha_\pi$	0.1; 1.5
(B) Calibration: First moments					
Savers' discount factor	β_p	0.9943	Capital share in production	α	0.1440
Borrowers' discount factor	β_i	0.95	Real estate share in production	η	0.0847
Savers' housing weight	j_p	0.1210	Debt-to-assets, NFC risk-adjusted	γ_e	0.8508
Borrowers' housing weight	j_i	0.8134	Debt-to-assets, HH risk-adjusted	γ_i	0.9295
Weight in labor supply aggregator	ω_n	0.510	Depreciation rate of bank capital	δ	0.0366
Share of NFC and banks owned by HH$_p$	$\omega_e; \omega_b$	1.00; 0.00	Gross inflation target	$\overline{\overline{\pi}}$	1.00475
(C) Calibration: Second moments					
Std. HH collateral shock	σ_{me}	0.0049	Std. housing pref. shock	σ_h	0.0006
Std. NFC collateral shock	σ_{mh}	0.0024	Std. productivity shock	σ_A	0.0007
Std. bank capital depr. shock	σ_{kb}	0.2950	Std. interest rate shock	σ_r	0.0008

Table 3.2: Model fit

Variable	Description	Model	Data
(A) Steady state ratios			
C^{ss}/Y^{ss}	Total consumption-to-GDP ratio	0.7560	0.7607
I^{ss}/Y^{ss}	Gross fixed capital formation-to-GDP ratio	0.2290	0.2119
$q^{ss}IH^{ss}/Y^{ss}$	Total construction-to-GDP ratio	0.1121	0.1176
r_b^{ss} x 400	Annualized bank rate on loans	5.8538	5.60
$(\beta_p^{-1} - 1)$ x 400	Annualized bank rate on deposits	2.2931	2.30
$(r_b^{ss} - r_d^{ss})$x 400	Annualized Bank Spread	3.727	3.4
$(\bar{\pi} - 1)$ x 400	Inflation target	1.9000	1.90
$(1 - \gamma_e)/(1 - \gamma_i)$	Capital requirement of NFC loans-to-HH loans	2.1176	2.1176
K_b^{ss}/B^{ss}	Capital requirements on HH and NFC loans	0.1059	0.1050
$B_i^{ss}/(Y^{ss})$	HH loans-to-GDP ratio	2.1475	2.1291
$B_e^{ss}/(Y^{ss})$	NFC loans-to-GDP ratio	1.7577	1.7530
B_i^{ss}/B^{ss}	Fraction of HH loans	0.5499	0.5490
B_e^{ss}/B^{ss}	Fraction of NFC loans	0.4501	0.4510
d_b^{ss}/J_b^{ss}	Bank dividend payout-ratio	0.5612	0.5625
$(q^{ss}H^{ss})/(4Y^{ss})$	Housing wealth-to-GDP ratio	2.8036	2.8018
(B) Relative volatilities			
σ_{d_b} / σ_{J_b}	Std. bank dividends	0.2395	0.2546
σ_{Bi} / σ_Y	Std. HH loans	2.1009	2.413
σ_{Be} / σ_Y	Std.NFC loans	3.4827	3.806
σ_I / σ_Y	Std. investment	2.3688	2.6419
σ_C / σ_Y	Std. consumption	0.7368	0.7478
σ_Y	Std.(GDP) x 100	2.5897	2.1382

Table 3.3: Welfare gains of optimal policy rules

	Savers	Borrowers	Social
(A^S) Taylor Rule (TR)			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 2.13]$	0.1725	0.2900	0.0155
(B^S) Dividend Prudential Target (DPT)			
$[\rho_x^* = 28.59, \kappa = 10]$	0.1518	0.3062	0.0162
(C^S) Countercyclical Capital Buffer (CCyB)			
$[\gamma_x^* = -1]$	0.3021	0.1746	0.0105

Table 3.4: Welfare gains of coordinated and uncoordinated optimal monetary - prudential policies

	Savers	Borrowers	Social
(A^C) TR & DPT			
(i) Uncoordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 2.13, \rho_x^* = 28.59]$	0.2498	0.2886	0.0159
(ii) Coordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.00, \alpha_\pi^* = 2.27, \rho_x^* = 43.00]$	0.2685	0.3267	0.0179
(B^C) TR & CCyB			
(i) Uncoordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 2.13, \gamma_x^* = -1.00]$	0.3099	0.5544	0.0295
(ii) Coordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 3.00, \gamma_x^* = -1.00]$	0.3122	0.5565	0.0296
(C^C) TR, DPT & CCyB			
(i) Uncoordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 2.13, \rho_x^* = 28.59, \gamma_x^* = -1.00]$	0.3305	0.5046	0.0271
(ii) Coordinated			
$[\rho_r^* = 0.50, \alpha_Y^* = 0.50, \alpha_\pi^* = 3.00, \rho_x^* = 6.22, \gamma_x^* = -1.00]$	0.3002	0.5728	0.0304

Chapter 4

Macroprudential Policy and the Role of Institutional Investors in Housing Markets

4.1 Introduction

The low-for-long interest rates environment has exerted a downward pressure on fixed income returns, thereby providing institutional investors with incentives to search for yield in alternative markets such as the real estate sector. Over the last decade, the increasing presence of institutional investors in housing markets - together with a tightening of lending standards - has revitalized rental housing markets, leading to higher rents and depressed homeownership rates (see Gete and Reher 2018 and Lambie-Hanson, Li and Slonkosky 2019). Real estate funds and other housing investment firms have been leveraging large-scale buy-to-rent investments in real estate assets; a pattern that seems to have conferred them with some capacity to set rents in the areas were they have concentrated.

The euro area is one of the economies in which the increasing presence of institutional investors in housing markets has been more evident. Since 2012, institutional investment in euro area real estate assets has more than quadrupled in absolute terms and as a share of total housing investment (see figure 4.1). Importantly, a non-negligible proportion of these investments seems to have been leveraged via non-bank lending (i.e., lending that is not subject to regulatory LTV limits). In addition, real estate funds are generally not subject to leverage limits in the EU and there is significant uncertainty surrounding their actual leverage measures, among other reasons, due to the fact that investment funds often lever up synthetically through the use of derivatives.[1]

The aim of this chapter is to contribute to the ongoing debate on strengthening the macroprudential policy framework for non-banks by assessing the effectiveness of countercyclical LTV ratios that limit the REIFs' borrowing capacity in smoothing credit and housing price cycles. In order to do so, I adopt a DSGE perspective and develop a quantitative two-sector business cycle model in which households, real estate funds and final goods-producing firms interact in a real, closed, decentralized and time-discrete economy. The model is calibrated to quarterly data of the euro area and matches a number of first and second moments of macroeconomic aggregates. The proposed quantitative analysis concludes that optimized (countercyclical) LTV rules limiting the borrowing capacity of institutional investors (i.e., LTV limits on commercial mortgages) are more effective in smoothing housing price and credit cycles than those affecting the borrowing limit of impatient households (i.e., LTV limits on residential mortgages). Importantly, such result is notably robust across alternative calibrations (of key parameters) and specifications of the model.

One of the main novelties of the paper is the modelling of real estate funds (and other housing investment firms) within a DSGE set up that is intended to capture several key features of this industry (as documented in the recent empirical literature). That is, the paper presents a model that has the potential to serve as a useful tool for assessing the macroeconomic effects of such sector. The supply side of the model has its similarities to Davis and Heathcote (2005) and Iacoviello and Neri (2010) in that it differentiates between housing producing firms and non-housing producing firms.[2] The demand side accounts for three different types of representative households which crucially differ from one another in the role they play in the real estate sector. Patient households save and purchase property housing to do both, live in and supply homogeneous rental services under perfectly competitive conditions; impatient households get indebted to acquire property for their own use, and renter households demand rental housing (services) to live in. In addition, real estate investment funds (also referred to as REIFs or funds) demand loans to buy homes and transform them into slightly differentiated rental housing services that are supplied under monopolistic competition.[3] That is, the real estate sector of this economy consists of a property housing market and a rental housing market. A key feature of the model is that, as in reality, pa-

[1] Real estate funds operating in the European Union fall within the category of funds that are subject to the AIFMD (Alternative Investment Fund Managers Directive), for which no leverage limits apply.

[2] Such firms produce housing (or durable goods) and final non-durable goods, respectively.

[3] Although I indistinctively refer - throughout the paper - to real estate investment firms as institutional investors or real estate funds, the type of economic agent that I am attempting to model englobes all types of institutional investors whose main business is to carry out large-scale purchases of real estate assets to offer rental housing services (e.g., real estate funds, real estate investment trusts and other companies with a similar business model).

tient households (i.e., savers) and institutional investors simultaneously supply services in the rental housing market to (renter) households and (non-housing) producing firms.

The model features two frictions which closely interconnect credit and housing markets in the economy and amplify the effects of exogenous shocks to the real economy. First, in the tradition of Kiyotaki and Moore (1997) and Iacoviello (2005), the borrowing capacity of indebted agents (i.e., impatient households and fund managers) is tied to the expected value of their housing stock. Second, institutional investors operate in the rental housing market under monopolistic competition. In this regard, the modelling of the real estate fund industry has some similarities to that of the banking sector in Gerali et al. (2010) and the motivation for that is twofold. Housing markets are, in practice, segmented according to some of their main features (location, type of construction, style, etc) and; the existence of a positive demand for different types of houses suggests there is a preference for variety at the aggregate level. From the supply side, purchasing a large amount of housing with a common characteristic (e.g., the neighborhood) grants the REIF market power in that particular segment of the market.

The macroprudential authority is assumed to have two policy instruments at hand; dynamic LTV policy rules that limit the borrowing capacity of both, impatient households and REIFs. Such policy rules are dynamic in the sense that they react to steady state deviations of a macroeconomic indicator of the choice of the regulator. In this regard, a key contribution of the paper is its assessment on the workings of the LTV rule that affects the borrowing capacity of REIFs (something that, to the best of my knowledge, has not been explored in the literature before). Such policy rule operates through the following transmission mechanism; a tightening of the REIFs' LTV limit in the face of a positive exogenous shock restricts funds' borrowing capacity and, thus, their activity. Fund managers eventually find optimal to demand less property housing and to supply less rental housing services. Consequently, property prices soar less abruptly and the share of savers' supply in rental housing markets increases, thereby exerting a downward pressure on the competitive rental price. That is, countercyclical LTV ratios affecting the borrowing capacity of REIFs have the potential to smooth lending, property prices and reference (i.e., competitive) rental housing prices over the cycle.

The main findings of the chapter can be summarized as follows. First, the market power real estate funds have in rental markets induce significant (negative) level effects on real and financial aggregates, when compared to the benchmark, perfect competition scenario. Second, optimized (countercyclical) LTV rules limiting the borrowing capacity of institutional investors (i.e., LTV limits on commercial mortgages) are more effective in smoothing the housing and credit cycle than those affecting the borrowing limit of impatient households (i.e., LTV limits on residential mortgages). Moreover, if the aim of the prudential authority is to tame the financial cycle (characterized by lending and property prices), the best option is to solely have a dynamic LTV rule on commercial mortgages in place (i.e., countercyclical LTV limits on residential mortgages are basically redundant). The underlying reason behind these results relates to the strong interconnectedness of REIFs' activity with the dynamics of key economic sectors, including the rental housing market as well as the housing and non-housing production sectors. Third, such results are remarkably robust across alternative calibrations (of key parameters) and specifications of the model.[4] Fourth, the robustness checks suggest that the effectiveness of dynamic LTV ratios restricting institutional investors' borrowing capacity is increasing in the market power, leverage and productivity levels of such funds as well as in the fraction of total housing held by them.

These findings suggest that REIFs' behavior has the potential to amplify financial and business cycles and brings some clarity on how this type of leverage-induced procyclicality could be mitigated through the use of macroprudential tools. There are at least two policy instruments that could be considered to tackle this issue in practice and which are still not in place: (dynamic) limits on REIFs' leverage and countercyclical LTV limits on non-bank lending. Moreover, the quantitative analysis notes that such (quantity) regulation would allow for reference prices in rental housing markets to increase less abruptly during the boom, an issue that policymakers in several countries of the euro area have attempted to handle via price regulation (an alternative that is prone to generate price distortions).

The chapter is organized as follows. Section 4.2 discusses how the contents of this chapter fit into the existing literature. Section 4.3 describes the model. Section 4.4 develops a quantitative exercise to assess the effectiveness of dynamic LTV ratios in smoothing housing price and credit cycles. Section 4.5 offers a robustness checks analysis. Section 4.6 concludes.

4.2 Related Literature

The chapter is motivated by recent empirical studies documenting the increasing presence of institutional investors in housing markets, recent developments in rental housing markets, as well as the leverage-induced procyclicality generated by certain investment funds.

[4] However, the effectiveness of the two types of LTV policy rules materially declines if the assumption that allows for a certain degree of complementarity between the consumption of non-durable goods and that of durable goods (i.e.,housing) is relaxed. It is worth noting, however, that such assumption is relevant not only to account for a variety of empirical facts at the macroeconomic level (see, e.g., Ogaki and Reinhart 1998 and Monacelli 2008) but also to provide the model with a greater deal of *realism* from a microeconomic perspective. Much of the (non-durable) consumption activities undertaken by household members in practice occur when they are inside their houses. That is, there are complementarities between the two types of consumption.

Lambie-Hanson, Li and Slonkosky (2019) establish a causality relationship between the increasing presence of institutional investors in housing markets and both, the steady recovery in housing prices as well as the decline in homeownership rates that followed the Great Recession. Similarly, Mills et al. (2016) conclude that large-scale buy-to-rent investors have pushed prices and rents upwards in the neighborhoods where they have concentrated, while the empirical analysis proposed in Gay (2015) suggests that, when operating in housing markets, institutional investors have applied a mark up and decreased affordability. These trends seem to have been exacerbated by the tightening in lending standards that followed the Global Financial Crisis, which according to Gete and Reher (2018) has led to higher rents, depressed homeownership rates and increased rental supply.

Leverage seems to have played a key role in conducting such large-scale buy-to-rent institutional investments in real estate assets.Tzur-Ilan (2018) studies the effects of hard LTV limits implemented in Israel in 2012 and finds that investors have been the most affected and constrained type of borrowers in housing markets, signalling their heavy reliance on borrowing to purchase real estate assets. In addition, Hoesli et al. (2017) concludes that the Basel III framework has imposed a regulatory burden on real estate companies, thereby providing them with incentives to opt for funding sources other than bank lending. In recent years, market analysts have recurrently reported that a significant proportion of these investments is being leveraged via direct lending, often provided by debt funds; something that has raised fears of a credit bubble building up in the debt fund industry.[5] Recent empirical studies have found that debt funds are among the most leveraged investment funds in Europe, with fund managers in leveraged funds reacting in a relatively more procyclical manner (than those in non-leveraged funds) and leverage reportedly amplifying financial fragility in the investment fund sector (see, e.g., van der Veer et al. 2017 and Molestina Vivar et al. 2020).

At the same time, the contents of this chapter connect with three strands of the literature that are well differentiated. First, the chapter contributes to the strand of literature that incorporates housing markets in otherwise standard DSGE models (see Piazessi 2016 for a recent and extensive literature review on housing and macroeconomics). In particular, the model builds on a large literature that incorporates a multi-sector structure with housing and non-housing goods (see, e.g., Greenwood and Hercowitz 1991, Benhabib, Rogerson and Wright 1991, Chang 2000, Davis and Heathcote 2005, Fisher 2007, Iacoviello and Neri 2010, and Justiniano et al. 2015) and credit restrictions by which the borrowing capacity of certain

[5] See, among others, Evans, J., (2019). "Real Estate: post-crisis boom draws to a close." Financial Times. June 18, https://www.ft.com/content/64c381c8-8798-11e9-a028-86cea8523dc2, and Wigglesworth, R., (2017). "Rise of private debt creates fears of a bubble." Financial Times. April 13, https://www.ft.com/content/e405a256-1fbf-11e7-b7d3-163f5a7f229c.

agent types is tied to the expected value of their housing collateral, as in Kiyotaki and Moore (1997) and Iacoviello (2005 and 2015). In this regard, Iacoviello and Neri (2010) is perhaps my closest antecedent as it combines both features. However, I omit a number of ingredients their model incorporates (e.g., intermediate goods, nominal rigidities, monetary policy and a wide range of shocks) in order to include other key features (e.g., rental housing markets and real estate funds) while keeping the complexity of the model to a minimum. Yet, I allow for a variety of technology and housing demand shocks, the type of exogenous shocks that have been shown to explain the bulk of the variability in housing investment and housing prices (see Iacoviello and Neri 2010) .

The chapter also connects to the literature in macroeconomics that attempts to model rental housing markets. Among others, Chambers et al. (2009a and 2009b), Kiyotaki et al. (2011), Ortega et al. (2011), Sommer et al. (2013), Alpanda and Zubairy 2016), Kaplan et al. (2017), Sun and Tsang (2017), Garriga et al. (2019), and Greenwald and Guren (2019). With regards to the heterogeneity of households, the closest model to the one I propose in this paper is probably Alpanda and Zubairy (2016). There are three types of households (i.e., savers, borrowers and renters) which crucially differ from one another in their subjective discount factor (and, consequently, in the role each of them plays in financial markets) as well as in the role they play in the real estate sector. This assumption allows to strike a balance between the caveats related to assuming a unique representative household (in a model that integrates property and rental housing markets) and the limitations - in terms of tractability (and quantitative analysis) - a full heterogeneous agents model is subject to. As in Ortega et al. (2011) and Sun and Tsang (2017), suppliers in rental markets transform property housing into rental services by means of a simple linear technology.

A novel and distinctive feature of this chapter is the modelling of real estate funds. As in reality, they offer rental housing services, although they do it under different conditions than patient households; Their capacity to carry out large-scale purchases of houses with a similar feature permits them to set prices in such segment of rental housing markets. Even though, there is no DSGE model that incorporates such a specific type of agent (to the best of my knowledge) its modelling, nevertheless, has some similarities to other contributions in the literature. As in Basak and Pavlova (2013), institutional investors coexist with retail investors (in this case, patient households) and both trade the same asset class (in this model, rental housing). Similar to the modelling of banks in Gerali et al. (2010), real estate funds can be decomposed into two branches (i.e., fund managers and retailers) and supply their services under monopolistic competition.

Third, the chapter also relates to recent work that adopts a DSGE perspective to study and quantify the effects of macroprudential policies aimed at mitigating and preventing macro-financial imbalances stemming from housing market dynamics. Among others, Kannan et al. (2012), Gelain et al. (2013), Lambertini et al. (2013), Quint and Rabanal (2014), Mendicino and Punzi (2014) and Alpanda and Zubairy (2017). While none of these models incorporate rental markets or institutional investors, they all have nominal rigidities to study the interactions between monetary and macroprudential policies. In order to focus the modelling on features of housing markets, clearly identify the transmission mechanism through which dynamic LTV ratios affecting fund managers operate, and keep the complexity of the rest of the model to a minimum, I omit the monetary block.

4.3 The Model

Consider an economy populated by households, real estate funds and producing firms who interact in a real, closed, decentralized and time-discrete economy. As in Alpanda and Zubairy (2016), there are three types of households. Patient households (savers) work, consume, rent the physical capital they own, accumulate housing for owner-occupied and rental purposes and supply funds to impatient households and real estate funds. Impatient households (borrowers) work, consume, accumulate housing for owner-occupied reasons and borrow funds from savers.[6] Renter households (renters) work, consume and demand rental housing services. In the supply side, housing producing firms generate new (property) housing by using capital and labor whereas non-housing producing firms produce final consumption and business investment goods by using capital, commercial real estate and labor.[7] The real estate fund industry is populated by two types of agents. For each fund, there is a manager who acquires new housing and issues debt in order to produce rental housing services and a retailer who obtains such services and differentiates them at no cost in order to rent them applying a mark-up. For each type of agent, there is a continuum of individuals in the $[0, 1]$ interval.

Some other assumptions have been made for empirical purposes and to improve the fit of the model to the data. Among others, household GHH preferences; the presence of complementarities between the consumption of durable and non-durable goods; an endogenous capital utilization rate; and a Dixit-Stiglitz aggregator to allow for intratemporal imperfect substitutability between the two types of individual labor supply (i.e., labor supply to the consumption sector and to the housing sector), on the one hand, and between homogeneous

[6] The relationship between the discount factors of savers and borrowers is such that there are financial flows in equilibrium and the borrowing limits are binding in a neighborhood of the steady state (see Iacoviello 2005).

[7] 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).

rental housing services (provided by savers) and slightly differentiated rental housing services (provided by REIFs), on the other hand.

4.3.1 Households: Savers and Borrowers

The representative patient (and impatient) household seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^{t} \left[\frac{1}{1-\sigma_h} \quad Z_{\varkappa,t} - \frac{\widetilde{N}_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} \right], \tag{4.1}$$

where $x = s, b$ denotes the type of household the problem refers to (i.e., saver or borrower), $\beta_{\varkappa} \in (0,1)$ is the household's discount factor ($\beta_s < \beta_b$), σ_h stands for the risk parameter of the household and $\phi > 0$ refers to the inverse of the Frisch elasticity. The representative saver (or borrower) consumes a basket of durable and non-durable final goods:

$$Z_{\varkappa,t} = C_{\varkappa,t}^{(1-\gamma_t)} H_{\varkappa,t}^{p\ \gamma_t}, \tag{4.2}$$

where $C_{\varkappa,t}$ denotes consumption of the final non-durable good, $H_{\varkappa,t}^{p}$ refers to the services from the stock of owner-occupied housing (durable good) and $\gamma_t = \gamma \varepsilon_t^{\gamma}$ is the possibly time-varying share of $H_{\varkappa,t}$ in consumption, where $\gamma \in [0,1]$ and ε_t^{γ} captures housing preference shocks.[8] $\widetilde{N}_{\varkappa,t}$ is a composite index of labor supply to the consumption sector, $N_{\varkappa,t}^{c}$, and the housing sector, $N_{\varkappa,t}^{h}$.

$$\widetilde{N}_{\varkappa,t} = \left[\omega_n^{1/\varepsilon} \left(N_{\varkappa,t}^{c} \right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N_{\varkappa,t}^{h} \right)^{(1+\varepsilon)/\varepsilon} \right]^{\varepsilon/(\varepsilon+1)}, \tag{4.3}$$

where $\omega_n \in (0,1)$ is a weight parameter and ε is the elasticity of substitution between types of labor supply.[9]

[8] Note that $Z_{\varkappa,t} = C_{\varkappa,t}^{(1-\gamma_t)} H_{\varkappa,t}^{p\ \gamma_t}$ is just a particular case of a more general specification of the final consumption index, $Z_{\varkappa,t} = \left[(1-\gamma_t)^{1/\nu} (C_{\varkappa,t})^{(\nu-1)/\nu} + \gamma_t^{1/\nu} \left(H_{\varkappa,t}^{p} \right)^{(\nu-1)/\nu} \right]^{\nu/(\nu-1)}$, for which the elasticity of substitution between non-durables and durables (i.e., housing), $\nu = 1$.Such specification allows for the presence of empirically relevant complementarities between the two types of consumption. For the various empirical facts this specification of the consumption basket permits to account for, see among others, Ogaki and Reinhart (1998) and Monacelli (2008), with the latter also assuming that impatient households' borrowing limit is tied to the expected future value of the durable stock.

[9] Households are assumed to have GHH preferences (see Greenwood et al. 1988). This type of preferences - under which wealth effects on labor supply are arbitrarily close to zero - has been extensively used in the business cycle literature as a useful device to match several empirical regularities. As in this chapter, 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).

Patient households (savers)

In the case of savers, the maximization of (4.1) is subject to the sequence of budget constraints:

$$
\begin{aligned}
C_{s,t} + B_t + \sum_{i=c,h} \left[I_t^i + \Phi_i(K_{s,t}^i) \right] + q_t \sum_{j=p,r} \left[H_{s,t}^j - (1-\delta_h) H_{s,t-1}^j \right] \\
= \; P_{s,t} X_{s,t} + R_{b,t-1} B_{t-1} + \sum_{i=c,h} \left[W_t^i N_{s,t}^i + r_t^i u_t^i K_{s,t-1}^i \right] + \Pi_t,
\end{aligned}
$$

where $i = c, h$ refers to the corresponding production sector (final consumption or housing) and $j = p, r$ denotes the final use of housing (owner-occupied or rental). B_t is lending at time t and $R_{b,t}$ is the gross interest rate on lending. I_t^i and K_t^i stand for net investment in physical capital and the stock of capital, respectively. The standard law of motion for capital applies,

$$
K_{s,t}^i = (1 - \delta_t^i) K_{s,t-1}^i + I_t^i, \tag{4.4}
$$

where δ_t^i is the depreciation rate of physical capital rented by firms producing in sector i and δ_t^i is an increasing and convex function of the rate of capital utilization, u_t^i :[10]

$$
\delta_t^i (u_t) = \delta_0^i + \delta_1^i (u_t^i - 1)^2 + \frac{\delta_2^i}{2} (u_t^i - 1)^2. \tag{4.5}
$$

Housing depreciates at rate δ_h. $H_{s,t}^r$ is the part of housing accumulated by the representative saver to produce rental housing services, $X_{s,t}$, according to the following technology:

$$
X_{s,t} = A_{s,t} H_{s,t-1}^r, \tag{4.6}
$$

where $A_{s,t}$ captures productivity shocks in the competitive segment of the rental housing market. $P_{s,t}$ is the unitary price (or rent) of homogeneous rental housing services offered to renters (under competitive conditions), W_t^i is the wage rate prevailing in production sector i, r_t^i is the corresponding rental rate on physical capital and Π_t denotes net profits from institutional investors.

[10] This specification of the depreciation rate of physical capital has become standard in the business cycle literature. For the empirical relevance of the assumption see, among others, Taubman and Wilkinson (1970) and Baxter and Farr (2005). Other DSGE models in which such specification of the capital depreciation rate is assumed include, among others, Gerali et al. (2010) and Schmitt-Grohé and Uribe (2012).

Impatient households (borrowers)

In the case of borrowers, the maximization of (4.1) is restricted by a sequence of budget constraints and a borrowing limit,

$$C_{b,t} + R_{b,t-1}B_{b,t-1} + q_t \left[H^p_{b,t} - (1-\delta_h)H^p_{b,t-1}\right] = B_{b,t} + W^c_t N^c_{bt} + W^h_t N^h_{b,t}, \tag{4.7}$$

$$B_{b,t} \leq m_b E_t \left[\frac{q_{t+1}}{R_{bt}} H^p_{b,t}\right]. \tag{4.8}$$

According to (4.7), each period, the representative impatient household devotes her resources in terms of wage earnings and borrowings to consume durable and non-durable goods as well as to repay her debt. Expression (4.8) stipulates that constrained households cannot borrow more than a fraction $m_b \in [0,1]$ of the expected value of their owner-occupied housing stock.

4.3.2 Renter Households

Renters seek to maximize:

$$U(Z_{r,t}, \widetilde{N}_{r,t}) = \log Z_{r,t} - \frac{\widetilde{N}^{1+\phi}_{r,t}}{(1+\phi)}, \tag{4.9}$$

where $\widetilde{N}_{r,t}$ is a composite index of labor supply analogous to the one in expression (**??**) and $Z_{\varkappa,t}$ is a Dixit-Stiglitz aggregator of final (non-durable) consumption goods $C_{r,t}$ and rental housing services $\widetilde{X}_{r,t}$. Formally,

$$\widetilde{N}_{r,t} = \left[\omega_n^{1/\varepsilon}\left(N^c_{r,t}\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon}\left(N^h_{r,t}\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(1+\varepsilon)}, \tag{4.10}$$

$$Z_{r,t} = C^{(1-\gamma_t)}_{r,t} \widetilde{X}^{\gamma_t}_{r,t}, \tag{4.11}$$

where $\widetilde{X}_{r,t}$ is a composite of homogeneous rental housing services provided by savers under perfect competition, $X_{sr,t}$, and slightly differentiated rental housing services provided by institutional investors under monopolistic competition, $x_{fr,t}$.

$$\widetilde{X}_{r,t} = \left[\omega_x^{1/\eta_r}\left(x_{fr,t}\right)^{(\eta_r-1)/\eta_r} + (1-\omega_x)^{1/\eta_r}\left(X_{sr,t}\right)^{(\eta_r-1)/\eta_r}\right]^{\eta_r/(\eta_r-1)}, \tag{4.12}$$

where $\omega_x \in (0,1)$ is a weight parameter, $\eta_r \geqslant 0$ is the elasticity of substitution between types of rental housing services and $x_{fr,t}$ is a composite index that aggregates a continuum of rental housing varieties represented by the interval $[0,1]$,

$$x_{fr,t} = \int_0^1 \left[x_{fr,t}(i)^{(\eta_r - 1)/\eta_r} \, di \right]^{(\eta_r-1)/\eta_r}, \tag{4.13}$$

with $x_{fr,t}(i)$ representing the quantity of variety i consumed by the representative renter in period t.[11] Although the assumption of preference for rental housing varieties at the micro level may seem unrealistic, this is just a modeling device to capture the fact that, at the aggregate level, there is a preference for variety in the rental housing market.[12]

Maximization of (4.9) is subject to a budget constraint given by

$$C_{r,t} + P_{s,t} X_{sr,t} + \int_0^1 p_{fr,t}(i) \, x_{fr,t}(i) \, di = W_t^c N_{r,t}^c + W_t^h N_{r,t}^h, \tag{4.14}$$

where $p_{fr,t}(i)$ stands for the unitary price of variety i. Total resources in terms of wage earnings obtained by renters in period t are devoted to consume non-durable goods and rental housing services within the same period. That is, the optimization problem of the representative renter household is static.[13]

The inverse demand functions for the homogeneous rental housing services and for variety i can be derived from the first order conditions of the problem

$$P_{s,t} = \frac{\gamma_t}{\widetilde{X}_{r,t} \lambda_{r,t}} \left[(1 - \omega_x) \frac{\widetilde{X}_{r,t}}{X_{sr,t}} \right]^{1/\eta_r}, \tag{4.15}$$

$$p_{fr,t}(i) = \frac{\gamma_t}{\widetilde{X}_{r,t} \lambda_{r,t}} \left[\omega_x \frac{\widetilde{X}_{r,t}}{x_{fr,t}(i)} \right]^{1/\eta_r}. \tag{4.16}$$

4.3.3 Firms

Non-housing producing firms

The representative non-housing producing firm chooses the demand schedules for labor $N_{c,t}$, physical capital $K_{c,t}$ rental housing variety supplied by real estate fund j, $x_{fc,t}(j)$, and homogeneous rental housing services provided by savers $X_{sc,t}$ that maximize

[11] Note that, for the shake of simplicity, I have assumed that the elasticity of substitution between rental housing services provided by savers and those provided by institutional investors, η_r, is constant and identical to the elasticity of substitution across varieties.

[12] Product differentiation in rental housing markets can be interpreted from very different perspectives (e.g., neighbourhood and location, number of rooms, services included in the rent, type of housing and building, furniture, etc).

[13] In this model, renter households play the role of "hand-to-mouth" as they fully consume their disposable income every period.

$$Y_{c,t} - W_t^c N_{,t}^c - r_{k,t}^c K_{t-1}^c - \int_0^1 p_{fc,t}(j)\, x_{fc,t}(j)\, dj - P_{s,t} X_{sc,t}. \tag{4.17}$$

The homogeneous final good is produced by using a Cobb-Douglas technology that combines labor, physical capital and rental housing services as follows

$$Y_{c,t} = A_{c,t}(u_t^c K_{t-1}^c)^{\alpha} \widetilde{X}_{c,t}^{\nu} N_t^{c(1-\alpha-\nu)}, \tag{4.18}$$

where $A_{c,t}$ captures technology shocks in the non-housing production sector, α and υ are the weights of physical capital and commercial real estate in non-housing production, respectively, and $\widetilde{X}_{c,t}$ is a composite of homogeneous rental housing services provided by savers under perfect competition, $X_{sc,t}$, and slightly differentiated rental housing services provided by institutional investors under monopolistic competition, $x_{fc,t}$.

$$\widetilde{X}_{c,t} = \left[\omega_x^{1/\eta_c} (x_{fc,t})^{(\eta_c-1)/\eta_c} + (1-\omega_x)^{1/\eta_c} (X_{sc,t})^{(\eta_c-1)/\eta_c}\right]^{\eta_c/(\eta_c-1)}, \tag{4.19}$$

where $\omega_x \in (0,1)$ is a weight parameter, $\eta_c \geqslant 0$ is the elasticity of substitution between types of rental housing services and $x_{fc,t}$ is a composite index that aggregates a continuum of rental housing varieties represented by the interval $[0,1]$

$$x_{fc,t} = \int_0^1 \left[x_{fc,t}(j)^{(\eta_c-1)/\eta_c} dj\right]^{(\eta_c-1)/\eta_c}, \tag{4.20}$$

with $x_{fc,t}(j)$ representing the quantity of variety j consumed by the representative non-housing producing firm in period t

Housig producing firms

Similarly, the representative housing producing firm chooses the demand schedules for labor N_t^h and physical capital K_t^h that maximize:

$$IH_t - W_t^h N_{,t}^h(j) - r_{k,t}^h K_{t-1}^h, \tag{4.21}$$

where IH_t stands for net investment in real estate (or total construction) in period t and is produced by using a Cobb-Douglas technology that combines labor and physical capital as follows

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\theta} N_t^{h(1-\theta)} \tag{4.22}$$

where $A_{h,t}$ captures technology shocks in the housing production sector and θ is the share of physical capital in housing production. The standard law of motion for capital accumulation applies to the stock of real estate, H_t. Formally,

$$H_t = (1-\delta_h)H_{t-1} + IH_t. \tag{4.23}$$

with δ_h being the depreciation rate of housing.

4.3.4 Real Estate Funds

In a context in which renter households and non-housing producing firms have a preference for variety in the rental housing market, real estate funds play the key role of providing such agent types with slightly differentiated rental housing services under monopolistic competition. Fund managers accumulate housing and issue debt in order to produce rental housing services. Fund retailers obtain such services and differentiate them at no cost in order to rent them (to renter households and no housing producing firms) applying a mark-up. The aim of assuming that real estate fund managers operate in the rental housing market under monopolistic competition is twofold. First, from the demand side, renters exhibit a preference for variety at the aggregate level. Second, from the supply side, a real estate fund typically purchases a large amount of housing with a common characteristic (e.g., same neighborhood, similar type of housing, etc) that confers her the capacity to set prices in that specific segment of the market (i.e., the representative real estate fund has market power in the market of her own variety).

Fund managers

Let $\Pi_{f,t}$ be net profits, σ the elasticity of intertemporal substitution and $\Lambda_{0,t}^{f} = \beta_s \dfrac{\lambda_{s,t+1}}{\lambda_{s,t}}$ the stochastic discount factor of fund managers with $\lambda_{s,t}$ being the Lagrange multiplier on the budget constraint of the representative patient household. Then, the representative fund manager maximizes

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{f} \quad \frac{1}{\left(1-\frac{1}{\sigma}\right)} \Pi_{f,t}^{\left(1-\frac{1}{\sigma}\right)} \tag{4.24}$$

Subject to

$$\Pi_{f,t} + R_{b,t} B_{f,t-1} + q_t \left[H_{fr,t}^{r} + H_{fc,t}^{r} - (1-\delta_h)\left(H_{fr,t-1}^{r} + H_{fc,t-1}^{r}\right)\right] = B_{f,t} + P_{fr,t} X_{fr,t} + P_{fc,t} X_{fc,t}, \tag{4.25}$$

$$B_{f,t} \leq m_f E_t \left[\frac{q_{t+1}}{R_{b,t}} \left(H^r_{fr,t} + H^r_{fc,t} \right) \right], \tag{4.26}$$

$$X_{fr,t} = \overline{A}_{fr,t} H^r_{fr,t-1}, \tag{4.27}$$

$$X_{fc,t} = \overline{A}_{fc,t} H^r_{fc,t-1}, \tag{4.28}$$

where equations (4.25), (4.26), (4.27) and (4.28) refer to the sequence of cash flow restrictions, the borrowing limit and the corresponding technologies by which fund managers transform their stock of housing into rental housing services for renter households and final goods producing firms, respectively.

$H^r_{fr,t}$ and $H^r_{fc,t}$ stand for the quantities of housing accumulated by the representative fund manager to produce rental housing services for renter households, $X_{fr,t}$, and non-housing producing firms, $X_{fc,t}$, whereas $P_{fr,t}$ and $P_{fc,t}$ denote the corresponding market prices for rental housing services. $B_{f,t}$ is debt issued by the fund manager in period t and $m_b \in [0, 1]$ the fraction of the expected value of her housing stock that limits her borrowing capacity. $\overline{A}_{fr,t} = A_{fr} A_{f,t}$ and $\overline{A}_{fc,t} = A_{fc} A_{f,t}$ are dynamic productivity parameters; $A_{fr} > 0$ and $A_{fc} > 0$ measure the efficiency with which fund managers transform property housing into rental services whereas $A_{f,t}$ captures productivity shocks in the segment of the rental housing market operated by REIFs.

The following optimality conditions can be derived from the first order conditions of the problem:

$$\Pi_{f,t}^{-\frac{1}{\sigma}} \left[q_t - m_f E_t \left(\frac{q_{t+1}}{R_{b,t}} \right) \right] = \Lambda^e_{0,t} E_t \left\{ \Pi_{f,t+1}^{-\frac{1}{\sigma}} \left[P_{fr,t+1} \overline{A}_{fr,t+1} q_{t+1} (1 - \delta_h - m_f) \right] \right\}, \tag{4.29}$$

$$\Pi_{f,t}^{-\frac{1}{\sigma}} \left[q_t - m_f E_t \left(\frac{q_{t+1}}{R_{b,t}} \right) \right] = \Lambda^e_{0,t} E_t \left\{ \Pi_{f,t+1}^{-\frac{1}{\sigma}} \left[P_{fc,t+1} \overline{A}_{fc,t+1} q_{t+1} (1 - \delta_h - m_f) \right] \right\}. \tag{4.30}$$

Fund retailers

Each retailer obtains wholesale rental housing services, $X_{fr,t}(i)$ and $X_{fc,t}(j)$, from the wholesale unit at prices $P_{fr,t}$ and $P_{fc,t}$, differentiate them at no cost and rent them to renter households and non-housing producing firms applying two different mark-ups. The problem of the representative fund retailer is to choose $\{p_{fr,t}(i), p_{fc,t}(j)\}$ that maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{f} \quad [p_{fr,t}(i)x_{fr,t}(i) + p_{fc,t}(j)x_{fc,t}(j) - P_{fr,t}X_{fr,t}(i) - P_{fc,t}X_{fc,t}(j)] \tag{4.31}$$

subject to the aggregate demand functions for rental housing varieties i and j

$$x_{fr,t}(i) = \left(\frac{p_{fr,t}(i)}{p_{fr,t}}\right)^{-\eta_r} x_{fr,t}, \tag{4.32}$$

$$x_{fc,t}(j) = \left(\frac{p_{fc,t}(j)}{p_{fc,t}}\right)^{-\eta_c} x_{fc,t}, \tag{4.33}$$

where $p_{fr,t}$ and $p_{fc,t}$ can be interpreted as rental housing price indices for renter households and non-housing producing firms, respectively.

$$p_{fr,t} = \left[\int_0^1 p_{fr,t}(i)^{(1-\eta_r)} \, di\right]^{1/(1-\eta_r)}, \tag{4.34}$$

$$p_{fc,t} = \left[\int_0^1 p_{fc,t}(j)^{(1-\eta_c)} \, dj\right]^{1/(1-\eta_c)}. \tag{4.35}$$

The first order conditions yield, after imposing a symmetric equilibrium

$$p_{fr,t} = \frac{\eta_r}{(\eta_r - 1)} P_{fr,t}, \tag{4.36}$$

$$p_{fc,t} = \frac{\eta_c}{(\eta_c - 1)} P_{fc,t}. \tag{4.37}$$

4.3.5 Aggregation and Market Clearing

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

$$Y_t = Y_{c,t} + q_t IH_t, \tag{4.38}$$

$$Y_t = C_{,t} + I_{c,t} + I_{h,t} + q_t IH_t + \Phi(K_{c,t}) + \Phi(K_{h,t}). \tag{4.39}$$

where expressions (4.38) and (4.39) refer to the GDP of the economy from the output and the expenditure approach perspectives, respectively, and $C_t = C_{s,t} + C_{b,t} + C_{r,t}$ denotes aggregate consumption. Similarly, the labor market, the physical capital markets,the credit market, the property housing market and the different segments of the rental housing services market all clear in equilibrium (see Appendix B for the full set of equilibrium conditions).

4.3.6 Macroprudential Policy

Consider three macroprudential policy scenarios alternative to the baseline case presented above. In each of them, the macroprudential authority has at hand - as an instrument - one or two of the following dynamic LTV ratios

$$m_{b,t} = \rho_b m_{b,t-1} + (1-\rho_b)m_b + (1-\rho_b)\, m_{bx}(\frac{x_t}{x} - 1), \tag{4.40}$$

$$m_{f,t} = \rho_f m_{f,t-1} + (1-\rho_f)m_f + \big(1-\rho_f\big)\, m_{fx}(\frac{x_t}{x} - 1), \tag{4.41}$$

where ρ_b and ρ_f are the corresponding autorregresive parameters, m_b and m_f are the static LTV limits (recall expressions 4.8 and 4.26), m_{bx} and m_{fx} are the macroprudential response parameters and x_t is a macroeconomic indicator of the choice of the regulator, while x corresponds to its steady state level.

The transmission mechanism

As the macroprudential rule that has not yet been explored in the literature refers to equation 4.41), I investigate its workings and the main transmission channel through which it operates. In doing so, I assume that the economy initially is in the steady state, where optimality conditions (4.29) and (4.30) read:

$$P_{fr} = \frac{q\left[1 - \Lambda^e(1-\delta_h) - m_f\left(\dfrac{1}{R_b} - \Lambda^e\right)\right]}{\Lambda^e A_{fr}}, \tag{4.42}$$

$$P_{fc} = \frac{q\left[1 - \Lambda^e(1-\delta_h) - m_f\left(\dfrac{1}{R_b} - \Lambda^e\right)\right]}{\Lambda^e A_{fc}}. \tag{4.43}$$

Expressions (4.42) and (4.43) stipulate that the sign of $\dfrac{\partial P_{fr}}{\partial m_f}$ and $\dfrac{\partial P_{fc}}{\partial m_f}$ (and, ultimately, the impact a tightening in $m_{f,t}$ has on imperfectly competitive prices $p_{fr,t}$ and $p_{fc,t}$), after a particular shock has hit the economy, depends on the sign of the term $\left(\dfrac{1}{R_b} - \Lambda^e\right)$. In many cases, a positive shock pushes lending rates downwards (i.e., $R_{b,t} < R_b$), implying $\left(\dfrac{1}{R_b} - \Lambda^e\right) > 0$ and, consequently, $\dfrac{\partial P_{fr}}{\partial m_f} < 0$ and $\dfrac{\partial P_{fc}}{\partial m_f} < 0$. That is, tightening LTV ratios in the face of certain positive exogenous shocks restricts the borrowing capacity of fund managers and, thus, their activity. Fund managers then find optimal to demand less housing, which favours property prices to evolve in a smoother fashion. The corresponding decline in supplied differentiated rental housing services pushes $p_{fr,t}$ and $p_{fc,t}$ upwards. As a result of this, the share of savers in the rental housing market increases, thereby exerting a downward pressure on the competitive rental housing price, $P_{s,t}$. The bottom line is that, under plausible conditions, countercyclical LTV ratios affecting the borrowing capacity of REIFs smooth lending, property prices and reference (i.e., competitive) rental housing prices over the cycle.

4.4 Quantitative Analysis

The main goal of this section is to assess the potential of dynamic LTV limits to smooth lending and housing prices over the cycle. In order to do so, I assume that the prudential authority seeks to minimize an ad-hoc loss function specified as the weighted asymptotic variance (or linear combination of variances) of a macroeconomic indicator (or set of indicators) of the choice of the regulator.[14]

4.4.1 Calibration

I calibrate the model to quarterly euro area data for the period 2002:I-2018:II in three steps. First, several parameters are set following convention (table 4.1A). 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, the elasticity of substitution between labor types and the elasticity of substitution between rental housing varieties are fixed to standard values of 2, 1 and 2, respectively. Loan-to-value ratios on residential and commercial real estate are set equal to 0.7 and 0.6, respectively. The former is based on data of the big four euro area economies and coincides with the value presented in Gerali et al. (2010), and Quint and Rabanal

[14] Importantly, this exercise should not be interpreted as an attempt to adopt a normative approach and replace a hypothetical welfare analysis. Instead, the goal is to evaluate the effectiveness of countercyclical LTV limits in smoothing aggregates whose developments are closely monitored by macroprudential authorities due to the fact that they incorporate information on the potential build up of macro-financial imbalances (e.g., the credit-to-GDP gap and property prices). A welfare analysis is beyond the scope of this paper and the proposed set up may not be the most adequate one for carrying out such exercise as it would require to make very strong value judgements that could be easily rejected (e.g., to select a criterion for aggregating individual preferences in a context in which the objective function specified for the case of savers and borrowers differs from that of renters due to the fact that the optimization problem faced by the former is dynamic and the one faced by the latter is static).

(2014), among many others. The latter coincides with the maximum LTV limit the EU regulation on prudential requirements for credit institutions and investment firms imposes for the case of commercial mortgages.[15] The parameter values of the dynamic depreciation rates of physical capital and that of the real estate's share in non-housing production, υ, are taken from Iacoviello and Neri (2010), Gerali et al. (2010) and Iacoviello (2015).

Second, another group of parameters is calibrated by using steady state targets (see tables 4.1B and 4.2A). The patient households' discount factor, $\beta_s = 0.995$, is chosen such that the annual interest rate equals 2%. The impatient households' discount factor is set to 0.975, so as to match a household loans-to-GDP ratio of 2.14. The housing weight parameter of the households' consumption aggregator, γ, is fixed to a value of 0.168 to match an aggregate consumption-to-GDP ratio of 0.76. The physical capital's share in non-housing and housing production, α and θ, are set to 0.144 and 0.025 to match an aggregate investment-to-GDP ratio of 0.212 and a housing investment-to-GDP ratio of 0.118, respectively. The weight parameter of hours worked in the non-housing production sector that enters the housholds' labor supply aggregator is set to 0.51 to match a housing wealth-to-GDP ratio of 2.802. The weight parameter of real estate funds' rental housing in rental aggregators is fixed to a value of 0.445 to match an institutional investors' real estate-to-total housing ratio of approximately 0.05.[16] The depreciation rate of real estate is set to 0.010 to match a rental housing-to-total housing ratio of 0.327.

Third, the size of shocks and the physical capital adjustment cost parameter are calibrated to improve the fit of the model to the data in terms of relative volatilities (see tables 4.1C and 4.2B). The capital adjustment cost parameter ϕ_k is set to target a relative standard deviation of total lending of 6.47%. I have matched the second moments of key macroeconomic aggregates, including housing investment and property prices, by calibrating the size of the various productivity and housing preference shocks. As in other references

[15] Note that uncertainty surrounding the empirical value of parameter m_f is high, among other reasons because a significant fraction of total credit flowing to REIFs is not being provided by the banking sector. Moreover, in this set up m_f crucially determines the debt-to-assets ratio of REIFs, whose empirical value is also uncertain, among other reasons, because investment funds often lever up synthetically through the use of derivatives (for which data is not readily available). Consequently, m_f is one of the parameters for which the sensitivity of the main results of the chapter is checked in section 4.5.

[16] The estimate of the numerator of this ratio is based on the balance sheet's information of real estate funds whose main geographical focus is the euro area as well as on estimates of the share of REIFs in rental markets provided by various property consulting firms. However, this estimate should be taken cautiously as there is still a lack of full transparency regarding all transactions and balance sheets of REIFs. The ESRB has already recommended to close real estate data gaps related to housing investors: https://www.esrb.europa.eu/pub/pdf/recommendations/esrb.recommendation190819_ESRB_2019-3~6690e1fbd3.en.pdf). For this reason, one of the robustness checks presented in section 5 consists in evaluating how results of the quantitative analysis change as the share of REIFs in rental markets vary, by exploiting the fact that changes in ω_x lead to variations in the institutional investors' housing-to-total housing ratio without significantly affecting the rest of the calibration targets.

of the macro-finance literature (see, e.g., Clerc et al. 2015 and Mendicino et al. 2018), the autoregressive coefficients in the AR(1) processes followed by all shocks are set equal to 0.9. With regards to the policy block, I follow Lambertini et al. (2013) and fix ρ_b and ρ_f to a value of 0.5.[17]

4.4.2 Optimized LTV Policy Rules

With the aim of evaluating the effectiveness of dynamic LTV limits in smoothing the credit and the housing cycle in this environment, I assume the macroprudential authority solves the following problem under full commitment

$$\arg\min_{\Theta} L^{mp} = \omega_z \sigma_z^2 \qquad \omega_z > 0, \tag{4.44}$$

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 the choice of the regulator (i.e., z_t).[18] Based on the literature and without loss of generality, the exercise assumes that $\omega_z = 1$ and $x_t = Y_t$ (see, e.g., Angelini et al. 2014 and Muñoz 2020).

I consider three macroprudential policy scenarios alternative to the baseline case presented in section 4.3, each of them associated to one of the three eligible macroprudential parameter vectors $\Theta \equiv \{m_{bx}; m_{fx}; (m_{bx}, m_{fx})\}$. In order to identify the optimized LTV rules within the classes (4.40) and (4.41) that solve (4.44) for the three considered policy scenarios, it has been searched over the following grids of parameter values: $m_{bx}\,\{(-9) - 0\}$ and $m_{fx}\,\{(-100) - 0\}$. Based on the recent literature on optimized LTV ratios, I have restricted the grids of values to those related to non-procyclical LTV policy rules (i.e., $m_{bx} \leq 0$ and $m_{fx} \leq 0$). While I follow Lambertini et al. (2013) to set the grid of values for m_{bx}, I select a wider range of values for m_{fx} as this policy parameter has not been explored in the recent literature.

Table 4.3 reports the optimized policy parameters related to the solution to problem (4.44) and the corresponding percentage change in macroprudential losses with respect to the baseline scenario. The exercise is carried out for four different arguments of the loss function, $z \equiv \{B/Y; B; P_s; q\}$ (i.e., the credit-to-output ratio, aggregate lending, rental housing prices in the perfectly competitive segment, and property housing prices), and for

[17] 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 C.

[18] In a more general set up σ_z^2 could represent a linear combination of variances of indicators of the choice of the public authority.

the three alternative policy scenarios (see the main results for the solution to problem (4.44) with respect to m_{bx}, m_{fx} and $\{m_{bx}, m_{fx}\}$ in parts (i), (ii) and (iii) of table 4.3, respectively).[19]

The main findings can be summarized as follows. The optimized rule within the class of policy rules (4.41) is more effective in smoothing property prices and the credit cycle (and the credit-to-output gap) than the optimized rule within the class (4.40), even though the stocks of housing and borrowing held by impatient households are notably larger than those held by fund managers. Moreover, if the aim of the prudential authority is to minimize the asymptotic variance of a credit gap or that of property prices, the best option is to solely have a dynamic LTV rule of the type (4.41) in place (i.e., policy rule (4.40) is basically redundant). The key reason underlying these results relates to the strong interconnectedness of REIFs' activity with the dynamics of key economic sectors, including the rental housing market as well as the housing and non-housing production sectors. Lastly, while both rules complement each other when it comes to smoothing perfectly competitive rental prices, the optimized rule within the class (4.41) is substantially more responsive than that of the type (4.40).

Figures 4.2 to 4.6 report the impulse responses of selected key aggregates to the exogenous shocks that are assumed to hit the economy. Without loss of generality, this exercise assumes that $z_t = P_{s,t}$ (i.e., perfectly competitive rental prices), the only case in which the optimized LTV policy rule on residential mortgages, $m^*_{bx,t}$, is more effective than the optimized LTV policy rule on commercial mortgages, $m^*_{fx,t}$.[20] Interestingly, even in this case, the optimized policy rule within the class (4.41) seems to be more effective in smoothing aggregates of the real economy - such as output, final consumption or housing investment (i.e., total construction) - than that of the type (4.40).

4.4.3 Competition Policy vs Dynamic LTV Limits

Table 4.4 informs about the mean effects and volatility effects of introducing: (i) perfect competition in the real estate funds' industry, and (ii) optimized (countercyclical) LTV limits. Column (A) reports the percentage changes in the stochastic means and standard deviations of selected aggregates under an alternative scenario of perfect competition (in the segment of the rental housing market operated by real estate funds) with respect to the baseline scenario. While most of the level effects are positive and significant, stabilization effects are negligible if not negative. The levels of housing and non-housing economic activity

[19] Problem (4.44) has been solved numerically by means of the *osr* (i.e., optimal simple rule) command in dynare (see Adjemian et al. 2011).

[20] Note that the term "effective" in this case refers to the capacity of the policy rule to minimize the asymptotic variance of the indicator under consideration (i.e., $z_t = P_{s,t}$), under full commitment.

increase but that comes at the cost of having to tolerate higher and more volatile levels of debt, property housing prices and competitive rental housing prices.[21]

Columns (B) and (C) report the same information, with the difference that the alternative scenarios differ from the baseline case in that the optimized LTV ratio that limits the borrowing capacity of real estate funds, $m^{*}_{fx,t}$, has been introduced. Not surprisingly, while level effects are comparatively modest in these cases, this type of macroprudential policies are effective in smoothing lending, housing prices and, ultimately, aggregates of the real economy. That is, in this case competition and macroprudential policies seem to complement one another.

Interestingly, columns (B) and (C) provide quantitative information on the transmission of dynamic LTV limit (on commercial mortgages) effects through rental housing markets. The countercyclical limit to their borrowing capacity obliges REIFs to restrict their rental housing supply, $X_f = X_{fr} + X_{fc}$. Consequently, their share in the rental housing industry, X_f/X, declines and rental prices charged by REIFs, P_{fr} and P_{fc} increase. A larger proportion of the market being operated under perfect competition means that overall rental housing supply, X, increases. The policy smooths competitive rental housing prices, which now apply to a larger proportion of the transactions held in rental markets.

4.5 Robustness Checks

This section investigates the robustness of the main results of the quantitative analysis (reported in table 4.3) to changes in key parameter values and in certain assumptions considered for empirical purposes. The exercise suggests that such results are remarkably robust across alternative specifications and calibrations (of key parameters) of the model.

4.5.1 Alternative Parameter Values

In the first part of this subsection, I further assume that $z_t = p_{s,t}$ to investigate how changes in key parameters (related to institutional investors and rental housing markets) affect the results presented in table 4.3. Table 4.5 reports the corresponding results after having solved problem (4.44) for different values of the elasticity of substitution between rental housing varieties (it has been assumed that $\eta_r = \eta_c = \eta$). Interestingly, the higher the degree of fund retailers' market power is (i.e., the closer the value of η is to unity), the more responsive optimized rules are and the more effective dynamic LTV ratios are in minimizing

[21] Andrés and Arce (2012) find that policies aimed at fostering competition in a banking sector that operates under monopolistic competition induce similar mean and volatility effects.

macroprudential losses.

Table 4.6 presents the same type of results after having solved problem (4.44) for different values of the fund manager's productivity parameter A_f (assuming that $A_f = A_{fr} = A_{fc}$). The more productive fund managers are in transforming property housing into rental housing services, the more effective countercyclical LTV ratios are and the less responsive the policy rule within the class (4.41) needs to be in order to minimize macroprudential losses.

Table 4.7 informs about the sensitivity of the same results to changes in the static LTV limit on commercial mortgages, m_f, and, hence, to changes in REIFs' leverage. While changes in m_f only modestly affect the effectiveness of countercyclical LTV policies; the larger the LTV limit on commercial mortgages is, the more responsive optimized countercyclical LTV rules on residential mortgages are and the less responsive optimized LTV rules within the class (4.41) are.

Table 4.8 checks the robustness of the main results to changes in the weight parameter of funds' rental services in the rental services aggregator of renters and non-housing producing firms, ω_x (i.e., expressions 4.12 and 4.19). The larger the proportion of total housing held by fund managers is (i.e., the higher the value of ω_x is), the more effective rules within the class (4.41) are and the less responsive they need to be in order to minimize macroprudential losses.[22]

Figures 4.7 to 4.10 report, for the alternative calibrations of the four parameters under consideration, the impulse-responses of key selected aggregates to all shocks under a hypothetical macroprudential scenario in which $m_{fx} = -10$. Not surprisingly, those calibrations under which countercyclical LTV rules on commercial mortgages are comparatively more effective in smoothing the financial cycle, are those under which the same type of policy rules are relatively more effective in taming the business cycle.

In the second part of this subsection, I consider $z \equiv \{B/Y; B; q\}$ to assess whether the main results presented in table 4.3 still hold under the above considered parameterizations for which optimized LTV policy rules on commercial mortgages are comparatively less effective (i.e., $\eta = 6$, $A_f = 0.5$, $m_f = 0.4$, and $\omega_x = 0.10$). Indeed, tables 4.9, 4.10, 4.11 and 4.12 make clear that, even in these cases the main findings of the quantitative analysis still apply. The optimized policy rule within the class (4.41) is more effective in stabilizing the credit gap, the credit-to-output gap, and property prices than the optimized rule within the class (4.40). Furthermore, if the objective of the prudential authority is to minimize property price and credit cycles, the best alternative is to fully rely on a countercyclical LTV policy

[22] Recall that changing the value of parameter ω_x affects the proportion of housing held by fund managers while leaving the rest of the steady state calibration targets roughly unchanged. A value of 0.10; 0.445, and 0.80 for parameter ω_x corresponds to a REIFs' housing-to-total housing ratio of roughly 1%, 5%, and 10%, respectively.

rule of the type (4.41) (i.e., policy rule (4.40) is redundant).

4.5.2 Alternative Assumptions

In this subsection I assume that $z \equiv \{B/Y; B; P_s; q\}$ to check the robustness of the results reported in table 4.3 to changes in selected key assumptions that were incorporated to the model due to empirical purposes and in order to improve the fit of the model to the data. Table 4.13 presents the corresponding results after having solved problem (4.44) for the case in which physical capital depreciation rates are exogenous and constant, rather than variable and dependant on the capital utilization rate (recall equation 4.5). Overall conclusions remain unchanged. However, under constant capital depreciation rates, optimized LTV policy rules on commercial mortgages are even more responsive and relatively more effective in taming the credit cycle and property prices whereas optimized LTV policy rules on residential mortgages are comparatively less effective.

Lastly, table 4.14 reports the main results of the quantitative analysis for the particular case in which preferences on consumption of durable goods and non-durable goods are separable. In particular, the objective function of patient and impatient households is specified as follows:

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t \left[\frac{1}{1-\sigma_h} \quad C_{\varkappa,t} - \frac{\widetilde{N}_{\varkappa,t}^{1+\phi}}{(1+\phi)} \Bigg)^{1-\sigma_h} + \gamma_t \log H_{\varkappa,t}^p \right]. \tag{4.45}$$

Similarly, the objective function of renter households now reads

$$U(C_{r,t}, \widetilde{X}_{r,t}, \widetilde{N}_{r,t}) = \log C_{r,t} + \gamma_t \log \widetilde{X}_{r,t} - \frac{\widetilde{N}_{r,t}^{1+\phi}}{(1+\phi)}, \tag{4.46}$$

The most important conclusion of this exercise is that, absent any degree of complementarity between the consumption of durables and non-durables, the main findings still apply but the overall effectiveness of countercyclical LTV policies in this set up becomes marginal. This result highlights the importance of allowing for the presence of complementarities between the two types of consumption in order for the transmission mechanism underscored in expressions (4.42) and (4.43) to operate and countercyclical LTV policies to be effective. If the consumption of durables and non-durables is complementary, a tightening of LTV ratios (in the face of positive shocks) that moderates the increase of lending and housing investment is going to call for a more moderate increase of final (non-durables) consumption and will, ultimately, be effective in smoothing the business cycle.

Beyond the importance of assuming that households consume a basket of durables and non-durables of the type (4.2) and (4.11) in order to account for a variety of empirical facts at the macroeconomic level (see, e.g., Ogaki and Reinhart 1998 and Monacelli 2008), allowing for a certain degree of complementarity between the consumption of durables and non-durables seems to be empirically relevant from a microeconomic perspective; Much of the (non-durable) consumption activities undertaken by household members in practice occur when they are inside their houses. That is, there are complementarities between the two types of consumption.

4.6 Conclusion

Based on recent empirical studies, the chapter incorporates real estate institutional investors and rental housing markets in a two-sector DSGE model populated by three types of households (savers, borrowers and renters). These investors leverage buy-to-rent housing investments and supply slightly differentiated rental housing services that permits them to apply a mark up. The quantitative analysis reveals several important conclusions. First, the activity of housing investment firms seems to have non-negligible macroeconomic effects and amplifies procyclicality. Second, dynamic LTV ratios that directly impact the borrowing's capacity of these investors are more effective in smoothing the property and the credit cycle than the already well investigated LTV limits affecting indebted households' decisions. Moreover, if the sole objective of the macroprudential authority is to tame the housing price and credit cycle, the best she can do is to have an LTV rule affecting REIFs' borrowing limits at hand (i.e., the LTV rule limiting households' borrowing capacity seems to be redundant). Such findings are impressively robust across key alternative specifications and calibrations of the model.

These findings may shed light on some of the potential avenues for strengthening the macroprudential policy framework for non-banks. There are at least two policy instruments that could be considered to tackle the issue of funds' leverage-induced procyclicality in practice and which are still not in place: (dynamic) limits on REIFs' leverage and countercyclical LTV limits on non-bank lending. Moreover, the quantitative analysis notes that such (quantity) regulation would allow for reference prices in rental housing markets to increase less abruptly during the boom, an issue that policymakers in several countries of the euro area have attempted to handle via price regulation (an alternative that could generate price distortions).

There are various dimensions along which the current analysis could be extended in order to have a better understanding of the workings, trade-offs and policy interactions of LTV limits affecting real estate funds' decisions. Among others, by assuming full heterogeneity of households or by including the monetary block in the model to assess the interactions between monetary and macroprudential policies in this environment. These results shed light on some of the potential avenues for strengthening the macroprudential policy framework for non-banks. There are at least two policy instruments that could be considered to tackle the issue of funds' leverage-induced procyclicality in practice: (dynamic) limits on REIFs' leverage and countercyclical LTV limits on non-bank lending. Importantly, the quantitative exercise notes that such (quantity) regulation would allow for reference prices in rental housing markets to increase less abruptly during the boom, an issue that policymakers in several countries of the euro area have attempted to handle via price regulation (an alternative that could generate price distortions).

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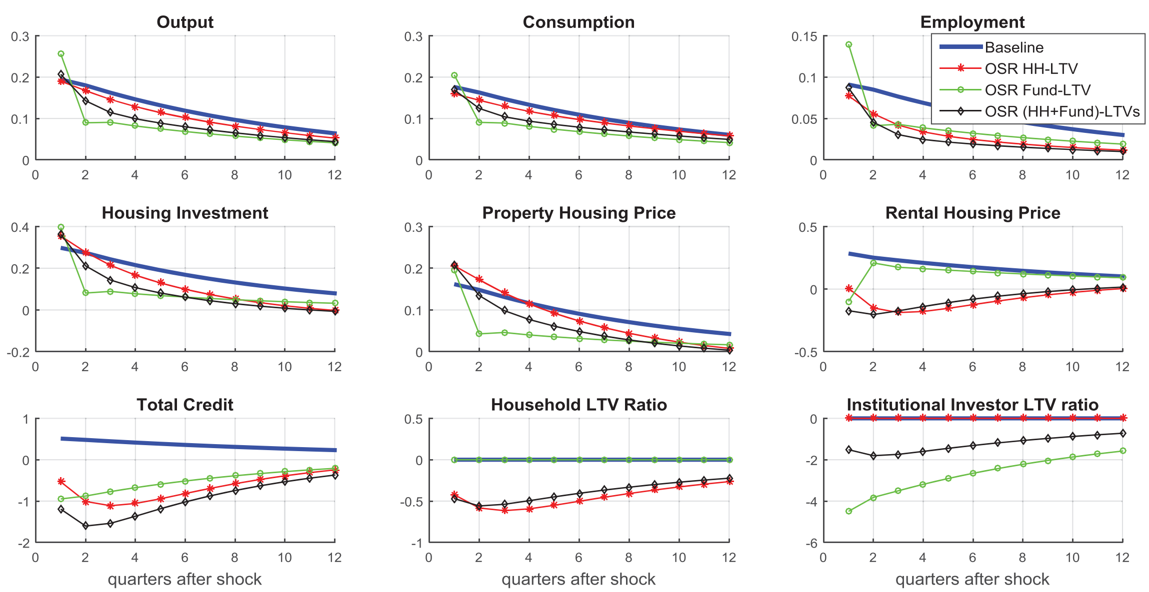
Figure 4.1:Real estate funds flows in the euro area

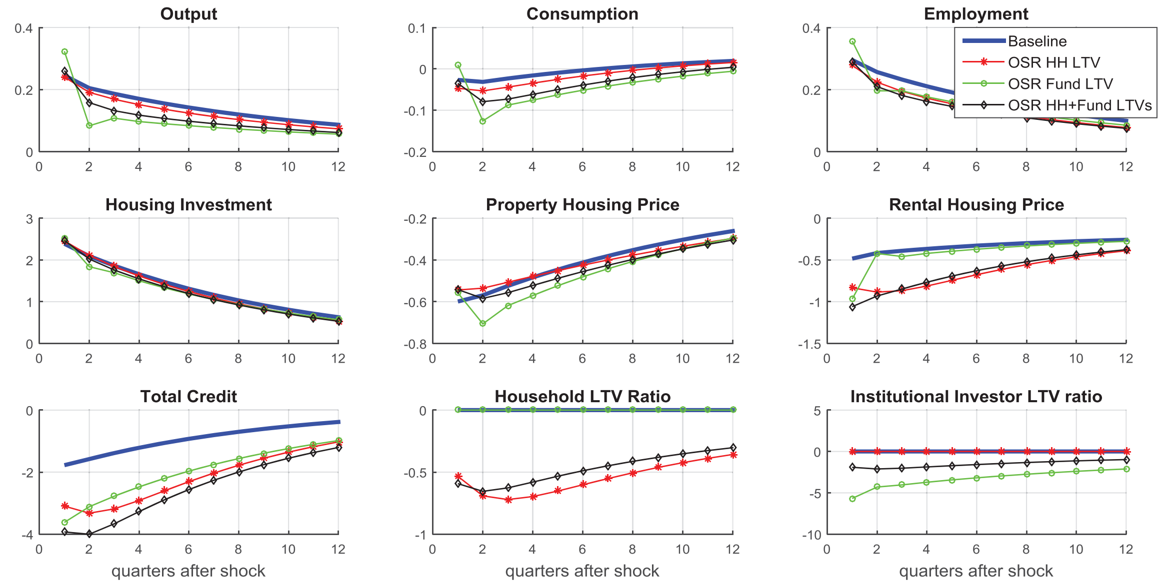
Note: This figure reports real estate funds flows (12-month flows) in the euro are both, in absolute terms and as a percentage of aggregate housing investment in the euro area. Time series are at quarterly frequency and have been plotted for the period 2012:III-2020:I. The figure is based on Battistini et al. (2018). Sources: ECB, Eurostat and own calculations.

Figure 4.2: Impulse-responses to a positive non-housing productivity shock



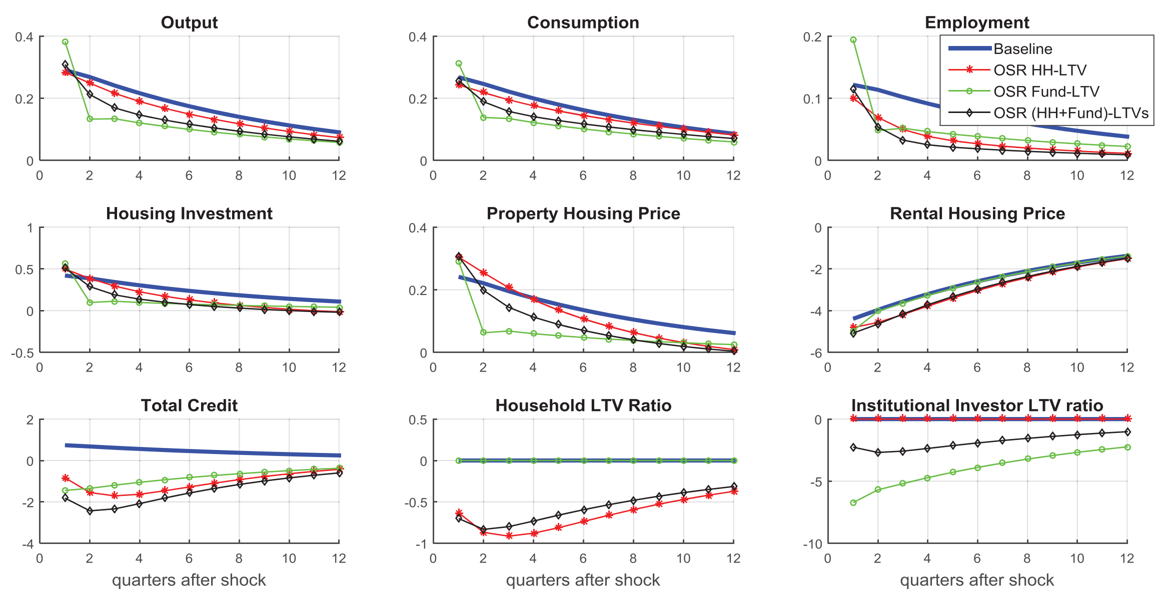
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to the optimized LTV ratio on residential mortgages (borrowers) scenario. The dotted line relates to the optimized LTV ratio on commercial mortgages (investors) scenario. The diamond line makes reference to the jointly-optimized LTV limits on residential and commercial mortgages scenario.

Figure 4.3: Impulse-responses to a positive housing productivity shock



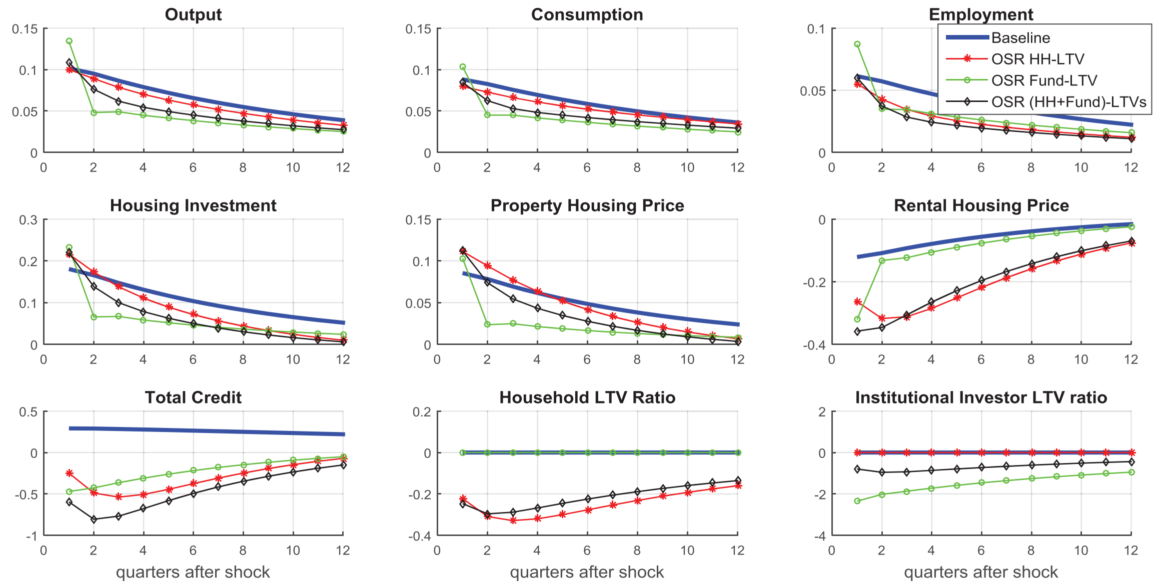
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to the optimized LTV ratio on residential mortgages (borrowers) scenario. The dotted line relates to the optimized LTV ratio on commercial mortgages (investors) scenario. The diamond line makes reference to the jointly-optimized LTV limits on residential and commercial mortgages scenario.

Figure 4.4: Impulse-responses to a positive household rental housing productivity shock



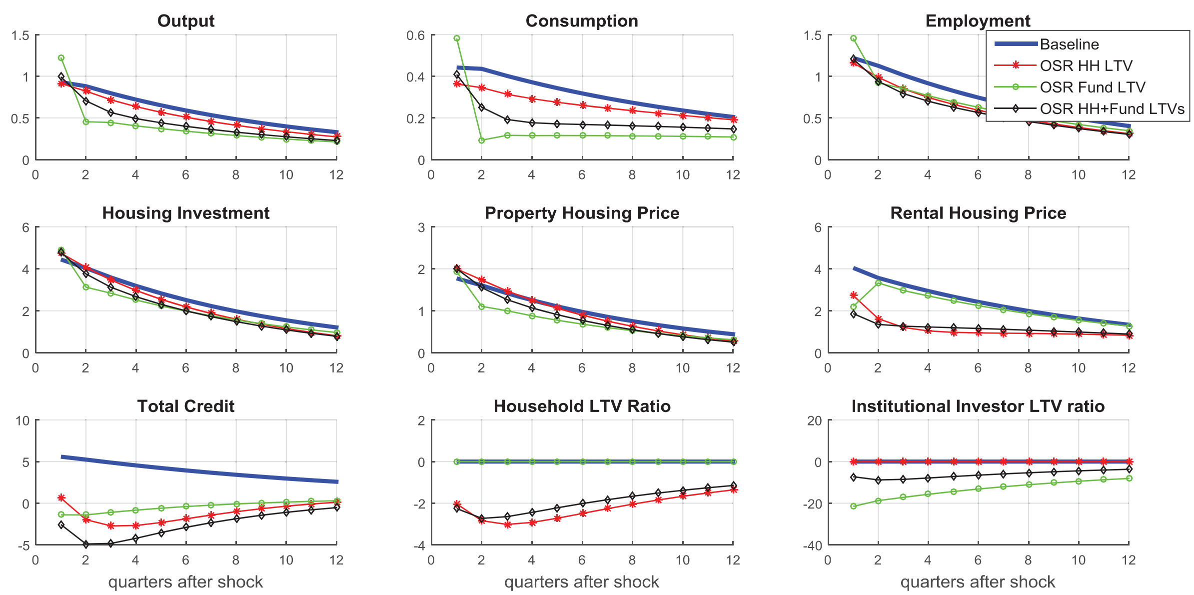
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to the optimized LTV ratio on residential mortgages (borrowers) scenario. The dotted line relates to the optimized LTV ratio on commercial mortgages (investors) scenario. The diamond line makes reference to the jointly-optimized LTV limits on residential and commercial mortgages scenario.

Figure 4.5: Impulse-responses to a positive fund rental housing productivity shock



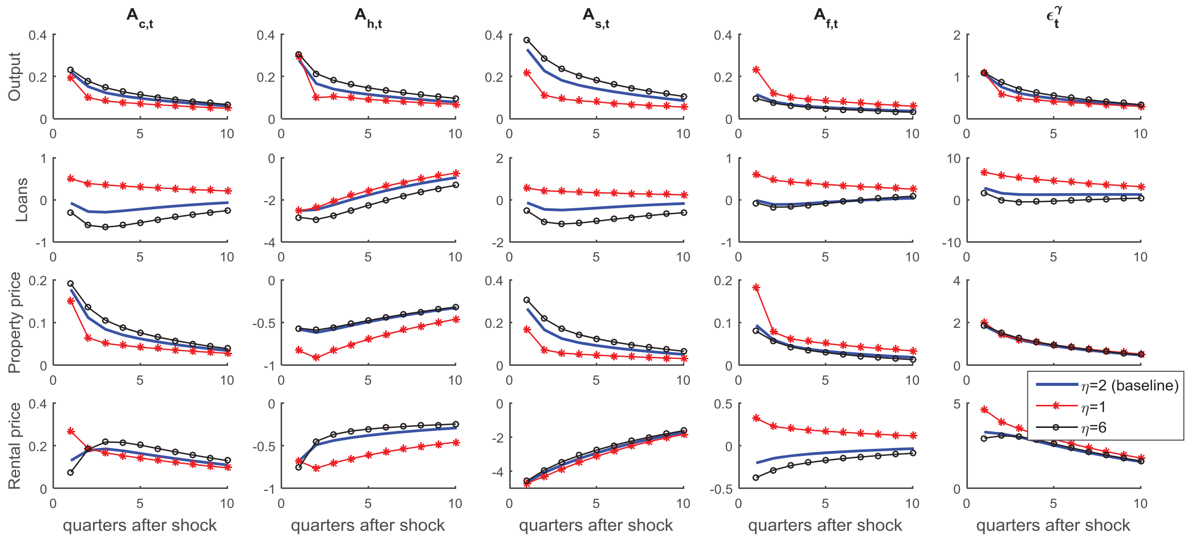
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to the optimized LTV ratio on residential mortgages (borrowers) scenario. The dotted line relates to the optimized LTV ratio on commercial mortgages (investors) scenario. The diamond line makes reference to the jointly-optimized LTV limits on residential and commercial mortgages scenario.

Figure 4.6: Impulse-responses to a positive preference shock



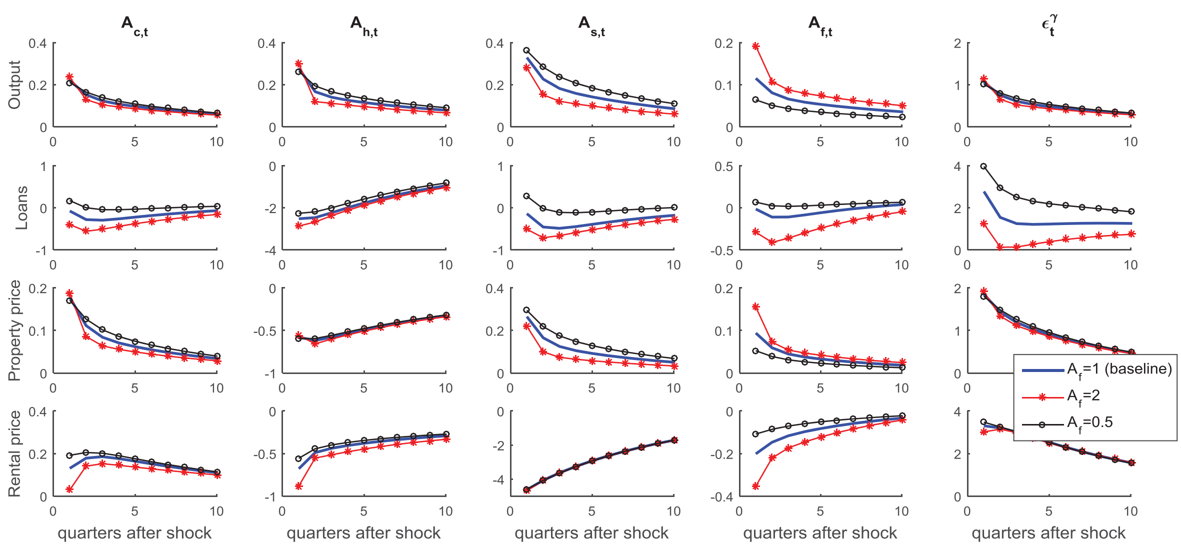
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario. The starred line corresponds to the optimized LTV ratio on residential mortgages (borrowers) scenario. The dotted line relates to the optimized LTV ratio on commercial mortgages (investors) scenario. The diamond line makes reference to the jointly-optimized LTV limits on residential and commercial mortgages scenario.

Figure 4.7: Robustness checks (η); Impulse-responses to all shocks



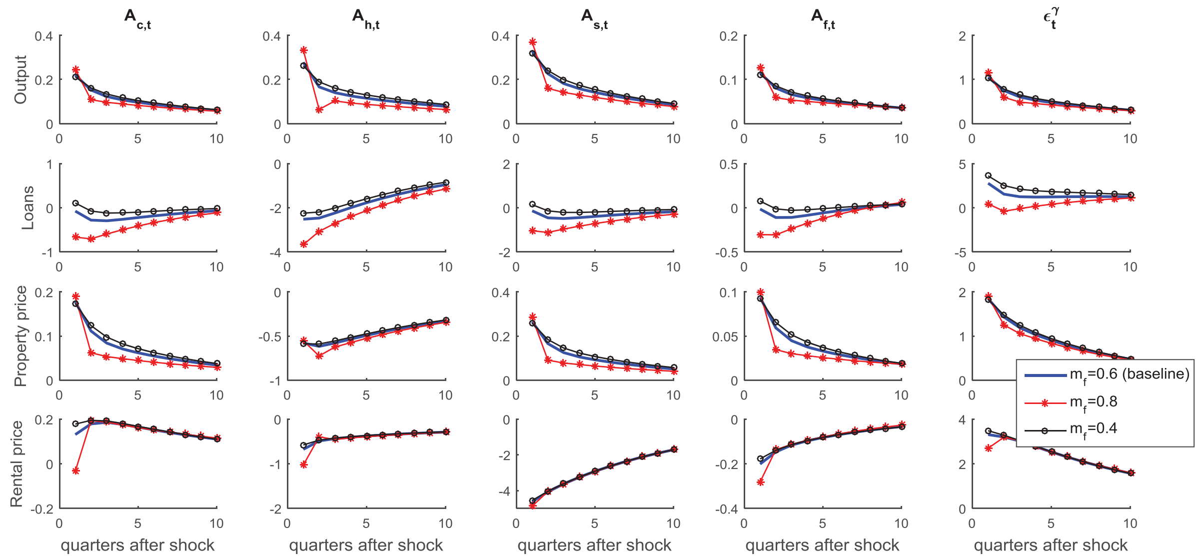
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to a scenario in which η=2 (i.e., as in the baseline scenario). The starred line corresponds to an alternative scenario in which η=1. The dotted line relates to an alternative scenario in which η=6. The macroprudential parameter of the LTV limit on commercial mortgages has been set to -10 in the three scenarios.

Figure 4.8: Robustness checks (A_{f}); Impulse-responses to all shocks



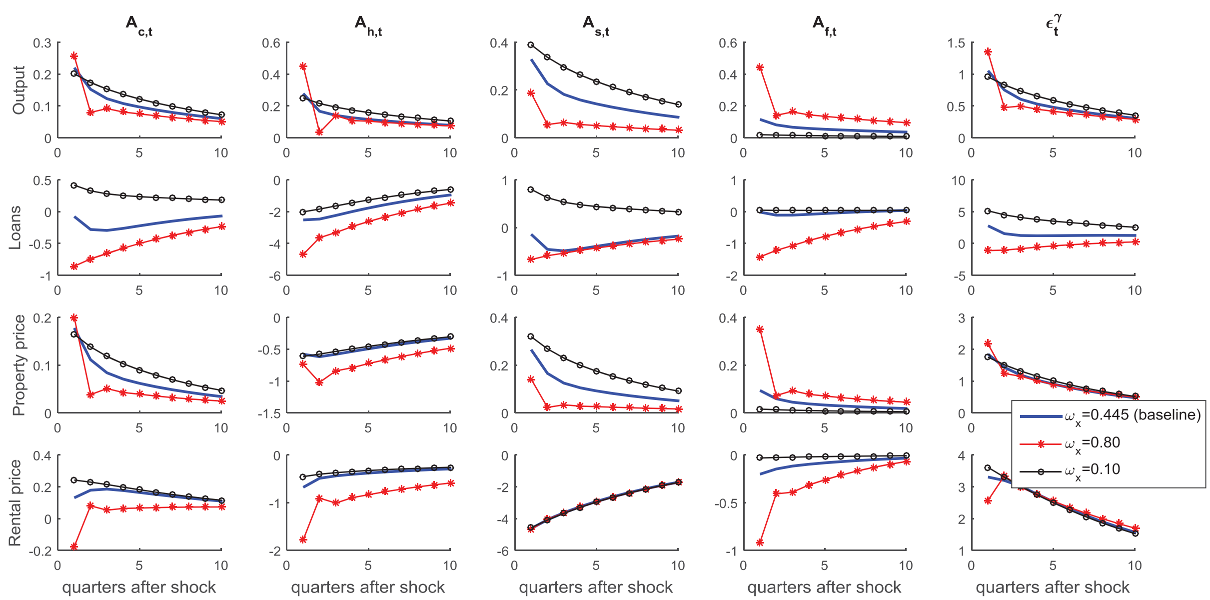
Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to a scenario in which A_f=1 (i.e., as in the baseline scenario). The starred line corresponds to an alternative scenario in which A_f=2. The dotted line relates to an alternative scenario in which A_f=0.5. The macroprudential parameter of the LTV limit on commercial mortgages has been set to -10 in the three scenarios.

Figure 4.9: Robustness checks (m_f); Impulse-responses to all shocks



Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to a scenario in which m_f=0.6 (i.e., as in the baseline scenario). The starred line corresponds to an alternative scenario in which m_f=0.8. The dotted line relates to an alternative scenario in which m_f=0.4. The macroprudential parameter of the LTV limit on commercial mortgages has been set to -10 in the three scenarios.

Figure 4.10: Robustness checks (ω_x); Impulse-responses to all shocks



Note: Variables are expressed in percentage deviations from the steady state. The solid line refers to a scenario in which ω_x=0.445 (i.e., as in the baseline scenario). The starred line corresponds to an alternative scenario in which ω_x=0.80. The dotted line relates to an alternative scenario in which ω_x=0.10. The macroprudential parameter of the LTV limit on commercial mortgages has been set to -10 in the three scenarios.

Table 4.1: 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
ε	Elast. of subst. labor types	1	Standard
$\eta_r; \eta_c$	Elast. of subst. rental RE varieties	2	Standard
m_b	LTV ratio on residential mortgages	0.7	Standard
m_f	LTV ratio on commercial mortgages	0.6	Standard
$\delta_0^c; \delta_0^h$	Depreciation rates of physical capital	0.025;0.03	Iacoviello & Neri (2010)
$\delta_1^i; \delta_2^i$	Endogenous depr. rate params.	r_{k_e};0.1*r_{k_e}	Gerali et al. (2010)
υ	RE share in non-RE production	0.04	Iacoviello (2015)
B) First moments			
β_s	Savers' discount factor	0.995	$R_h = (1.02)^{1/4}$
β_b	Borrowers' discount factor	0.975	$B_b/(Y) = 2.1403$
γ	Housing share in Cons. aggregator	0.168	$C/Y = 0.7607$
α	Capital share in non-RE production	0.144	$I/Y = 0.2119$
θ	Capital share in RE production	0.025	$qIH/Y = 0.1176$
ω_n	Weight in labor supply aggregator	0.510	$(qH)/(4Y) = 2.802$
ω_x	REIFs' weight in rental RE aggregator	0.445	$H_f^r/H \approx 0.050$
δ_h	Depreciation rate of RE	0.010	$X/H = 0.3269$
C) Second moments			
ϕ_k	Capital adj. cost param.	29.70	$\sigma_I \ / \ \sigma_Y = 2.642$
σ_γ	Std. preference shock	0.026	$\sigma_q \ / \ \sigma_Y = 2.429$
σ_{Ax_s}	Std. X_s productivity shock	0.051	$\sigma_C \ / \ \sigma_Y = 0.748$
σ_{Ax_f}	Std. X_f productivity shock	0.049	$\sigma_{B_f} \ / \ \sigma_Y = 6.099$
σ_{Ah}	Std. IH productivity shock	0.018	$\sigma_{IH} \ / \ \sigma_Y = 2.797$
σ_{Ac}	Std. Y_c productivity shock	0.001	$\sigma_Y = 2.138$

Table 4.2: Calibration targets

Variable	Description	Model	Data
A)First moments			
C/Y	Total consumption-to-GDP ratio	0.7791	0.7607
I/Y	Gross fixed capital formation-to-GDP ratio	0.2210	0.2119
$B_b/(Y)$	HH loans-to-GDP ratio	2.0149	2.1291
$(qH)/(4Y)$	Housing wealth-to-GDP ratio	2.8023	2.8018
qIH/Y	Total construction-to-GDP ratio	0.1121	0.1176
H_f^r/H	RE funds' rental housing-to-total housing	0.0500	0.0500
X/H	total rental housing-to-total housing	0.3020	0.3269
B)Second moments			
σ_{B_f} / σ_Y	Std. REIFs loans	6.383	6.099
σ_q / σ_Y	Std. property housing prices	1.691	2.429
σ_{qIH} / σ_Y	Std. housing investment	4.401	2.797
σ_I / σ_Y	Std. investment	2.632	2.642
σ_C / σ_Y	Std consumption	0.609	0.748
σ_Y	Std(GDP)*100	2.477	2.138

Table 4.3: Optimized LTV limits and prudential losses

		$\sigma^2_{B/Y}$ (1)	σ^2_B	$\sigma^2_{P_s}$	σ^2_q
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*(2)	(-63.91)	(-71.91)	(-15.00)	(-31.07)
	$m_{bx}^{(3)}$	-0.000	-0.000	-3.179	-0.000
	m_{fx}	-11.965	-14.786	-8.798	-30.762
(ii) $\{m_{bx}\}$	*Loss Variation*	(-61.20)	(-68.95)	(-14.63)	(-0.07)
	m_{bx}	-1.564	-1.911	-3.112	-0.459
(iii) $\{m_{fx}\}$	*Loss Variation*	(-63.91)	(-71.91)	(-6.12)	(-31.07)
	m_{fx}	-11.965	-14.786	-21.060	-30.762

Table 4.4: Aggregate effects of competition and macroprudential policies affecting REIFs

	$(A)\ \eta \to \infty$		$(B)\ \sigma_B^2$ [1]		$(C)\ \sigma_{P_s}^2$	
Variable	Δ% Mean[2]	Δ% Std	Δ% Mean	Δ% Std	Δ% Mean	Δ% Std
Y	1.98	-1.02	-0.12	-16.14	-0.14	-20.83
C	1.35	-4.82	-0.13	-18.94	-0.04	-23.58
IH	2.96	0.93	0.07	-3.86	-0.38	-7.55
N	0.95	-3.02	-0.02	-6.13	-0.16	-18.61
B	32.12	22.64	0.08	-26.02	-4.38	-1.70
H	2.96	1.13	0.07	-3.45	-0.38	-14.63
X	15.21	-10.46	0.69	4.74	0.39	0.86
$\frac{X}{H}$	11.88	-14.33	0.63	4.95	0.75	-0.16
$\frac{X_f}{X}$	158.37	96.91	-6.64	152.68	-1.58	59.22
q	3.56	3.28	0.06	-10.70	-0.23	-5.80
P_s	3.59	10.27	0.04	-2.26	-0.24	-8.32
P_{fr}	-48.06	-48.12	14.53	241.18	4.16	98.05

Table 4.5: Optimized LTV limits, prudential losses, REIFs' market power

		$\sigma_{P_s}^2/\eta = 1$ [1]	$\sigma_{P_s}^2/\eta = 2$	$\sigma_{P_s}^2/\eta = 6$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-24.86)	(-15.00)	(-12.33)
	m_{bx}[3]	-5.861	-3.179	-2.798
	m_{fx}	-14.816	-8.798	-5.305
(ii) $\{m_{bx}\}$	*Loss Variation*	(-23.39)	(-14.63)	(-12.04)
	m_{bx}	-3.656	-3.112	-2.861
(iii) $\{m_{fx}\}$	*Loss Variation*	(-10.89)	(-6.12)	(-1.65)
	m_{fx}	-31.752	-21.060	-10.992

Table 4.6: Optimized LTV limits, prudential losses, REIFs' productivity

		$\sigma_{P_s}^2/A_f = 0.5$ [1]	$\sigma_{P_s}^2/A_f = 1$	$\sigma_{P_s}^2/A_f = 2$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-11.12)	(-15.00)	(-21.44)
	m_{bx}[3]	-2.765	-3.179	-3.637
	m_{fx}	-11.726	-8.798	-7.412
(ii) $\{m_{bx}\}$	*Loss Variation*	(-10.81)	(-14.63)	(-20.50)
	m_{bx}	-2.690	-3.112	-3.639
(iii) $\{m_{fx}\}$	*Loss Variation*	(-3.61)	(-6.12)	(-10.92)
	m_{fx}	-30.825	-21.060	-15.790

Table 4.7: Optimized LTV limits, prudential losses, REIFs' structural LTV ratio

		$\sigma^2_{P_s}/m_f = 0.4$ [1]	$\sigma^2_{P_s}/m_f = 0.6$	$\sigma^2_{P_s}/m_f = 0.8$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-14.48)	(-15.00)	(-16.84)
	m_{bx}[3]	-3.092	-3.179	-3.380
	m_{fx}	-11.278	-8.798	-6.289
(ii) $\{m_{bx}\}$	*Loss Variation*	(-14.09)	(-14.63)	(-15.78)
	m_{bx}	-3.0665	-3.112	-3.167
(iii) $\{m_{fx}\}$	*Loss Variation*	(-5.98)	(-6.12)	(-6.31)
	m_{fx}	-30.450	-21.060	-11.497

Table 4.8: Optimized LTV limits, prudential losses, the weight of REIFs' rental services

		$\sigma^2_{P_s}/\omega_x = 0.10$ [1]	$\sigma^2_{P_s}/\omega_x = 0.445$	$\sigma^2_{P_s}/\omega_x = 0.80$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-7.65)	(-15.00)	(-32.25)
	m_{bx}[3]	-2.305	-3.179	-4.011
	m_{fx}	-27.352	-8.798	-6.693
(ii) $\{m_{bx}\}$	*Loss Variation*	(-7.49)	(-14.63)	(-30.52)
	m_{bx}	-2.243	-3.112	-4.337
(iii) $\{m_{fx}\}$	*Loss Variation*	(-1.90)	(-6.12)	(-21.34)
	m_{fx}	-79.724	-21.060	-12.162

Table 4.9: Optimized LTV limits, prudential losses, low REIFs' market power

		$\sigma^2_{B/Y}/\eta = 6$ [1]	$\sigma^2_{B}/\eta = 6$	$\sigma^2_{q}/\eta = 6$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-54.29)	(-62.85)	(-17.34)
	m_{bx}[3]	-0.000	-0.000	-0.000
	m_{fx}	-6.953	-8.518	-30.112
(ii) $\{m_{bx}\}$	*Loss Variation*	(-51.71)	(-60.53)	(-0.001)
	m_{bx}	-1.617	-1.982	-0.458
(iii) $\{m_{fx}\}$	*Loss Variation*	(-54.29)	(-62.85)	(-17.34)
	m_{fx}	-6.953	-8.518	-30.112

Table 4.10: Optimized LTV limits, prudential losses, low REIFs' productivity level

		$\sigma^2_{B/Y}/A_f = 0.5$ [1]	$\sigma^2_{B}/A_f = 0.5$	$\sigma^2_{q}/A_f = 0.5$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*[2]	(-49.78)	(-61.56)	(-25.66)
	m_{bx}[3]	-0.000	-0.000	-0.000
	m_{fx}	-12.977	-16.984	-47.700
(ii) $\{m_{bx}\}$	*Loss Variation*	(-48.74)	(-60.33)	(-0.00)
	m_{bx}	-1.07583	-1.395	-0.000
(iii) $\{m_{fx}\}$	*Loss Variation*	(-49.78)	(-61.56)	(-25.66)
	m_{fx}	-12.977	-16.984	-47.700

Table 4.11: Optimized LTV limits, prudential losses, low REIFs' LTV ratio

		$\sigma^2_{B/Y}/m_f = 0.4$ (1)	$\sigma^2_B/m_f = 0.4$	$\sigma^2_q/m_f = 0.4$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*(2)	(-67.27)	(-75.15)	(-30.71)
	m_{bx}(3)	-0.000	-0.000	-0.000
	m_{fx}	-15.809	-19.432	-45.302
(ii) $\{m_{bx}\}$	*Loss Variation*	(-61.64)	(-69.48)	(-0.14)
	m_{bx}	-1.460	-1.787	-0.683
(iii) $\{m_{fx}\}$	*Loss Variation*	(-67.27)	(-75.15)	(-30.71)
	m_{fx}	-15.809	-19.432	-45.302

Table 4.12: Optimized LTV limits, macroprudential losses, low weight of REIFs' rental services

		$\sigma^2_{B/Y}/\omega_x = 0.10$(1)	$\sigma^2_B/\omega_x = 0.10$	$\sigma^2_q/\omega_x = 0.10$
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*(2)	(-61.66)	(-69.91)	(-29.69)
	m_{bx}(3)	-0.000	-0.000	-0.000
	m_{fx}	-54.963	-67.691	-161.854
(ii) $\{m_{bx}\}$	*Loss Variation*	(-59.29)	(-67.35)	(-0.06)
	m_{bx}	-1.360	-1.659	-0.444
(iii) $\{m_{fx}\}$	*Loss Variation*	(-61.66)	(-69.91)	(-29.69)
	m_{fx}	-54.963	-67.691	-161.854

Table 4.13: Optimized LTV limits, prudential losses, constant capital depreciation rates

		$\sigma^2_{B/Y}$(1)	σ^2_B	$\sigma^2_{P_s}$	σ^2_q
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*(2)	(-65.86)	(-72.75)	(-15.89)	(-33.70)
	m_{bx}(3)	-0.000	-0.000	-3.650	-0.000
	m_{fx}	-13.700	-16.499	-9.891	-36.584
(ii) $\{m_{bx}\}$	*Loss Variation*	(-62.79)	(-69.54)	(-15.35)	(-0.36)
	m_{bx}	-1.807	-2.156	-3.570	-1.223
(iii) $\{m_{fx}\}$	*Loss Variation*	(-65.86)	(-72.75)	(-6.11)	(-33.70)
	m_{fx}	-13.700	-16.499	-24.086	-36.584

Table 4.14: Optimized LTV limits, prudential losses, separable preferences

		$\sigma^2_{B/Y}$(1)	σ^2_B	$\sigma^2_{P_s}$	σ^2_q
(i) $\{m_{bx}, m_{fx}\}$	*Loss Variation*(2)	(-0.0002)	(-3.96)	(-0.00)	(-0.001)
	m_{bx}(3)	-0.000	-0.000	-0.000	-0.000
	m_{fx}	-0.074	-1.080	-0.000	-2.054
(ii) $\{m_{bx}\}$	*Loss Variation*	(-0.000)	(-3.28)	(-0.00)	(-0.000)
	m_{bx}	-0.000	-0.416	-0.000	-0.000
(iii) $\{m_{fx}\}$	*Loss Variation*	(-0.0002)	(-3.96)	(-0.00)	(-0.001)
	m_{fx}	-0.074	-1.080	-0.000	-2.054

Chapter 5

Conclusion

This thesis adopts a DSGE approach to evaluate the macroeconomic effects of certain macroprudential policy rules which have the potential to strenghten the current prudential regulatory framework. The main findings of the quantitative analysis suggest that the adoption of the proposed regulatory schemes would help to preserve financial stability and improve the effectiveness of various macroprudential policies as stabilization tools.

Chapter 2 identifies a potential link between the observed high volatility in retained earnings (which translates into bank assets' volatility through a balance sheet effect) and the tendency of banks in the euro area to boost their capital ratios by deleveraging (in the lower phase of the cycle); dividend smoothing. Against this background, I propose a novel macroprudential policy rule - that I shall call Dividend Prudential Target (DPT) - aimed at complementing existing capital regulation by tackling this issue. Optimal DPTs are particularly effective in taming the financial and the business cycle due to the fact that they directly attack the root of the "problem" (i.e., banks' preference for dividend smoothing). This macroprudential policy rule complements existing microprudential and macroprudential capital regulation and induces significant welfare gains for both, savers and borrowers. In particular, the optimal DPT calls for restricting bank dividend distributions in bad times in order to maintain credit provision through capital conservation.

Central banks around the world have adopted a similar type of prudential measure (i.e., they have requested banks to temporarily refrain from distributing dividends even if they meet their capital requirements) in order to ensure that credit institutions keep funding households and firms amid the COVID-19 crisis. Such measure has been adopted in a context of significant monetary stimulus and a strong reluctance of the banking sector to draw on its capital buffers to sustain lending. Given banks' strong preference for dividend smoothing, existing (Basel III) capital regulation (which imposes automatic dividend restrictions when

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banks breach a specific capital threshold) does not seem to provide credit institutions with adequate incentives to draw on their capital buffers in bad times.

Chapter 3 incorporates nominal rigidities and a simple Taylor-type policy rule in the model presented in the previous chapter to evaluate the effects and interactions between this type of (macroprudential) dividend regulation and monetary policy, with and without having effective countercyclical capital regulation in place. First, optimal macroprudential dividend regulation is more effective (in smoothing the business cycle) than the optimal simple Taylor rules or the optimal CCyB. Second, perfect coordination between monetary policy, the CCyB, and macroprudential dividend regulation induces significant welfare gains. Third, when monetary policy hits the zero lower bound, countercyclical dividend regulation and the CCyB become particularly effective and the need for combining measures of capital conservation with those of capital usability (in bad times) is underscored.

Chapter 4 documents the steady increase in the presence of institutional investors in euro area housing markets since the onset of the Global Financial Crisis. Real estate funds (REIFs) and other housing investment firms leverage large-scale buy-to-rent investments in real estate assets that enable them to set prices in rental housing markets. A significant fraction of this funding is being provided in the form of non-bank lending (i.e., lending that is not subject to regulatory LTV limits). The quantitative analysis suggests that optimized LTV rules limiting the borrowing capacity of such funds are more effective in smoothing property prices, credit and business cycles than those affecting (indebted) households' borrowing limit. This finding is remarkably robust across alternative calibrations (of key parameters) and specifications of the model. The underlying reason behind such an important and unexpectedly robust finding relates to the strong interconnectedness of REIFs with various sectors of the economy.

Appendix A

Appendix to Chapter 2

A.1 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.[1] 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.[2]

[1]"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.

[2]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 2.2, retained earnings has

Total Equity: Bank's total assets minus its total liabilities. Calculated as: Common Equity + Minority Interest + Preferred Equity.[3] Simple sum of the SX7E members. Seasonally adjusted data (TRAMO/SEATS). Source: Bloomberg.[4]

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.

A.2 Equations of the Basic Model

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

A.2.1 Households

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

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

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

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

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

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

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

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been constructed as the simple sum of all SX7E member's retained earnings.

[3] "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.

[4] 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 shares outstanding. In order to report its cyclical component in figure 2.2 and for calibration purposes, total equity has been constructed as the simple sum of all SX7E member's total equity.

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

A.2.2 Entrepreneurs (net borrowers)

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

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

$$Y_t = H_{e,t-1}^{\upsilon} N_t^{1-\upsilon}, \tag{A.7}$$

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

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

$$\lambda_t^e = \frac{1}{C_{e,t}}, \tag{A.9}$$

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

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

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 the optimality conditions shows that the collateral constraint 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 such optimality conditions are presented:

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

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

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

A.2.3 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)

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

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

The law of motion for bank equity reads

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

The resulting optimality condition reads

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

A.2.4 Macroprudential Authority

The dividend prudetial target is specified as follows

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

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

$$T(d_{b,t}, d_t^*) = \; \frac{\kappa}{2}\left(d_{b,t} - d_t^*\right)^2. \quad \text{(A.17)}$$

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

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

A.2.5 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:

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

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 corresponds 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,

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

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

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

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

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

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

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

A.2.6 Shocks

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

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

A.3 Equations of the Extended Model

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

A.3.1 Patient Households

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

$$C_{p,t} + D_t + q_t(H_{p,t} - H_{p,t-1}) = (R_{d,t-1})D_{t-1} + W_t N_{p,t} + \omega_b d_{b,t} + \chi T_t + \omega_e d_{e,t}. \tag{A.25}$$

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

$$\lambda_t^p = \left. \quad C_{p,t} - \frac{N_{p,t}^{1+\phi}}{(1+\phi)} \right)^{-\sigma_h}, \tag{A.26}$$

$$\lambda_t^p = \beta_p R_{d,t} E_t \lambda_{t+1}^p, \tag{A.27}$$

$$q_t \lambda_t^p = \frac{j \varepsilon_t^h}{H_{p,t}} + \beta_p E_t \left(q_{t+1} \lambda_{t+1}^p \right), \tag{A.28}$$

$$W_t = N_{p,t}^{\phi}, \tag{A.29}$$

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

A.3.2 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 the corresponding objective function subject to a budget constraint and a borrowing limit:

$$C_{i,t} + R_{i,t-1}B_{i,t-1} + q_t(H_{i,t} - H_{i,t-1}) + \Phi_i(B_{i,t})$$
$$= B_{i,t} + W_t N_{i,t} + (1-\omega_b)d_{b,t} + (1-\chi)T_t + (1-\omega_e)d_{e,t}, \quad \text{(A.30)}$$

$$B_{i,t} \leq m^H_{i,t} E_t \left[\frac{q_{t+1}}{R_{i,t}} H_{i,t} \right]. \quad \text{(A.31)}$$

The resulting optimality conditions are

$$\lambda^i_t = \quad \left. C_{i,t} - \frac{N^{1+\phi}_{i,t}}{(1+\phi)} \right)^{-\sigma_h}, \quad \text{(A.32)}$$

$$W_t = N^{\phi}_{i,t}, \quad \text{(A.33)}$$

$$\lambda^i_t \left[q_t - \left(1 - \frac{\partial \Phi_i(B_{i,t})}{\partial B_{i,t}} \right) E_t \left(m^H_{i,t} \frac{q_{t+1}}{R_{i,t}} \right) \right] = \frac{j\varepsilon^h_t}{H_{i,t}} + \beta_i E_t \left[q_{t+1} \lambda^i_{t+1} \left(1 - m^H_{i,t} \right) \right], \quad \text{(A.34)}$$

where λ^i_t is the Lagrange multiplier on the budget constraint of the representative impatient household.

A.3.3 Entrepreneurs

Entrepreneurs seek to maximize their objective function subject to the following restrictions

$$d_{e,t} + R_{b,t}B_{e,t-1} + q^k_t \left[K_{e,t} - (1-\delta^k_t)K_{e,t-1} \right] + q_t(H_{e,t} - H_{e,t-1}) + W_t N_t + \Phi_e(B_{e,t}) = Y_t + B_{e,t}, \quad \text{(A.35)}$$

$$Y_t = A_t(u_t k_{e,t-1})^{\alpha} H^{\eta}_{e,t-1} N^{(1-\alpha-\eta)}_t, \quad \text{(A.36)}$$

$$B_{e,t} \leq m^H_{e,t} E_t \left(\frac{q_{t+1}}{R_{e,t+1}} H_{e,t} \right) - m^N W_t N_t. \quad \text{(A.37)}$$

$$\delta^k_t\,(u_t) = \delta^k_0 + \delta^k_1(u_t - 1) + \frac{\delta^k_2}{2}\,(u_t - 1)^2. \quad \text{(A.38)}$$

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

$$
\begin{aligned}
& d_{e,t}^{-\frac{1}{\sigma}} \left[q_t - \left(1 - \frac{\partial \Phi_e(B_{e,t})}{\partial B_{e,t}} \right) m_{e.t}^H E_t \left(\frac{q_{t+1}}{R_{e,t+1}} \right) \right] \\
& \qquad = \Lambda_{0,t}^e E_t \left\{ d_{e,t+1}^{-\frac{1}{\sigma}} \left[q_{t+1}(1 - m_{e,t}^H) + \eta \left(\frac{Y_{t+1}}{H_{e,t}} \right) \right] \right\}, \quad \text{(A.39)}
\end{aligned}
$$

$$
d_{e,t}^{-\frac{1}{\sigma}} \left[W_t + m^N W_t \left(1 - \frac{\partial \Phi_e(B_t)}{\partial B_t} \right) - (1 - \alpha - \eta) \frac{Y_t}{N_t} \right] = \Lambda_{0,t}^e E_t \left[d_{e,t+1}^{-\frac{1}{\sigma}} m^N W_t R_{e,t+1} \right], \quad \text{(A.40)}
$$

$$
d_{e,t}^{-\frac{1}{\sigma}} q_t^k = \Lambda_{0,t}^e E_t \left\{ d_{e,t+1}^{-\frac{1}{\sigma}} \left[q_{t+1}^k \left(1 - \delta_t^k \right) + \alpha \left(\frac{Y_{t+1}}{k_{e,t}} \right) \right] \right\}, \quad \text{(A.41)}
$$

$$
\delta_1^k + \delta_2^k \left(u_t - 1 \right) = \alpha \left(\frac{Y_t}{u_t k_{e,t-1}} \right). \quad \text{(A.42)}
$$

A.3.4 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 the corresponding objective function subject to a cash flow restriction and a borrowing limit (capital adequacy constraint)

$$
\begin{aligned}
& d_{b,t} + B_{it} + B_{e,t} - D_{b,t} - (1 - \delta_t) \left(B_{i,t-1} + B_{e,t-1} - D_{b,t-1} \right) \\
& \qquad = r_{e,t} B_{e,t-1} + r_{i,t-1} B_{i,t-1} - r_{d,t-1} D_{b,t-1} - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - T(d_{b,t}, d_t^*), \quad \text{(A.43)}
\end{aligned}
$$

$$
D_{b,t} = \gamma_{i,t} B_{i,t} + \gamma_{e.t} B_{e,t}, \quad \text{(A.44)}
$$

The law of motion for bank equity reads

$$
K_{b,t} = J_{b,t} - \ d_{b,t} + \ (1 - \delta_t) K_{b,t-1}. \quad \text{(A.45)}
$$

The resulting optimality conditions read

$$\frac{(1-\gamma_{i,t})+\dfrac{\partial\Phi_{bi}(B_{i,t})}{\partial B_{i,t}}}{d_{b,t}^{\frac{1}{\sigma}}\left[1+\kappa(d_{b,t}-d_t^*)\right]}=\Lambda_{0,t}^b E_t\left\{\frac{\left(r_{i,t}-\gamma_{i,t}r_{d,t}\right)+(1-\gamma_{i,t})\left(1-\delta_{t+1}\right)}{d_{b,t+1}^{\frac{1}{\sigma}}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]}\right\}, \tag{A.46}$$

$$\frac{(1-\gamma_{e,t})+\dfrac{\partial\Phi_{be}(B_{e,t})}{\partial B_{e,t}}}{d_{b,t}^{\frac{1}{\sigma}}\left[1+\kappa(d_{b,t}-d_t^*)\right]}=\Lambda_{0,t}^b E_t\left\{\frac{\left(r_{e,t+1}-\gamma_{e,t}r_{d,t}\right)+(1-\gamma_{e,t})\left(1-\delta_{t+1}\right)}{d_{b,t+1}^{\frac{1}{\sigma}}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]}\right\}. \tag{A.47}$$

A.3.5 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

$$\begin{aligned}1=q_{k,t}&\left[1-\frac{\psi_I}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2-\psi_I\left(\frac{I_t}{I_{t-1}}-1\right)\frac{I_t}{I_{t-1}}\right]\\&+E_t\left[\Lambda_{0,t}^e q_{k,t+1}\psi_I\left(\frac{I_{t+1}}{I_t}-1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right].\end{aligned} \tag{A.48}$$

The law of motion for physical capital reads

$$K_t=(1-\delta_t^k)K_{t-1}+I_t\left[1-\frac{\psi_I}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2\right]. \tag{A.49}$$

A.3.6 Macroprudential Authority

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

$$d_t^*=\rho_d+\rho_\chi(\frac{x_t}{x^{ss}}-1). \tag{A.50}$$

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

$$T(d_{b,t},d_t^*)=\frac{\kappa}{2}\left(d_{b,t}-d_t^*\right)^2. \tag{A.51}$$

The prudential authority has full control over regulatory capital ratios, $\left(1-\gamma_{i,t}\right)$ and

$(1-\gamma_{e,t})$. The sectorial debt-to-asset ratios associated to such capital regulatory scheme read

$$\gamma_{i,t} = \gamma_i + \gamma_x(\frac{x_t}{x^{ss}} - 1), \tag{A.52}$$

$$\gamma_{e,t} = \gamma_e + \gamma_x(\frac{x_t}{x^{ss}} - 1). \tag{A.53}$$

A.3.7 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:

$$Y_t = C_{p,t} + C_{i,t} + q_t^k I_t + \delta_t K_{b,t-1} + Adj_t, \tag{A.54}$$

where the term Adj_t corresponds 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,

$$N_t = N_{p,t} + N_{i,t}. \tag{A.55}$$

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

$$K_t = K_{e,t}. \tag{A.56}$$

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

$$B_t = B_{i,t} + B_{e,t}. \tag{A.57}$$

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

$$D_t = D_{b,t}. \tag{A.58}$$

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

$$\overline{H} = H_{p,t} + H_{i,t} + H_{e,t}. \tag{A.59}$$

A.3.8 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:

$$\log \varepsilon_t^{mh} = \rho_{mh} \log \varepsilon_{t-1}^{mh} + e_{mh,t},\ e_{mh,t} \sim N(0, \sigma_{mh}), \tag{A.60}$$

$$\log \varepsilon_t^{mk} = \rho_{mk} \log \varepsilon_{t-1}^{mk} + e_{mk,t},\ e_{mk,t} \sim N(0, \sigma_{mk}), \tag{A.61}$$

$$\log \varepsilon_t^{kb} = \rho_{mk} \log \varepsilon_{t-1}^{kb} + e_{kb,t},\ e_{kb,t} \sim N(0, \sigma_{kb}), \tag{A.62}$$

$$\log \varepsilon_t^{h} = \rho_{h} \log \varepsilon_{t-1}^{h} + e_{h,t},\ e_{h,t} \sim N(0, \sigma_{h}), \tag{A.63}$$

$$\log A_t = \rho_A \log A_{t-1} + e_{A,t},\ e_{A,t} \sim N(0, \sigma_A). \tag{A.64}$$

A.4 Policy Discussion

The DPT vs the CCyB The wide acceptance of the CCyB as a fundamental macroprudential 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.[5] Second, arguably, the DPT should be more effective than the CCyB in reducing the probability of bank default over the cycle, since it discourages equity distributions when the likelihood of bank failure is relatively high (i.e., during the downturn).[6]

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

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

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

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

Appendix B

Appendix to Chapter 3

B.1 Data and Sources

This section presents the full data set employed to calibrate the model in section 4.

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.

Total Construction: (Gross) total construction (within Gross fixed capital formation), Euro, Chain linked volume (rebased), 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.

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 (banks): 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 (banks): 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 (banks): 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.

B.2 Equations of the Model

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

B.2.1 Patient Households

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

$$\begin{aligned} C_{p,t} + D_t + q_t \left[H_{p,t} - (1-\delta_h)H_{p,t-1}\right] + \sum_{i=c,h} q^i_{k,t}\left[K^i_{p,t} - (1-\delta^i_t)K^i_{p,t-1}\right] \\ = R_{d,t-1}\frac{D_{t-1}}{\pi_t} + \sum_{i=c,h}\left[w^i_t N^i_{s,t} + r^i_{k,t}u^i_t K^i_{p,t-1}\right] + \omega_e d_{e,t} + \omega_b d_{b,t} + \chi T(d_{b,t}, d^*_t), \end{aligned} \quad \text{(B.1)}$$

$$\widetilde{N}_{p,t} = \left[\omega_n^{1/\varepsilon}\left(N^c_{p,t}\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon}\left(N^h_{p,t}\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(\varepsilon+1)}, \quad \text{(B.2)}$$

$$\delta_t^c(u_t) = \delta_0^c + \delta_1^c(u_t^c - 1) + \frac{\delta_2^c}{2}\,(u_t^c - 1)^2, \tag{B.3}$$

$$\delta_t^h(u_t) = \delta_0^h + \delta_1^h(u_t^h - 1) + \frac{\delta_2^h}{2}\,(u_t^h - 1)^2, \tag{B.4}$$

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

$$\lambda_t^p = \left(C_{p,t} - \frac{N_{p,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \tag{B.5}$$

$$\lambda_t^p = \beta_p E_t(\lambda_{t+1}^p R_{d,t}/\pi_{t+1}), \tag{B.6}$$

$$q_t\lambda_t^p = \frac{j\varepsilon_t^h}{H_{p,t}} + \beta_p\,(1-\delta_h)\,E_t\left(q_{t+1}\lambda_{t+1}^p\right), \tag{B.7}$$

$$w_t^c\lambda_{p,t} = \widetilde{N}_{p,t}^{\phi}\left[\omega_n\frac{N_{p,t}^c}{\widetilde{N}_{p,t}}\right]^{1/\varepsilon}\left(C_{p,t} - \frac{\widetilde{N}_{p,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \tag{B.8}$$

$$w_t^h\lambda_{p,t} = \widetilde{N}_{p,t}^{\phi}\left[(1-\omega_n)\frac{N_{p,t}^h}{\widetilde{N}_{p,t}}\right]^{1/\varepsilon}\left(C_{p,t} - \frac{\widetilde{N}_{p,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \tag{B.9}$$

$$\lambda_{p,t} = \beta_p E_t\left\{\lambda_{p,t+1}\left[q_{k,t+1}^c\left(1-\delta_{t+1}^c\right) + u_{t+1}^c r_{t+1}^c\right]\right\}, \tag{B.10}$$

$$\lambda_{p,t} = \beta_p E_t\left\{\lambda_{p,t+1}\left[q_{k,t+1}^h\left(1-\delta_{t+1}^h\right) + u_{t+1}^h r_{t+1}^h\right]\right\}, \tag{B.11}$$

$$\delta_1^c + \delta_2^c\,(u_t^c - 1) = r_t^c, \tag{B.12}$$

$$\delta_1^h + \delta_2^h\left(u_t^h - 1\right) = r_t^h. \tag{B.13}$$

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

B.2.2 Impatient Households

The representative impatient household chooses the trajectories of consumption $C_{i,t}$, property housing $H_{i,t}$, labor supply in each of the two production sectors, $N_{i,t}^c$ and $N_{i,t}^h$, and demand for loans $B_{i,t}$ that maximize the corresponding objective function subject to the following restrictions:

$$\begin{aligned} C_{i,t} + R_{i,t}\frac{B_{i,t-1}}{\pi_t} + q_t\left[H_{i,t} - (1-\delta_h)H_{i,t-1}\right] + \Phi_i(B_{i,t}) \\ = B_{i,t} + w_t^c N_{i,t}^c + w_t^h N_{i,t}^h + (1-\omega_e)d_{e,t} + (1-\omega_b)d_{b,t} + (1-\chi)T(d_{b,t}, d_t^*), \end{aligned} \quad \text{(B.14)}$$

$$\widetilde{N}_{p,t} = \left[\omega_n^{1/\varepsilon}\left(N_{p,t}^c\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon}\left(N_{p,t}^h\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(\varepsilon+1)}, \quad \text{(B.15)}$$

$$B_{i,t} \leq m_{i,t}^H E_t\left[\frac{q_{t+1}}{R_{it+1}} H_{it}\pi_{t+1}\right]. \quad \text{(B.16)}$$

The resulting optimality conditions are

$$\lambda_t^i = \left. \quad C_{i,t} - \frac{N_{i,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \quad \text{(B.17)}$$

$$w_t^c\lambda_{i,t} = \widetilde{N}_{i,t}^{\phi}\left[\omega_n\frac{N_{i,t}^c}{\widetilde{N}_{i,t}}\right]^{1/\varepsilon}\left. \quad C_{i,t} - \frac{\widetilde{N}_{i,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \quad \text{(B.18)}$$

$$w_t^h\lambda_{i,t} = \widetilde{N}_{i,t}^{\phi}\left[(1-\omega_n)\frac{N_{p,t}^h}{\widetilde{N}_{p,t}}\right]^{1/\varepsilon}\left. \quad C_{i,t} - \frac{\widetilde{N}_{i,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \quad \text{(B.19)}$$

$$\lambda_t^i\left[q_t - \left(1 - \frac{\partial\Phi_i(B_{i,t})}{\partial B_{i,t}}\right)E_t\left(m_{i,t}^H\frac{q_{t+1}}{R_{i,t}}\pi_{t+1}\right)\right] = \frac{j\varepsilon_t^h}{H_{i,t}} + \beta_i E_t\left[q_{t+1}\lambda_{t+1}^i\left(1-\delta_h - m_{i,t}^H\right)\right], \quad \text{(B.20)}$$

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

B.2.3 Housing Producers

Housing producing firms choose the demand schedules for labor N_t^h and physical capital K_t^h that maximize their objective function subject to the available technology:

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\upsilon} N_t^{h(1-\upsilon)}. \tag{B.21}$$

Their choice variables are N_t^h and K_t^h. The optimality conditions are as follows,

$$w_t^h = (1-\upsilon)\frac{IH_t}{N_t^h}, \tag{B.22}$$

$$r_t^h = \upsilon\left(\frac{IH_t}{u_t^h K_{t-1}^h}\right). \tag{B.23}$$

B.2.4 Entrepreneurial Managers

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

$$d_{m,t} + R_{e,t-1}B_{e,t-1} + q_t(H_{e,t}^c - H_{e,t-1}^c) + \Phi_e(B_{e,t}) = r_{h,t}H_{e,t-1}^c + B_{e,t}, \tag{B.24}$$

$$B_{e,t} \leq m_{e,t}^H E_t\left(\frac{q_{t+1}}{R_{e,t}} H_{e,t}\pi_{t+1}\right). \tag{B.25}$$

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

$$\begin{aligned} d_{m,t}^{-\frac{1}{\sigma}}\left[q_t - \left(1 - \frac{\partial\Phi_e(B_{e,t})}{\partial B_{e,t}}\right) m_{e.t}^H E_t\left(\frac{q_{t+1}}{R_{e,t}}\pi_{t+1}\right)\right] \\ = \Lambda_{0,t}^e E_t\left\{d_{m,t+1}^{-\frac{1}{\sigma}}\left[q_{t+1}(1-\delta_h - m_{e,t}^H) + r_{h,t+1}\right]\right\}. \end{aligned} \tag{B.26}$$

B.2.5 Entrepreneurial Retailers

Entrepreneurial retailers solve a two-stages problem. In the first stage, they choose the trajectories of N_t^c, K_t^c, and H_t^c that minimize total real costs:

$$\frac{w_t^c}{r_{k,t}^c} = \frac{(1-\alpha-\eta)}{\alpha}\frac{u_t^c K_{t-1}^c}{N_t^c}, \tag{B.27}$$

$$\frac{r_{h,t}}{r_{k,t}^{c}} = \frac{\eta}{\alpha}\frac{u_t^c K_{t-1}^c}{H_{t-1}^c}, \tag{B.28}$$

$$mc_t = \frac{\left(w_t^c\right)^{(1-\alpha-\eta)}\left(r_{k,t}^c\right)^{\alpha}\left(r_{h,t}\right)^{\eta}}{A_t\left(1-\alpha-\eta\right)^{(1-\alpha-\eta)}\alpha^{\alpha}\eta^{\eta}}. \tag{B.29}$$

In the second stage, they choose the price that maximizes discounted real profits. The firms that can change prices in period t set them to satisfy:

$$g_t^1 = \left[\ \omega_e\lambda_t^p +\ (1-\omega_e)\lambda_t^i\right] mc_t Y_{c,t} + \left[\ \omega_e\beta_p +\ (1-\omega_e)\beta_i\right]\theta E_t\left(\frac{\pi_t^{\chi}}{\pi_{t+1}}\right)^{-\varepsilon} g_{t+1}^1, \tag{B.30}$$

$$g_t^2 = \left[\ \omega_e\lambda_t^p +\ (1-\omega_e)\lambda_t^i\right]\pi_t^* Y_{c,t} + \left[\ \omega_e\beta_p +\ (1-\omega_e)\beta_i\right]\theta E_t\left(\frac{\pi_t^{\chi}}{\pi_{t+1}}\right)^{1-\varepsilon}\left(\frac{\pi_t^*}{\pi_{t+1}^*}\right) g_{t+1}^2, \tag{B.31}$$

$$\varepsilon g_t^1 = (\varepsilon-1)\, g_t^2. \tag{B.32}$$

The price level evolves as:

$$1 = \theta\left(\frac{\pi_{t-1}^{\chi}}{\pi_t}\right)^{1-\varepsilon} + (1-\theta)\,\pi_t^{\chi 1-\varepsilon}. \tag{B.33}$$

B.2.6 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 the corresponding objective function subject to a cash flow restriction and a borrowing limit (capital adequacy constraint)

$$\begin{aligned} &d_{b,t} + B_{it} + B_{e,t} - D_{b,t} - (1-\delta_t)\left(B_{i,t-1} + B_{e,t-1} - D_{b,t-1}\right)/\pi_t \\ &\quad = \left(r_{e,t-1}B_{e,t-1} + r_{i,t}B_{i,t-1} - r_{d,t-1}D_{b,t-1}\right)/\pi_t - \Phi_{be}(B_{e,t}) - \Phi_{bi}(B_{i,t}) - T(d_{b,t}, d_t^*), \end{aligned} \tag{B.34}$$

$$D_{b,t} = \gamma_{i,t}B_{i,t} + \gamma_{e.t}B_{e,t}, \tag{B.35}$$

$$K_{b,t} = J_{b,t} - \ d_{b,t} + \ (1-\delta_t)K_{b,t-1}/\pi_t. \tag{B.36}$$

The resulting optimality conditions read

$$\frac{(1-\gamma_{i,t}) + \dfrac{\partial \Phi_{bi}(B_{i,t})}{\partial B_{i,t}}}{d_{b,t}^{\frac{1}{\sigma}}\left[1+\kappa(d_{b,t}-d_t^*)\right]} = \Lambda_{0,t}^b E_t \left\{ \frac{\left[\left(r_{i,t+1} - \gamma_{i,t} r_{d,t}\right) + (1-\gamma_{i,t})\left(1-\delta_{t+1}\right)\right]/\pi_{t+1}}{d_{b,t+1}^{\frac{1}{\sigma}}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]} \right\}, \tag{B.37}$$

$$\frac{(1-\gamma_{e,t}) + \dfrac{\partial \Phi_{be}(B_{e,t})}{\partial B_{e,t}}}{d_{b,t}^{\frac{1}{\sigma}}\left[1+\kappa(d_{b,t}-d_t^*)\right]} = \Lambda_{0,t}^b E_t \left\{ \frac{\left[\left(r_{e,t} - \gamma_{e,t} r_{d,t}\right) + (1-\gamma_{e,t})\left(1-\delta_{t+1}\right)\right]/\pi_{t+1}}{d_{b,t+1}^{\frac{1}{\sigma}}\left[1+\kappa\left(d_{b,t+1}-d_{t+1}^*\right)\right]} \right\}. \tag{B.38}$$

B.2.7 Capital Goods Producers

For each of the two production sectors, capital-good-producing firms seek to maximize their objective function with respect to net investment in physical capital, I_t^c and I_t^h. The resulting optimal conditions are

$$\begin{aligned} 1 = q_{k,t}^c &\left[1 - \frac{{}^{c}_{I}}{2}\left(\frac{I_t^c}{I_{t-1}^c}-1\right)^2 - \psi_I^c\left(\frac{I_t^c}{I_{t-1}^c}-1\right)\frac{I_t^c}{I_{t-1}^c}\right] \\ &+ E_t\left[\Lambda_{0,t}^e q_{k,t+1}^c \psi_I^c \left(\frac{I_{t+1}^c}{I_t^c}-1\right)\left(\frac{I_{t+1}^c}{I_t^c}\right)^2\right]. \end{aligned} \tag{B.39}$$

$$\begin{aligned} 1 = q_{k,t}^h &\left[1 - \frac{{}^{h}_{I}}{2}\left(\frac{I_t^h}{I_{t-1}^h}-1\right)^2 - \ {}^{h}_{I}\left(\frac{I_t^h}{I_{t-1}^h}-1\right)\frac{I_t^h}{I_{t-1}^h}\right] \\ &+ E_t\left[\Lambda_{0,t}^e q_{k,t+1}^h \psi_I^h \left(\frac{I_{t+1}^h}{I_t^h}-1\right)\left(\frac{I_{t+1}^h}{I_t^h}\right)^2\right]. \end{aligned} \tag{B.40}$$

For each of the two production sectors, the law of motion for physical capital reads

$$K_t^c = (1-\delta_t^c)K_{t-1}^c + I_t^c\left[1 - \frac{\psi_I}{2}\left(\frac{I_t^c}{I_{t-1}^c}-1\right)^2\right], \tag{B.41}$$

$$K_t^h = (1-\delta_t^h)K_{t-1}^h + I_t^h\left[1 - \frac{\psi_I}{2}\left(\frac{I_t^h}{I_{t-1}^h} - 1\right)^2\right]. \tag{B.42}$$

B.2.8 Public Authorities

The central bank sets the policy rate r_t according to a Taylor-type policy rule:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left(r^{ss} + \alpha_\pi \tilde{\pi}_t + \alpha_Y \tilde{y}_t\right) + e_{r,t}, \tag{B.43}$$

The dividend prudential target is specified as follows

$$d_t^* = \rho_d + \rho_\chi(\frac{x_t}{x^{ss}} - 1). \tag{B.44}$$

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

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2}\left(d_{b,t} - d_t^*\right)^2. \tag{B.45}$$

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

$$\gamma_{i,t} = \gamma_i + \gamma_x(\frac{x_t}{x^{ss}} - 1), \tag{B.46}$$

$$\gamma_{e,t} = \gamma_e + \gamma_x(\frac{x_t}{x^{ss}} - 1). \tag{B.47}$$

B.2.9 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:

$$Y_t = C_{p,t} + C_{i,t} + q_t^c I_t^c + q_t^h I_t^h + q_t IH_t + \delta_t K_{b,t-1}/\pi_t + Adj_t, \tag{B.48}$$

$$Y_t = Y_{c,t} + q_t IH_t, \tag{B.49}$$

Expression (B.48) refers to the real GDP of the economy from the expenditure approach perspective and the term Adj_t corresponds to the sum of all resources dedicated in the economy to adjust bank loans in period t. Expression (B.49) makes reference to the real GDP of the economy from the output approach perspective, which comprises housing production, $q_t IH_t$, and non-housing production:

$$Y_{c,t} = \frac{A_t (u_t^c K_{t-1}^c)^{\alpha} \left(H_{t-1}^c\right)^{\eta} N_t^{c(1-\alpha-\eta)}}{v_t^p}, \tag{B.50}$$

where

$$v_t^p = \theta \left(\frac{\pi_{t-1}^{\chi}}{\pi_t}\right)^{-\varepsilon} v_{t-1}^p + (1-\theta)\, \pi_t^{\chi-\varepsilon}. \tag{B.51}$$

Similarly, in equilibrium labor demand equals total labor supply in each of the two production sectors,

$$N_t^c = N_{p,t}^c + N_{i,t}^c, \tag{B.52}$$

$$N_t^h = N_{p,t}^h + N_{i,t}^h. \tag{B.53}$$

The stock of physical capital accumulated by savers must equal the one rented by firms in each of the two production sectors,

$$K_{p,t}^c = K_t^c, \tag{B.54}$$

$$K_{p,t}^h = K_t^h. \tag{B.55}$$

Similarly, in equilibrium the stock of commercial real estate accumulated by entrepreneurial managers must be equal to the one rented by entrepreneurial retailers,

$$H_{e,t}^c = H_t^c, \tag{B.56}$$

The aggregate stock of produced real estate must be equal to the stock of housing held by savers, borrowers and entrepreneurial managers:

$$H_t = H_{p,t} + H_{i,t} + H_{e,t}^c, \tag{B.57}$$

where H_t evolves according to the standard law for capital accumulation,

$$H_t = (1 - \delta_h) H_{t-1} + IH_t. \tag{B.58}$$

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

$$B_t = B_{i,t} + B_{e,t}. \tag{B.59}$$

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

$$D_t = D_{b,t}. \tag{B.60}$$

B.2.10 Shocks

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

$$\log \varepsilon_t^{mh} = \rho_{mh} \log \varepsilon_{t-1}^{mh} + e_{mh,t},\ \ e_{mh,t} \sim N(0, \sigma_{mh}), \tag{B.61}$$

$$\log \varepsilon_t^{mk} = \rho_{mk} \log \varepsilon_{t-1}^{mk} + e_{mk,t},\ \ e_{mk,t} \sim N(0, \sigma_{mk}), \tag{B.62}$$

$$\log \varepsilon_t^{kb} = \rho_{mk} \log \varepsilon_{t-1}^{kb} + e_{kb,t},\ \ e_{kb,t} \sim N(0, \sigma_{kb}), \tag{B.63}$$

$$\log \varepsilon_t^{h} = \rho_{h} \log \varepsilon_{t-1}^{h} + e_{h,t},\ \ e_{h,t} \sim N(0, \sigma_{h}), \tag{B.64}$$

$$\log A_t = \rho_A \log A_{t-1} + e_{A,t},\ \ e_{A,t} \sim N(0, \sigma_A). \tag{B.65}$$

Appendix C

Appendix to Chapter 4

C.1 Data and Sources

This section presents the full data set employed to construct figure 1 and to calibrate the model.

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.

Total Construction: (Gross) total construction (within Gross fixed capital formation), Euro, Chain linked volume (rebased), Calendar and seasonally adjusted data. Source: Eurostat.

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.

Percentage of owner-occupied housing:Type of tenure - Owner-occupied accommodation, total, Percentage, Euro area 19 (fixed composition). Source: Structural Housing Indicators Statistics, European Central Bank.

Percentage of rented housing: Type of tenure - Rented accommodation, total, Percentage, Euro area 19 (fixed composition). Source: Structural Housing Indicators Statistics, European Central Bank.

Property 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.

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.

Real Estate Funds Loans and Deposits: Outstanding amounts at the end of the period (stocks) of loans and deposits received by real estate funds in the euro area, Total maturity, denominated in Euro. Neither seasonally nor working day adjusted. Source: Investment Funds Balance Sheet Statistics, European Central Bank.

Real Estate Funds Total Assets and Non-financial Assets (stocks): Outstanding amounts at the end of the period (stocks) of total assets and non-financial assets held by real estate funds in the euro area, denominated in Euros. Neither seasonally nor working day adjusted. Source: Investment Funds Balance Sheet Statistics, European Central Bank.

Real Estate Funds Total Assets (flows): Transactions (flows) of total assets held by real estate funds in the euro area, denominated in Euros. Neither seasonally nor working day adjusted. Source: Investment Funds Balance Sheet Statistics, European Central Bank.

C.2 Equations of the Model

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

C.2.1 Patient Households

Patient households seek to maximize (4.1) subject to the following constraints:

$$\begin{aligned} C_{s,t} + B_t + \sum_{i=c,h}\left[I_t^i + \Phi_i(K_{s,t}^i)\right] + q_t \sum_{j=p,r}\left[H_{s,t}^j - (1-\delta_h)H_{s,t-1}^j\right] \\ = P_{s,t}X_{s,t} + R_{b,t-1}B_{t-1} + \sum_{i=c,h}\left[W_t^i N_{s,t}^i + r_t^i u_t^i K_{s,t-1}^i\right] + \Pi_t, \end{aligned} \tag{C.1}$$

$$Z_{s,t} = C_{s,t}^{(1-\gamma_t)} H_{s,t}^{p\ \gamma_t}, \tag{C.2}$$

$$\widetilde{N}_{s,t} = \left[\omega_n^{1/\varepsilon} \left(N^c_{s,t}\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N^h_{s,t}\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(\varepsilon+1)}, \tag{C.3}$$

$$K^c_{s,t} = (1-\delta^c_t)K^c_{s,t-1} + I^c_t, \tag{C.4}$$

$$K^h_{s,t} = (1-\delta^h_t)K^h_{s,t-1} + I^h_t, \tag{C.5}$$

$$\delta^c_t\,(u_t) = \delta^c_0 + \delta^c_1(u^c_t - 1) + \frac{\delta^c_2}{2}\,(u^c_t - 1)^2, \tag{C.6}$$

$$\delta^h_t\,(u_t) = \delta^h_0 + \delta^h_1(u^h_t - 1) + \frac{\delta^h_2}{2}\,(u^h_t - 1)^2, \tag{C.7}$$

$$X_{s,t} = A_{s,t}H^r_{s,t-1}. \tag{C.8}$$

Their choice variables are $C_{s,t}$, B_t, $H^p_{s,t}$, $H^r_{s,t}$, $N^c_{s,t}$, $N^h_{s,t}$, $K^c_{s,t}$, $K^h_{s,t}$, u^c_t and u^h_t. The optimality conditions of the problem read

$$\lambda_{s,t} = (1-\gamma_t)\frac{Z_{s,t}}{C_{s,t}} \quad \left. Z_{s,t} - \frac{\widetilde{N}^{1+\phi}_{s,t}}{(1+\phi)}\right)^{-\sigma_h}, \tag{C.9}$$

$$\lambda_{s,t} = \beta_s R_{b,t} E_t \lambda_{s,t+1}, \tag{C.10}$$

$$q_t\lambda_{s,t} = \gamma_t\frac{Z_{s,t}}{H^p_{s,t}} \quad \left. Z_{s,t} - \frac{\widetilde{N}^{1+\phi}_{s,t}}{(1+\phi)}\right)^{-\sigma_h} + \beta_s(1-\delta_h)E_t\left(q_{t+1}\lambda_{s,t+1}\right), \tag{C.11}$$

$$q_t\lambda_{s,t} = \lambda_{s,t}P_{s,t}A_{s,t} + \beta_s(1-\delta_h)E_t\left(q_{t+1}\lambda_{s,t+1}\right), \tag{C.12}$$

$$W^c_t\lambda_{s,t} = \widetilde{N}^{\phi}_{s,t}\left[\omega_n\frac{N^c_{s,t}}{\widetilde{N}_{s,t}}\right]^{1/\varepsilon} \quad \left. Z_{s,t} - \frac{\widetilde{N}^{1+\phi}_{s,t}}{(1+\phi)}\right)^{-\sigma_h}, \tag{C.13}$$

$$W^h_t\lambda_{s,t} = \widetilde{N}^{\phi}_{s,t}\left[(1-\omega_n)\frac{N^h_{s,t}}{\widetilde{N}_{s,t}}\right]^{1/\varepsilon} \quad \left. Z_{s,t} - \frac{\widetilde{N}^{1+\phi}_{s,t}}{(1+\phi)}\right)^{-\sigma_h}, \tag{C.14}$$

$$\left(1 + \frac{\partial\Phi_c(K^c_{s,t})}{\partial K^c_{s,t}}\right)\lambda_{s,t} = \beta_s E_t\left[\lambda_{s,t+1}(1 + u^c_{t+1}r^c_{t+1} - \delta^c_{t+1})\right], \tag{C.15}$$

$$1+\frac{\partial\Phi_c(K^h_{s,t})}{\partial K^h_{s,t}}\Bigg)\lambda_{s,t}=\beta_s E_t\left[\lambda_{s,t+1}(1+u^h_{t+1}r^h_{t+1}-\delta^h_{t+1})\right], \tag{C.16}$$

$$\delta^c_1+\delta^c_2\left(u^c_t-1\right)=r^c_t, \tag{C.17}$$

$$\delta^h_1+\delta^h_2\left(u^h_t-1\right)=r^h_t, \tag{C.18}$$

where $\lambda_{s,t}$ is the Lagrange multiplier on the budget constraint of the representative patient household.

C.2.2 Impatient Households

The representative impatient household chooses the trajectories of consumption $C_{b,t}$, property housing $H^p_{b,t}$, labor supply in each of the two production sectors, $N^c_{b,t}$ and $N^h_{b,t}$, and demand for loans $B_{b,t}$ that maximize (4.1) subject to the following restrictions:

$$C_{b,t}+R_{b,t-1}B_{b,t-1}+q_t\left[H^p_{b,t}-(1-\delta_h)H^p_{b,t-1}\right]=B_{b,t}+W^c_tN^c_{bt}+W^h_tN^h_{b,t}, \tag{C.19}$$

$$Z_{b,t}=C^{(1-\gamma_t)}_{b,t}H^{p\ \gamma_t}_{b,t}, \tag{C.20}$$

$$\widetilde{N}_{b,t}=\left[\omega_n^{1/\varepsilon}\left(N^c_{b,t}\right)^{(1+\varepsilon)/\varepsilon}+(1-\omega_n)^{1/\varepsilon}\left(N^h_{b,t}\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(\varepsilon+1)}, \tag{C.21}$$

$$B_{b,t}\leq m_{b,t}E_t\left[\frac{q_{t+1}}{R_{bt}}H^p_{b,t}\right]. \tag{C.22}$$

The resulting optimality conditions are,

$$\lambda_{b,t}=(1-\gamma_t)\frac{Z_{b,t}}{C_{b,t}}\quad Z_{b,t}-\frac{\widetilde{N}^{1+\phi}_{b,t}}{(1+\phi)}\Bigg)^{-\sigma_h}, \tag{C.23}$$

$$\lambda_{b,t}\left[q_t-E_t\left(m_{b,t}\frac{q_{t+1}}{R_{b,t}}\right)\right]=\gamma_t\frac{Z_{b,t}}{H^p_{b,t}}\quad Z_{b,t}-\frac{\widetilde{N}^{1+\phi}_{b,t}}{(1+\phi)}\Bigg)^{-\sigma_h}+\beta_bE_t\left[q_{t+1}\lambda_{b,t+1}\left(1-\delta_h-m_{b,t}\right)\right], \tag{C.24}$$

$$W_t^c \lambda_{b,t} = \widetilde{N}_{b,t}^{\phi} \left[\omega_n \frac{N_{b,t}^c}{\widetilde{N}_{b,t}} \right]^{1/\varepsilon} \left(Z_{b,t} - \frac{\widetilde{N}_{b,t}^{1+\phi}}{(1+\phi)} \right)^{-\sigma_h}, \tag{C.25}$$

$$W_t^h \lambda_{b,t} = \widetilde{N}_{b,t}^{\phi} \left[(1-\omega_n) \frac{N_{b,t}^h}{\widetilde{N}_{b,t}} \right]^{1/\varepsilon} \left(Z_{b,t} - \frac{\widetilde{N}_{b,t}^{1+\phi}}{(1+\phi)} \right)^{-\sigma_h}, \tag{C.26}$$

where $\lambda_{b,t}$ is the Lagrange multiplier on the budget constraint of the representative impatient household.

C.2.3 Renter Households

The representative renter household seeks to maximize (4.9) subject to:

$$C_{r,t} + P_{s,t} X_{sr,t} + p_{fr,t} x_{fr,t} = W_t^c N_{r,t}^c + W_t^h N_{r,t}^h, \tag{C.27}$$

$$Z_{r,t} = C_{r,t}^{(1-\gamma_t)} \widetilde{X}_{r,t}^{\gamma_t}, \tag{C.28}$$

$$\widetilde{N}_{r,t} = \left[\omega_n^{1/\varepsilon} \left(N_{r,t}^c \right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N_{r,t}^h \right)^{(1+\varepsilon)/\varepsilon} \right]^{\varepsilon/(1+\varepsilon)}, \tag{C.29}$$

$$\widetilde{X}_{r,t} = \left[\omega_x^{1/\eta_r} \left(x_{fr,t} \right)^{(\eta_r-1)/\eta_r} + (1-\omega_x)^{1/\eta_r} \left(X_{sr,t} \right)^{(\eta_r-1)/\eta_r} \right]^{\eta_r/(\eta_r-1)}. \tag{C.30}$$

Its choice variables are $C_{r,t}$, $x_{fr,t}$, $X_{sr,t}$, $N_{s,t}^c$ and $N_{s,t}^h$. The optimality conditions of the problem read,

$$\lambda_{r,t} = \frac{(1-\gamma_t)}{C_{r,t}}, \tag{C.31}$$

$$P_{s,t} \lambda_{r,t} = \frac{\gamma_t}{\widetilde{X}_{r,t}} \left[(1-\omega_x) \frac{\widetilde{X}_{r,t}}{X_{sr,t}} \right]^{1/\eta_r}, \tag{C.32}$$

$$p_{fr,t} \lambda_{r,t} = \frac{\gamma_t}{\widetilde{X}_{r,t}} \left[\omega_x \frac{\widetilde{X}_{r,t}}{x_{fr,t}} \right]^{1/\eta_r}, \tag{C.33}$$

$$W_t^c \lambda_{r,t} = \widetilde{N}_{r,t}^{\phi} \left[\omega_n \frac{N_{r,t}^c}{\widetilde{N}_{s,t}} \right]^{1/\varepsilon}, \tag{C.34}$$

$$W_t^h \lambda_{r,t} = \widetilde{N}_{r,t}^{\phi} \left[(1-\omega_n) \frac{N_{r,t}^h}{\widetilde{N}_{r,t}} \right]^{1/\varepsilon}, \tag{C.35}$$

where $\lambda_{r,t}$ is the Lagrange multiplier on the budget constraint of the representative renter household.

C.2.4 Non-housing Producing Firms

Non-housing producing firms seek to maximize their objective function subject to the following constraints

$$Y_{c,t} = A_{c,t}(u_t^c K_{t-1}^c)^{\alpha} \widetilde{X}_{c,t}^{\nu} N_t^{c(1-\alpha-\nu)}, \tag{C.36}$$

$$\widetilde{X}_{c,t} = \left[\omega_x^{1/\eta_c} \left(x_{fc,t} \right)^{(\eta_c-1)/\eta_c} + (1-\omega_x)^{1/\eta_c} \left(X_{sc,t} \right)^{(\eta_c-1)/\eta_c} \right]^{\eta_c/(\eta_c-1)}. \tag{C.37}$$

Their choice variables are $N_{c,t}$, $K_{c,t}$, $x_{fc,t}$ and $X_{sc,t}$. The following optimality conditions can be derived from the first order conditions of the problem:

$$W_t^c = (1-\alpha-\nu) \frac{Y_{c,t}}{N_t^c}, \tag{C.38}$$

$$r_t^c = \alpha \left(\frac{Y_{c,t}}{u_t^c K_{t-1}^c} \right), \tag{C.39}$$

$$P_{s,t} = \nu \frac{Y_{c,t}}{\widetilde{X}_{c,t}} \left[(1-\omega_x) \frac{\widetilde{X}_{c,t}}{X_{sc,t}} \right]^{1/\eta_c}, \tag{C.40}$$

$$p_{fc,t} = \nu \frac{Y_{c,t}}{\widetilde{X}_{c,t}} \left[\omega_x \frac{\widetilde{X}_{c,t}}{x_{fc,t}} \right]^{1/\eta_c}. \tag{C.41}$$

C.2.5 Housing Producing Firms

Housing producing firms choose the demand schedules for labor N_t^h and physical capital K_t^h that maximize (4.21) subject to the available technology:

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\theta} N_t^{h(1-\theta)}. \tag{C.42}$$

Their choice variables are N_t^h and K_t^h. The optimality conditions are as follows,

$$W_t^h = (1-\theta)\frac{IH_t}{N_t^c}, \tag{C.43}$$

$$r_t^h = \theta\left(\frac{IH_t}{u_t^h K_{t-1}^h}\right). \tag{C.44}$$

C.2.6 Real Estate Fund Managers

The representative fund manager seeks to maximize (4.24) subject to a sequence of cash flow restrictions, a borrowing limit and the corresponding technologies to transform housing into rental services:

$$\Pi_{f,t} + R_{b,t}B_{f,t-1} + q_t\left[H_{fr,t}^r + H_{fc,t}^r - (1-\delta_h)\left(H_{fr,t-1}^r + H_{fc,t-1}^r\right)\right] = B_{f,t} + P_{fr,t}X_{fr,t} + P_{fc,t}X_{fc,t}, \tag{C.45}$$

$$B_{f,t} \leq m_{f,t}E_t\left[\frac{q_{t+1}}{R_{b,t}}\left(H_{fr,t}^r + H_{fc,t}^r\right)\right], \tag{C.46}$$

$$X_{fr,t} = \overline{A}_{fr,t}H_{fr,t-1}^r, \tag{C.47}$$

$$X_{fc,t} = \overline{A}_{fc,t}H_{fc,t-1}^r. \tag{C.48}$$

The resulting optimality conditions read:

$$\Pi_{f,t}^{-\frac{1}{\sigma}}\left[q_t - m_{f,t}E_t\left(\frac{q_{t+1}}{R_{b,t}}\right)\right] = \Lambda_{0,t}^e E_t\left\{\Pi_{f,t+1}^{-\frac{1}{\sigma}}\left[P_{fr,t+1}\overline{A}_{fr,t+1}q_{t+1}(1-\delta_h - m_{f,t})\right]\right\}, \tag{C.49}$$

$$\Pi_{f,t}^{-\frac{1}{\sigma}}\left[q_t - m_{f,t}E_t\left(\frac{q_{t+1}}{R_{b,t}}\right)\right] = \Lambda_{0,t}^e E_t\left\{\Pi_{f,t+1}^{-\frac{1}{\sigma}}\left[P_{fc,t+1}\overline{A}_{fc,t+1}q_{t+1}(1-\delta_h - m_{f,t})\right]\right\}. \tag{C.49}$$

C.2.7 Real Estate Fund Retailers

The representative fund retailer maximizes (4.31). After having imposed a symmetric equilibrium, the first order conditions yield:

$$p_{fr,t} = \frac{\eta_r}{(\eta_r - 1)} P_{fr,t}, \tag{C.51}$$

$$p_{fc,t} = \frac{\eta_c}{(\eta_c - 1)} P_{fc,t}. \tag{C.52}$$

C.2.8 Macroprudential Authority

The policy instruments (dynamic LTV limits) of the macroprudential authority have the following specification:

$$m_{b,t} = \rho_b m_{b,t-1} + (1 - \rho_b) m_b + (1 - \rho_b)\, m_{bx}(\frac{x_t}{x} - 1), \tag{C.53}$$

$$m_{f,t} = \rho_f m_{f,t-1} + (1 - \rho_f) m_f + \left(1 - \rho_f\right) m_{fx}(\frac{x_t}{x} - 1). \tag{C.54}$$

C.2.9 Aggregation and market clearing

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

$$Y_t = C_{,t} + I_{c,t} + I_{h,t} + q_t IH_t + \Phi_c(K_{c,t}) + \Phi_h(K_{h,t}). \tag{C.55}$$

Similarly, in equilibrium labor demand equals total labor supply in each of the two production sectors,

$$N_t^c = N_{s,t}^c + N_{b,t}^c + N_{r,t}^c, \tag{C.56}$$

$$N_t^h = N_{s,t}^h + N_{b,t}^h + N_{r,t}^h. \tag{C.57}$$

The stock of physical capital accumulated by savers must equal the one rented by firms in each of the two production sectors,

$$K_{s,t}^c = K_t^c, \tag{C.58}$$

$$K_{s,t}^{h} = K_{t}^{h}. \tag{C.59}$$

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

$$B_t = B_{b,t} + B_{f,t}. \tag{C.60}$$

In equilibrium, the different segments of the rental housing services market clear:

$$X_{s,t} = X_{sr,t} + X_{sc,t}, \tag{C.61}$$

$$X_{fr,t} = x_{fr,t}, \tag{C.62}$$

$$X_{fc,t} = x_{fc,t}. \tag{C.63}$$

The aggregate stock of produced real estate must be equal to the stock of housing held by savers, borrowers and fund managers:

$$H_t = H_{s,t}^{p} + H_{s,t}^{r} + H_{b,t}^{p} + H_{fr,t}^{r} + H_{fc,t}^{r}, \tag{C.64}$$

where H_t evolves according to the standard law for capital accumulation,

$$H_t = (1 - \delta_h) H_{t-1} + IH_t. \tag{C.65}$$

C.2.10 Shocks

The following zero-mean, AR(1) shocks are present in the model: $A_{c,t}$, $A_{h,t}$, $A_{s,t}$, $A_{f,t}$, and ε_t^{γ}. These shocks follow the processes given by:

$$\log A_{c,t} = \rho_{Ac} \log A_{c,t-1} + e_{Ac,t},\ e_{Ac,t} \sim N(0, \sigma_{Ac}), \tag{C.66}$$

$$\log A_{h,t} = \rho_{Ah} \log A_{h,t-1} + e_{Ah,t},\ e_{Ah,t} \sim N(0, \sigma_{Ah}), \tag{C.67}$$

$$\log A_{s,t} = \rho_{As} \log A_{s,t-1} + e_{As,t},\ e_{As,t} \sim N(0, \sigma_{As}), \tag{C.68}$$

$$\log A_{f,t} = \rho_{Af} \log A_{f,t-1} + e_{Af,t},\ \ e_{Af,t} \sim N(0, \sigma_{Af}), \tag{C.69}$$

$$\log \varepsilon_t^{\gamma} = \rho_{\gamma} \log \varepsilon_{t-1}^{\gamma} + e_{\gamma,t},\ \ e_{\gamma,t} \sim N(0, \sigma_{\gamma}). \tag{C.70}$$