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Macroprudential policy and the role of institutional investors in housing markets

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Abstract

Since the onset of the Global Financial Crisis, the presence of institutional investors in housing markets has steadily increased over time. Real estate funds (REIFs) and other housing investment firms leverage large-scale buy-to-rent real estate investments that enable them to set prices in rental markets. A significant fraction of this funding is being provided in the form of non-bank lending - which is not subject to regulatory LTV ratios - and REIFs are generally not constrained by leverage limits. We develop a quantitative DSGE model that incorporates the main features of the REIF industry and identify leakages of existing macro-prudential policy: (i) already existing countercyclical LTV rules on residential mortgages trigger a credit reallocation towards the REIF sector that can amplify financial and business cycles; while (ii) "non-existent" countercyclical LTV rules on lending to REIFs are particularly effective in taming such cycles. Due to the different mechanisms through which they operate, both types of LTV rules complement each other and jointly yield larger welfare gains (for savers and borrowers) than in isolation.

Keywords:rental housing, real estate funds, loan-to-value ratios, leverage, leakages.

JEL classification: E44, G23, G28

1 Introduction

The financial reforms adopted in the aftermath of the Global Financial Crisis (GFC) resulted in a tightening of bank lending standards that has revitalized rental housing markets, leading to higher rents and depressed homeownership rates (see Gete and Reher 2018). In this new regulatory environment, institutional investors have found incentives to steadily increase their presence in the real estate sector. Recent empirical studies have shown that: (i) real estate funds and other housing investment firms (henceforth REIFs) leverage large-scale buy-to-rent real estate investments, a pattern that seems to have conferred them with some capacity to set rents in the areas where they have concentrated; (ii) more stringent prudential requirements on banks have incentivized REIFs to rely more on non-bank funding; and (iii) such patterns in the REIF industry are behind the recovery in housing investment and property prices that followed the GFC.[1]

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 1). Importantly, real estate funds located in the EU are generally not subject to leverage limits 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.[2] Ireland is an exception. Despite the fact that official data on the balance sheets' composition and flows of REIFs investing in euro area real estate assets is still very limited, findings based on a deep dive survey on the Irish REIF industry have recently confirmed that leverage levels of REIFs domiciled in Ireland are high (Daly et al. 2021). This should be interpreted as an important reference, since a significant share of the REIF industry that invests in euro area assets is domiciled in Ireland (ECB 2020). Against this background, the Central Bank of Ireland has formally proposed the introduction of a macroprudential leverage limit on REIFs that operate in Ireland (Central Bank of Ireland 2021). This policy tool is similar to the macroprudential LTV limit advocated by Muñoz (2020b), explicitly regarded by former Governor of the Central Bank of Ireland, Honohan (2020), as an interesting proposal to address this issue at the international level.[3]

The main contributions of this paper are threefold. First, we develop and calibrate a quantitative euro area DSGE model that captures the main features of the real estate investment firm

[1]See Lambie-Hanson, Li and Slonkosky (2019) for an empirical study that provides evidence on the existence of a causality relationship between the increasing presence of REIFs in the real estate sector and the recovery of housing investment and property prices as well as the decrease in homeownership rates in the US economy.

[2]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.

[3]Note that Muñoz (2020b) is a VoxEU article that summarizes the main findings and policy implications of a previous version of this paper (i.e., Muñoz 2020a).

industry, as documented in the recent empirical literature. Second, we identify leakages and unintended consequences of existing macroprudential policy as: (i) the countercyclical response of already existing LTV rules on residential mortgages triggers a credit reallocation towards the REIF sector that can amplify financial and business cycles; while (ii) "non-existent" countercyclical LTV rules on lending to REIFs are particularly effective in taming such cycles.[4] Third, we carry out a welfare analysis of both types of countercyclical LTV rules and show that - due to the different mechanisms through which they operate - they complement each other and jointly yield larger welfare gains than in isolation.

In section 3, we develop a quantitative two-sector DSGE model with REIFs and rental housing markets calibrated to the euro area economy. 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.[5] The demand side accounts for two types of representative households who crucially differ from one another in the role they play in housing and credit markets. Patient households save and purchase housing (as savers) to do both, live in and supply homogeneous rental services under perfectly competitive conditions (as landlords); impatient households get indebted against eligible (housing) collateral (as borrowers) to acquire property for their own use and to demand rental housing services (as renters). In addition, REIFs demand loans to buy real estate assets and transform them into slightly differentiated rental housing services that are supplied under monopolistic competition.[6] 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, patient households and institutional investors simultaneously supply services in the rental housing market to impatient households and (non-housing) producing firms.

The model features two frictions which closely interconnect credit and housing markets 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 and

[4] By "non-existent" we refer to the fact that REIFs investing in euro area real estate assets heavily rely on non-bank lending (for which no regulatory LTV limit applies) and are not subject to (dynamic) leverage limits (as they fall within the AIFMD - category of investment funds). Of course, any commercial mortgages they may obtain from banks are subject to the LTV limits established in the EU regulation on prudential requirements for credit institutions and investment firms.

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

[6] Although we indistinctively refer - throughout the paper - to real estate investment firms as institutional investors or real estate funds, the type of economic agent that we are 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).

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 that 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 model is completed with a policy block; The macroprudential authority sets the LTV limits on loans to borrowers (i.e., residential mortgages) and REIFs (i.e., commercial mortgages) according to policy rules that can be calibrated to react to steady state deviations of a macroeconomic indicator of the choice of the regulator.

We then calibrate the model to quarterly data of the euro area for the period 2002:I - 2018:II, and match various first and second moments from financial and macroeconomic aggregates.

In section 4, we study the transmission and business cycle effects of a traditional and well investigated macroprudential policy tool; i.e., a countercyclical LTV rule on residential mortgages. The study identifies certain leakages and unintended consequences of its use which relate to the role played by REIFs and rental housing markets in the economy. In a standard (two-sector) DSGE model with housing collateral constraints, this policy rule stabilizes real economic activity over the cycle through a credit supply smoothing effect. However, we find that in the same model augmented with rental housing markets and REIFs, the same policy rule can amplify financial and business cycles by increasing the volatility of: (i) housing investment and property prices; (ii) total lending; (iii) savers and borrowers' consumption patterns; and (iv) total output, through the housing and the non-housing production sectors.

To present the different mechanisms through which these destabilizing effects operate, we show how selected key aggregates respond to expansionary shocks that hit this model economy with and without a countercyclical LTV rule on loans to impatient households. In response to a countercyclical tightening in residential mortgage lending standards, borrowers partially replace property housing with rental housing services and savers reallocate resources to increase rental housing supply directly (by purchasing more housing to supply rental services themselves) and indirectly, by reallocating credit towards the REIF industry. As a result, rental services provided by savers and REIFs to borrowers and non-housing producers increase in the economy. Such redistribution of resources drives the above mentioned destabilizing effects. First, the increase in housing investment and property prices is amplified since the required increase in housing demand by savers and REIFs more than compensates the decrease in borrowers demand for property housing. Second, credit volatility increases unless the degree of countercyclical responsiveness of the rule is sufficiently low and the borrowers' credit demand destabilizing effect does not more than compensate the direct credit supply smoothing effect.[7] Third, due to the complementarities between the consumption of

[7] Note that by replacing property housing with rental housing services, borrowers are amplifying the LTV policy-

durables (i.e., housing) and that of non-durables, the magnitude of such reallocation of resources and the associated fluctuations in consumption patterns of savers and borrowers increase with the degree of countercyclical responsiveness of the LTV rule. Fourth, due to complementarities across productive factors, the increase in the supply of rental services also amplifies total output volatility through the non-housing production sector.

Our analysis shows that, to an important extent, these destabilizing effects are induced by a reallocation of credit towards REIFs (i.e., the sector that is not subject to macroprudential regulation). Against this background, section 5 investigates the transmission and business cycle effects of countercyclical LTV rules on loans to REIFs in the same environment. In response to a countercyclical tightening in lending standards that only applies to REIFs, borrowers partially replace REIFs' rental services with those supplied by savers (while maintaining credit and owner-occupied housing demand roughly unchanged) whereas savers increase their demand for housing and supply more rental services themselves. As opposed to the one induced by the policy rule evaluated in section 4, the reallocation of resources triggered by this sectoral LTV rule on REIFs stabilizes financial cycles (by smoothing property prices and total credit) and business fluctuations (via the housing and non-housing production sectors) through various mechanisms due to two key distinctive features: (i) borrowers find optimal to only replace REIF rental services with those supplied by savers (rather than with property housing); and (ii) REIFs cannot replace property housing (even if it would become costlier) since that is the only input with which they can produce rental services. There are two main implications behind these two distinctive features that explain why this policy rule has a prominent stabilization capacity. First, the increase in savers' demand for housing does not offset the decrease in REIFs' property demand and, therefore, housing investment and prices evolve in a smoother fashion. Second, there is no substitution mechanism through which REIFs can easily destabilize total lending from the credit demand side.

Our conclusions on the differing stabilization capacities of these two sectoral policy rules are formally confirmed on the basis of an exercise that considers different specifications and calibrations of a loss function that is minimized by the prudential authority under full commitment and with respect to LTV macroprudential response parameter/s. LTV rules on lending to REIFs are more effective (than already existing LTV rules on residential mortgages) in stabilizing indicators and aggregates closely monitored by macroprudential authorities in practice (e.g., the credit-to-GDP ratio, total lending, property prices and real GDP). Due to the fact that countercycliclal LTV rules on loans to households can destabilize aggregates such as property prices and real GDP, there is a number of specifications and calibrations of the loss function for which relying on such a policy rule is counterproductive and the best the prudential authority can do is to solely have a

induced downward pressure on lending. Unless the countercyclical degree of responsiveness of the LTV rule is sufficiently low, the size of this amplifying effect is such that total lending becomes countercyclical and more volatile.

countercyclical LTV rule on loans to REIFs in place.

To further understand the mechanisms through which they affect savers and borrowers' expected lifetime utility, section 6 offers a welfare analysis of the two types of LTV rules. We explore the individual and social welfare effects and trade-offs induced by countercyclical LTV rules. Then, optimal LTV 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 macroprudential policy parameter vector. Both types of rules induce welfare gains for savers and borrowers. Despite the destabilizing effects and the transfer of resources (from borrowers to savers) they trigger, LTV rules on residential mortgages induce comparatively larger welfare gains for savers and borrowers. As explained in the paper, this is the case as LTV induced - welfare effects and trade-offs are, to a large extent, driven by non-trivial level effects. While level effects triggered by countercyclical LTV rules on residential mortgages are more attractive to households than those induced by LTV rules on loans to REIFs, robustness checks (section 7) show that under assumptions that are plausible and standard in the literature (e.g., high elasticity of substitution across rental varieties; separable preferences on the consumption of durables and non-durables) the level effects triggered by the latter can become significantly more attractive. The two types of LTV rules complement each other, as they operate through different mechanisms, and jointly induce larger welfare gains for savers and borrowers than in isolation. The optimal LTV policy mix involves the simultaneous presence of countercyclical sectoral LTV rules on residential mortgages and on lending to REIFs.

The two main findings of the paper can be summarized as follows. First, our study identifies leakages and unintended consequences of macroprudential regulation that relate to the role played by REIFs and rental housing markets in the economy: (i) already existing countercyclical LTV rules on resiential mortgages can amplify financial and business cycles through a reallocation of credit towards the REIF industry; whereas (ii) "non-existent" countercyclical LTV rules on lending to REIFs are particularly effective in smoothing such cycles. Second, both types of macroprudential rules are welfare improving and - due to their complementarities - jointly induce larger welfare gains for savers and borrowers than in isolation.

The rest of the paper is organized as follows. Section 2 discusses how the paper fits into the existing literature. Section 3 describes and calibrates the model. Section 4 studies the transmission and business cycle effects of countercyclical LTV rules on residential mortgages. Section 5 investigates the transmission and effects of countercyclical LTV limits on lending to REIFs and the stabilization capacity of the two types of LTV rules. Section 6 presents a welfare analysis. Section 7 implements some robustness checks. Section 8 concludes.

2 Related Literature

The paper 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. 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 institutional large-scale buy-to-rent investments in real estate assets. The deep dive survey recently conducted by the Central Bank of Ireland for the case of Irish REIFs shows that leverage ratios within this industry are high (Daly et al. 2021). In addition, 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.[8] In this regard, it is worth noting that 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). According to the evidence, this reliance on non-bank lending relates to a comparatively more stringent prudential regulation on banks. 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, whereas Tzur-Ilan (2020) 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.

Either because REIFs are - in most jurisdictions - not subject to sectoral macroprudential (leverage) regulation and/or because their increasing activity is, to a large extent, being funded with non-bank lending (which is not subject to regulatory LTV limits), these empirical studies are

[8] 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.

suggestive of the existence of ample room for strengthening the macroprudential regulatory framework on this front. Taken together, the evidence on the increasing presence of REIFs in housing and credit markets together with that on the unintended effects of macroprudential regulation in the presence of unregulated sectors suggest that existing macroprudential regulation may have leakages along this dimension.[9]

The paper connects with several strands of the literature. First, the paper contributes to a strand of literature that incorporates a multi-sector structure with housing (durables) and non-housing goods (see, e.g., Greenwood and Hercowitz 1991, Benhabib, Rogerson and Wright 1991, Chang 2000, Davis and Heathcote 2005, Fisher 2007, Monacelli 2009, Iacoviello and Neri 2010, and Justiniano et al. 2015) and housing collateral constraints, as in Kiyotaki and Moore (1997) and Iacoviello (2005 and 2015). In this regard, Monacelli (2009) and Iacoviello and Neri (2010) are perhaps our closest antecedents as they combine both features. In addition, our study allows for the presence of certain empirically-relevant complementarities between the consumption of durables (i.e., housing) and that of non-durables (as in the former) and assumes that a variety of exogenous technology and housing demand shocks hit the model economy, the type of exogenous shocks that - according to the latter - have been shown to explain the bulk of the variability in housing investment and property prices.

Second, the paper 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), Sommer et al. (2013), Alpanda and Zubairy (2016), Sun and Tsang (2017), Garriga et al. (2019), Kaplan et al. (2020), and Greenwald and Guren (2021). In our model, there are two types of households (i.e., savers & landlords, and borrowers & renters) which crucially differ from one another in their subjective discount factor (and, consequently, in the role each of them plays in credit and rental housing markets). 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 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 paper 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 our knowledge) its modelling, nevertheless, has some similarities to other contributions in the literature. As in Basak

[9] Empirical studies showing leakages of macroprudential regulations to other sectors include Ongena et al. (2013), Aiyar et al. (2014), Cerutti et al. (2015), Reinhardt and Sowerbutts (2015), Jiménez et al. (2017) and Ahnert et al. (2021).

and Pavlova (2013), institutional investors coexist with retail investors (in our model; 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 paper also relates to recent work that adopts a general equilibrium perspective to study and quantify the effects of prudential regulation. In particular, our paper contributes to the literature that relies on DSGE models with collateral constraints to evaluate the aggregate and welfare implications of macroprudential policies (see, e.g., Lambertini et al. 2013, Alpanda and Zubairy 2017, and Bianchi and Mendoza 2018). Moreover, our model captures mechanisms and leads to conclusions that are similar to others in the literature that adopts a general equilibrium perspective to study the unintended consequences of prudential policies in the presence of an unregulated sector. For instance, as in Begenau and Landvoigt (2018), a tightening in prudential requirements on the regulated sector causes the unregulated sector to take over a larger share of total credit. Similar to the main take away from the quantitative analysis in Bengui and Bianchi (2021), our analysis also concludes that already existing macroprudential policy is desirable even if it is subject to leakages.

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. There are two types of households. Patient households (savers and landlords) 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 and renters) work, consume, accumulate housing for owner-occupied reasons, demand rental housing services and borrow funds from savers.[10] 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.[11] 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. Figure 2 illustrates the

[10] 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).

[11] 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).

interactions across the different types of agents in the real estate and credit markets by means of a flow of funds diagram.

3.1 Main features

3.1.1 Patient households (savers and landlords)

The representative patient household (and landlord) seeks to maximize

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

where $\beta_s \in (0,1)$ is the patient household's discount factor, σ_h stands for the risk parameter of the household and $\phi > 0$ refers to the inverse of the Frisch elasticity. The representative saver consumes a basket of durable and non-durable final goods:

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

where $C_{s,t}$ denotes consumption of the final non-durable good, $H_{s,t}^p$ 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 $H_{s,t}$ in consumption, where $\gamma \in [0,1]$ and ε_t^γ captures housing preference shocks.[12] $\widetilde{N}_{s,t}$ is a composite index of labor supply to the consumption sector, $N_{s,t}^c$, and the housing sector, $N_{s,t}^h$.

$$\widetilde{N}_{s,t} = \left[\omega_n^{1/\varepsilon} \left(N_{s,t}^c \right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N_{s,t}^h \right)^{(1+\varepsilon)/\varepsilon} \right]^{\varepsilon/(\varepsilon+1)}, \tag{3}$$

where $\omega_n \in (0,1)$ is a weight parameter and ε is the elasticity of substitution between types of labor supply.[13]

[12] Note that $Z_{s,t} = C_{s,t}^{(1-\gamma_t)} H_{s,t}^{p\ \gamma_t}$ is just a particular case of a more general specification of the final consumption index, $Z_{s,t} = \left[(1-\gamma_t)^{1/\nu} (C_{s,t})^{(\nu-1)/\nu} + \gamma_t^{1/\nu} \left(H_{s,t}^p \right)^{(\nu-1)/\nu} \right]^{\nu/(\nu-1)}$, 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.

[13] 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 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).

The maximization of (1) is subject to the sequence of budget constraints:

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

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,

$$K_{s,t}^i = (1-\delta_t^i)K_{s,t-1}^i + I_t^i, \tag{4}$$

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 :

$$\delta_t^i(u_t) = \delta_0^i + \delta_1^i(u_t^i - 1)^2 + \frac{\delta_2^i}{2}(u_t^i - 1)^2. \tag{5}$$

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:

$$X_{s,t} = A_{s,t}H_{s,t-1}^r, \tag{6}$$

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 $\Pi_{f,t}$ denotes net profits from institutional investors.

3.1.2 Impatient households (borrowers and renters)

The representative impatient household (and renter) seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_b^t \left[\frac{1}{1-\sigma_h}\left(Z_{b,t} - \frac{\widetilde{N}_{b,t}^{1+\phi}}{(1+\phi)}\right)^{1-\sigma_h}\right], \tag{7}$$

where $\beta_b \in (0,1)$ is the impatient household's discount factor $(\beta_s > \beta_b)$, $\widetilde{N}_{b,t}$ is a composite index of labor supply analogous to the one in expression (3) and $Z_{b,t}$ is a Dixit-Stiglitz aggregator of final (non-durable) consumption goods $C_{b,t}$ and housing services $\widetilde{HX}_{b,t}$. Formally,

$$\widetilde{N}_{b,t} = \left[\omega_n^{1/\varepsilon}\left(N_{b,t}^c\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon}\left(N_{b,t}^h\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(1+\varepsilon)}, \tag{8}$$

$$Z_{b,t} = C_{b,t}^{(1-\gamma_t)}\widetilde{HX}_{b,t}^{\gamma_t}, \tag{9}$$

where $\widetilde{HX}_{b,t}$ is a composite of rental housing services, $\widetilde{X}_{b,t}$, and owner-occupied housing services, $H_{b,t}^p$.

$$\widetilde{HX}_{b,t} = \left[\omega_b^{1/\eta_b}\left(\widetilde{X}_{b,t}\right)^{(\eta_b-1)/\eta_b} + (1-\omega_b)^{1/\eta_b}\left(H_{b,t}^p\right)^{(\eta_b-1)/\eta_b}\right]^{\eta_b/(\eta_b-1)}, \tag{10}$$

where $\omega_b \in (0,1)$ is a weight parameter, $\eta_b \geqslant 0$ is the elasticity of substitution between types of housing services (i.e., rental and owner-occupied) and $\widetilde{X}_{b,t}$ is a CES aggregator of homogeneous rental housing services provided by savers under perfect competition, $X_{sb,t}$, and slightly differentiated rental housing services provided by institutional investors under monopolistic competition, $x_{fb,t}$.

$$\widetilde{X}_{b,t} = \left[\omega_r^{1/\eta_r}\left(x_{fb,t}\right)^{(\eta_r-1)/\eta_r} + (1-\omega_r)^{1/\eta_r}\left(X_{sb,t}\right)^{(\eta_r-1)/\eta_r}\right]^{\eta_r/(\eta_r-1)}, \tag{11}$$

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

$$x_{fb,t} = \int_0^1 \left[x_{fb,t}(i)^{(\eta_r-1)/\eta_r}\, di\right]^{(\eta_r-1)/\eta_r}, \tag{12}$$

with $x_{fb,t}(i)$ representing the quantity of variety i consumed by the representative impatient household in her capacity of renter in period t.[14] Although the assumptions of preference for different types of housing services (i.e., rental and owner-occupied); different types of rental housing services (i.e., those provided by savers under perfect competition and those provided by institutional investors under monopolistic competition); and different rental housing varieties (within the segment of the rental housing market operated by institutional investors) may seem unrealistic at the micro level, these simply constitute a modelling approach to capture the fact that, at the aggregate level, there is a preference for variety in the residential real estate market.[15]

The maximization of (7) is restricted by a sequence of budget constraints and a borrowing

[14] Note that, for the shake of simplicity, we assume 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.

[15] 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).

limit,

$$C_{b,t}+q_t\left[H^p_{b,t}-(1-\delta_h)H^p_{b,t-1}\right]+P_{s,t}X_{sb,t}+\int_0^1 p_{fb,t}(i)\,x_{fb,t}(i)\,di+R_{b,t-1}B_{b,t-1}=W^c_tN^c_{bt}+W^h_tN^h_{b,t}+B_{b,t}, \tag{13}$$

$$B_{b,t}\le m_{b,t}E_t\left[\frac{q_{t+1}}{R_{bt}}H^p_{b,t}\right], \tag{14}$$

where $p_{fb,t}(i)$ stands for the unitary price of variety i. According to (13), in each period, the representative impatient household devotes her available resources in terms of wage earnings and borrowings to consume non-durable goods, demand (owner-occupied and rental) housing services and repay her debt. Expression (14) stipulates that constrained households cannot borrow more than a possibly time-varying fraction $m_{b,t}$ of the expected value of their owner-occupied housing stock.[16]

3.1.3 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

$$Y_{c,t}-W^c_tN^c_{,t}-r^c_{k,t}K^c_{t-1}-\int_0^1 p_{fc,t}(j)\,x_{fc,t}(j)\,dj-P_{s,t}X_{sc,t}. \tag{15}$$

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

$$Y_{c,t}=A_{c,t}(u^c_tK^c_{t-1})^{\alpha}\widetilde{X}^{\nu}_{c,t}N^{c(1-\alpha-\nu)}_t, \tag{16}$$

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

[16] See expression (30) for the specification of the macroprudential policy rule according to which $m_{b,t}$ is set.

monopolistic competition, $x_{fc,t}$.[17]

$$\widetilde{X}_{c,t} = \left[\omega_c^{1/\eta_c} \left(x_{fc,t}\right)^{(\eta_c-1)/\eta_c} + (1-\omega_c)^{1/\eta_c} \left(X_{sc,t}\right)^{(\eta_c-1)/\eta_c}\right]^{\eta_c/(\eta_c-1)}, \tag{17}$$

where $\omega_c \in (0,1)$ 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 $[0,1]$

$$x_{fc,t} = \int_0^1 \left[x_{fc,t}\left(j\right)^{(\eta_c-1)/\eta_c} dj\right]^{(\eta_c-1)/\eta_c}, \tag{18}$$

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

Housing 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:

$$IH_t - W_t^h N_{,t}^h(j) - r_{k,t}^h K_{t-1}^h, \tag{19}$$

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

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\theta} N_t^{h(1-\theta)} \tag{20}$$

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,

$$H_t = (1-\delta_h)H_{t-1} + IH_t. \tag{21}$$

with δ_h being the depreciation rate of housing.

[17] The assumption that REIFs supply rental services not only (to impatient households) for residential purposes but also (to non-housing producing firms) for commercial purposes is empirically relevant. Transaction level data for the case of Irish REIFs shows that REIFs' investment in commercial real estate (CRE) in the euro area has been increasing in recent years. According to a deep dive survey on REIFs in Ireland, REIFs domiciled in this country are estimated to hold over 40 percent of Irish CRE investments (Central Bank of Ireland 2021a).

3.1.4 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 $\Lambda_{t,t+1} = \beta_s \frac{\lambda_{s,t+1}}{\lambda_{s,t}}$ 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

$$E_0 \sum_{t=0}^{\infty} \Lambda_{t,t+1} \quad f\left(\Pi_{f,t}\right) \tag{22}$$

Subject to

$$\Pi_{f,t}+R_{b,t}B_{f,t-1}+q_t\left[H^r_{fb,t}+H^r_{fc,t}-(1-\delta_h)\left(H^r_{fb,t-1}+H^r_{fc,t-1}\right)\right] = B_{f,t}+P_{fb,t}X_{fb,t}+P_{fc,t}X_{fc,t}+J_{f,t}, \tag{23}$$

$$B_{f,t} \leq m_{f,t}E_t\left[\frac{q_{t+1}}{R_{b,t}}\left(H^r_{fr,t}+H^r_{fc,t}\right)\right], \tag{24}$$

$$X_{fb,t} = \overline{A}_{fb,t}H^r_{fb,t-1}, \tag{25}$$

$$X_{fc,t} = \overline{A}_{fc,t}H^r_{fc,t-1}, \tag{26}$$

where equations (23), (24), (25) and (26) 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.[18]

[18] Without loss of generality and for empirically-relevant purposes, we assume that $f\left(\Pi_{f,t}\right) = \log \Pi_{f,t}$. According to the evidence, dividend smoothing operates through two main channels; owners (i.e., patient households)' risk aversion and managers' propensity to smooth dividends (see, e.g., Wu 2018). See Iacoviello (2015) for a DSGE model with financial institutions maximizing an objective function that is also concave in dividends and Muñoz

$H^r_{fb,t}$ 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, $X_{fb,t}$, and non-housing producing firms, $X_{fc,t}$, whereas $P_{fb,t}$ and $P_{fc,t}$ denote the corresponding market prices for rental housing services. $J_{f,t}$ denotes net profits from fund retailers, $B_{f,t}$ is debt issued by the fund manager in period t and $m_{f,t}$ the possibly time-varying fraction of the expected value of her housing stock that limits her borrowing capacity.[19] $\overline{A}_{fb,t} = A_{fb}A_{f,t}$ and $\overline{A}_{fc,t} = A_{fc}A_{f,t}$ are dynamic productivity parameters; $A_{fb} > 0$ 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.

Fund retailers Each retailer obtains wholesale rental housing services, $X_{fb,t}(i)$ and $X_{fc,t}(j)$, from the wholesale unit at prices $P_{fb,t}$ 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 $\{p_{fb,t}(i), p_{fc,t}(j)\}$ that maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{t,t+1} \quad [p_{fb,t}(i)x_{fb,t}(i) + p_{fc,t}(j)x_{fc,t}(j) - P_{fb,t}X_{fb,t}(i) - P_{fc,t}X_{fc,t}(j)] \tag{27}$$

subject to the aggregate demand functions for rental housing varieties i and j: $x_{fb,t}\,(i) = \left(\frac{p_{fb,t}(i)}{p_{fb,t}}\right)^{-\eta_r} x_{fb,t}$ and $x_{fc,t}\,(j) = \left(\frac{p_{fc,t}(j)}{p_{fc,t}}\right)^{-\eta_c} x_{fc,t}$, where $p_{fb,t}$ and $p_{fc,t}$ can be interpreted as rental housing price indices for renter households and non-housing producing firms, respectively.[20]

3.1.5 Aggregation and Market Clearing

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

$$Y_t = Y_{c,t} + q_t IH_t, \tag{28}$$

$$Y_t = C_t + I^c_t + I^h_t + q_t IH_t + \Phi(K^c_t) + \Phi(K^h_t). \tag{29}$$

where expressions (28) and (29) refer to the GDP of the economy from the output and the expenditure approach perspectives, respectively, and $C_t = C_{s,t} + C_{b,t}$ denotes aggregate consumption. Similarly, the labor market, the physical capital markets,the credit market, the property housing

(2021); Burlon et al. (2022) for a model that replicates certain moments of euro area bank dividends by assuming that both, owners and managers are risk averse.

[19] See expression (31) for the specification of the macroprudential policy rule according to which $m_{f,t}$ is set.

[20] Formally; $p_{fb,t} = \left[\int_0^1 p_{fb,t}\,(i)^{(1-\eta_r)}\,di\right]^{1/(1-\eta_r)}$ and $p_{fc,t} = \left[\int_0^1 p_{fc,t}\,(j)^{(1-\eta_c)}\,dj\right]^{1/(1-\eta_c)}$

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).

3.1.6 Macroprudential policy

The macroprudential authority sets the LTV limit on residential mortgages (i.e., LTV limit on loans to impatient households or borrowers), $m_{b,t}$, and the LTV limit on commercial mortgages (i.e., LTV limit on loans to REIFs), $m_{f,t}$, according to the following policy rules

$$m_{b,t} = \rho_b m_{b,t-1} + (1-\rho_b)m_b + (1-\rho_b)\, m_{bx}(\frac{x_t}{x} - 1), \tag{30}$$

$$m_{f,t} = \rho_f m_{f,t-1} + (1-\rho_f)m_f + \left(1-\rho_f\right) m_{fx}(\frac{x_t}{x} - 1), \tag{31}$$

where ρ_b and ρ_f are the corresponding autorregresive parameters, $m_b \in [0,1]$ and $m_f \in [0,1]$ are the steady state LTV limits, m_{bx} and m_{fx} are the macroprudential response parameters and x_t is a macroeconomic indicator of the choice of the regulator, being x its steady state level.

3.1.7 Shocks

There are five different types of zero-mean, AR(1), shocks that hit this model economy: Housing preference shocks, ε_t^{γ}; technology shocks in the non-housing production sector, $A_{c,t}$; technology shocks in the housing production sector, $A_{h,t}$; technology shocks in the segment of the rental housing market operated by patient households, $A_{s,t}$; technology shocks in the segment of the rental housing market operated by REIFs, $A_{f,t}$.

3.2 Calibration

We 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 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 and the elasticity of substitution between labor types are fixed to standard values of 2 and 1, respectively. The elasticity of substitution between owner-occupied and rental housing services, η_b, is set to 1 in order to capture the empirical fact that, while the two types of housing are substitutes at the micro level, they also exhibit certain complementarities at the macroeconomic level. The elasticity of substitution across rental housing varieties, η_r and η_c, is fixed to a value of 2, thus striking a balance between the empirically relevant market power of REIFs (i.e., low $\eta_r > 0$ and $\eta_c > 0$) and the higher degree of substitutability between rental housing varieties (i.e., high

$\eta_r > 0$ and $\eta_c > 0$) when compared to that between owner-occupied and rental housing.[21] In line with the maximum LTV limit the EU regulation on prudential requirements for credit institutions and investment firms imposes for the case of residential and commercial mortgages, m_b and m_f are set to 0.8 and 0.6, respectively.[22] 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 1B and 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 0.9906, so as to match a household loans-to-GDP ratio of 2.13. The housing weight parameter of households' consumption aggregator, γ, is fixed to a value of 0.163 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 0.148 and 0.012 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 0.408 to match a housing wealth-to-GDP ratio of 2.802. The weight parameter of REIFs' rental housing in rental aggregators is fixed to a value of 0.426 to match an institutional investors' real estate-to-total housing ratio of approximately 0.05.[23] The weight parameter of rental services in borrowers' aggregators of rental and property housing services is set to 0.429 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 1C and 2B). The capital adjustment cost parameter ϕ_k is set to target a relative standard deviation of total investment of 2.64%. We approximately match the second moments of key macroeconomic

[21] Nevertheless, the robustness of the main conclusions on welfare effects and trade-offs to changes in the values of parameters η_b, η_r and η_c is checked in section 7.

[22] 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 paper is checked in section 7.

[23] 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 and discussed in section 7 and Appendix C 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_b lead to variations in the institutional investors' housing-to-total housing ratio without significantly affecting the rest of the calibration targets.

aggregates, including housing investment, property prices and lending to REIFs by calibrating the size of the various productivity and housing preference shocks. As standard in the literature, the autoregressive coefficients in the AR(1) processes followed by all shocks are set equal to 0.9 and LTV persistence parameters ρ_b and ρ_f are fixed to a value of 0.75 (see, e.g., Lambertini et al. 2013).[24]

4 Leakages of Macroprudential Regulation

One of the main objectives of macroprudential policy is to smooth the financial cycle.[25] Borio (2014) argues that *"the most parsimonious description of the financial cycle is in terms of credit and property prices"*. The strand of the literature that studies the effectiveness of macroprudential policy in taming the financial cycle in a general equilibrium model with housing markets often assumes that the public authority sets the LTV limit on borrowers (i.e., impatient households) according to a countercyclical macroprudential policy rule (see, e.g., Lambertini et al. 2013, Alpanda and Zubairy 2017). However, this literature generally limits the modelling of the housing sector to property markets. This section investigates: (i) the mechanisms through which aggregate effects induced by this policy rule (i.e., countercyclical LTV limits on residential mortgages) are transmitted to the economy; and (ii) its capacity to stabilize financial and business cycles, in a DSGE model economy with rental housing markets and REIFs which are not subject to macroprudential regulation.

In order to do so, we consider three LTV policy scenarios that differ from one another in the value taken by parameter m_{bx}. Let $\Psi_{m_{bx}} = (m_{bx,1},\ m_{bx,2},\ m_{bx,3})$ be a vector containing information on the value that macroprudential policy parameter m_{bx} takes under scenario h, for $h = 1, 2, 3$. For the purpose of this exercise, we assume that $\widetilde{\Psi}_{m_{bx}} = (-5,\ -10,\ -15)$ and $x_t = Y_t$. Each of these policy scenarios is compared against the baseline scenario of no countercyclical LTV limits (i.e., $m_{bx} = 0.00$). Since the analysis presented in this section is performed under the assumption that REIFs are not subject to any countercyclical macroprudential regulation, $m_{fx} = 0.00$ under all scenarios.

We describe the transmission of cyclical effects induced by countercyclical LTV limits on resi-

[24] 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.

[25] In particular, two main objectives of macroprudential policy are to prevent the endogenous build-up of systemic risk and to smooth the financial cycle (see, e.g., Constancio 2017). While the modelling of the former is less trivial and is not subject to a broad consensus, the proposed set-up offers an environment in which the capacity of macroprudential policies to smooth the financial cycle can be investigated. A complementary list of macroprudential policy objectives that also refers to the one on smoothing the financial cycle can be found at the ECB's webpage: https://www.ecb.europa.eu/ecb/tasks/stability/html/index.en.html

dential mortgages by plotting the impulse responses of key selected aggregates to a positive non-housing technology shock under the different scenarios (see figure 3). A positive productivity shock exerts an upward pressure on non-housing output that leads to a tightening in the LTV limit on residential mortgages for all policy scenarios that satisfy $m_{bx} < 0$. In response to a countercyclical tightening in residential mortgage lending standards, borrowers reduce their demand for credit and partially replace property housing (i.e., collateral), $H^p_{b,t}$, with rental services provided by savers and REIFs.[26] Savers respond by increasing their housing stock (both for owner-occupied and rental purposes) and promote an expansion in rental services' supply both, directly (by supplying more rental services themselves) and indirectly, by reallocating credit towards the REIF industry. The magnitude of these substitution effects and reallocation of resources increases with the degree of countercyclical responsiveness of the policy rule. For each household type, due to the complementarities between the consumption of durables and that of non-durables, patterns of non-durables consumption have similarities to those of housing services (see expressions 9 and 9).

Several destabilizing aggregate effects follow from this policy - induced reallocation of resources. First, the increase in housing investment, $q_t IH_t$, property prices, q_t, and the stock of total housing, H_t, is amplified since the required increase in housing demand by savers and REIFs more than compensates the decrease in borrowers demand for property housing. Second, due to the complementarities between durables and non-durables, the volatiliy of savers and borrowers' aggregate consumption (i.e., $Z_{s,t}$ and $Z_{b,t}$) also increase with the degree of countercyclical responsiveness of the LTV rule. Third, due to complementarities across productive factors, the increase in the supply of rental services also amplifies total output volatility through the non-housing production sector. That is, in this environment countercyclical LTV rules on residential mortgages destabilize real economic activity through various demand and supply channels.

In addition, the capacity of this policy rule to smooth the credit cycle is more limited in this environment. As borrowers react by partially replacing owner-occupied housing with rental services, their demand for credit decreases. That is, such effect amplifies the downward pressure on lending exerted by the tightening in the LTV limit from the credit supply side and if sufficiently large, it could cause total credit to actually become more volatile and even countercyclial. As shown in figure C.1, this policy rule stabilizes total lending only if its degree of countercyclical responsiveness is sufficiently low. Nonetheless, even if the rule is adequately calibrated so as to smooth lending over the cycle, it still amplifies fluctuations in housing investment and property prices and the impact it has on the volatility of real GDP is negligible to non-existent. These findings apply to the different types of shocks that are assumed to hit this model economy.

Figure 4 displays the impulse responses of key selected aggregates to the same exogenous

[26] Due to this countercyclical tightenting in mortgage lending standards, credit and property housing become costlier to borrowers. Due to the imperfect substitutability between owner-occupied housing and rental services captured by expression (10), borrowers react by partially replacing property housing with rental services.

shock in the same model but without rental housing markets and REIFs.[27] The conclusions fundamentally differ from those described above for the case of the model with rental housing and REIFs along three main dimensions. First, the downward adjustment in borrowers' demand for loans is more limited since there are no rental services that can partially replace owner-occupied housing. Second, there is no such direct and indirect (via credit to REIFs) reallocation of resources (in the form of rental services) towards the non-housing sector as there are no rental housing services supplied to these firms. Third, savers fundamentally adjust by increasing their demand for owner-occupied housing. Such increase, roughly matches the decrease in borrowers' housing demand and, thus, the increase in the stock of total housing during the first quarters after the shock is not materially amplified under a countercyclical LTV rule on residential mortgages. In other words, as in any other standard general equilibrium model with housing collateral constraints and property markets, this macroprudential policy rule can effectively contribute to tame credit and business cycles through their direct smoothing effect on credit supply.

Interestingly, in the model without REIFs but with rental housing markets (fully operated by savers under perfect competition) the conclusions from a stabilization perspective are very similar to those that can be drawn from the calibrated model with REIFs presented in section 3. This is the case because, even in the absence of REIFs, borrowers partially replace owner-occupied housing with rental services and savers reallocate resources to increase rental services' supply, which not only affects borrowers but also non-housing producing firms. Therefore, why is it relevant to account for the activity performed by REIFs in real estate and credit markets from a macroprudential perspective? The next section answers this question by studying the transmission and stabilization capacity of countercyclical LTV rules on loans to REIFs in the same environment.

5 Macroprudential Regulation and Real Estate Investment Firms

This section investigates the transmission and main business cycle effects of setting the LTV ratio on loans to REIFs according to a countercyclical policy rule (see expression 31). Then, the capacity of this policy rule to smooth the financial cycle is studied and compared against that of countercyclical LTV rules on residential mortgages (expression 30).

[27] In particular, we simulate a model whose parameter values are identical to those presented in section 3.2 and whose specification is identical to the one summarized in section 3.1 with the exception that there are neither rental housing markets nor REIFs.

5.1 Transmission

Again, we consider three LTV policy scenarios that differ from one another in the value taken - in this case - by parameter m_{fx}. Let $\Psi_{m_{fx}} = (m_{fx,1},\ m_{fx,2},\ m_{fx,3})$ be a vector containing information on the value that macroprudential policy parameter m_{fx} takes under scenario h, for $h = 1,\ 2,\ 3$. For the purpose of this exercise, we assume that $\widetilde{\Psi}_{m_{fx}} = (-5,\ -10,\ -15)$ and $x_t = Y_t$. Each of these policy scenarios is compared against the baseline scenario of no countercyclical LTV limits (i.e., $m_{fx} = 0.00$). In order to isolate the effects of macroprudential regulation on REIFs, we assume that $m_{bx} = 0.00$ under all scenarios.

Figure 5 depicts the impulse responses of selected aggregates to the same exogenous non-housing productivity shock. A tightening in lending standards to REIFs implies that these agents adjust by demanding less housing and supplying less rental services to borrowers and non-housing producing firms. A more stringent REIF rental services' supply exerts an upward pressure on the price of these differentiated rental varieties. Crucially, savers reallocate their resources to increase their demand for housing and their supply of rental services. Consequently, prices in the perfectly competitive segment of rental housing markets evolve in a smoother fashion. Borrowers and non-housing producing firms react by partially replacing costlier REIF rental services with those provided by savers without adjusting owner-occupied housing. In fact, borrowers' levels of lending and (owner-occupied) housing collateral are not affected by this policy rule. That is, the adjustment in response to exogenous shocks under this policy rule fundamentally takes place in rental housing markets (i.e., shift of resources towards the perfectly competitive segment operated by savers) without triggering any fundamental reallocation of resources in credit markets.

Due to the imperfect substitutability between the two main types of rental services (see expressions 11 and 17), these substitution effects imply that borrowers and non-housing producers' aggregate rental services evolve in a smoother fashion and so do borrowers' aggregate consumption and non-housing production. In the case of the housing production sector, it is worth noting that in this case the increase in savers' housing demand does not compensate for the downward adjustment for housing investment by REIFs. The amplitude of fluctuations in housing investment, property prices and the stock of total real estate assets over the cycle decreases. In a nutshell, in this environment a countercyclical LTV rule on loans to REIFs stabilizes financial and business cycles through various supply and demand mechanisms.

The main aggregate responses to the different types of shocks that affect this economy under this policy rule are suggestive of two main advantages of this policy rule when compared to the one studied in section 4 from the perspective of the stabilization capacity. First, credit, property prices and real GDP can simultaneously be stabilized. Second, a high degree of countercyclical responsiveness can be adopted without running the risk of destabilizing housing markets and real economic activity (see figure C.2).

5.2 Stabilization Capacity and the Financial Cycle

This section studies the capacity of the two types of LTV policy rules to smooth the financial cycle. Based on the literature, we consider the credit-to-GDP ratio, total credit and property prices as important determinants of the financial cycle whose dynamics deserve a special attention from macroprudential authorities. Assume that the macroprudential authority solves the following problem under full commitment

$$\arg\min_{\Theta} L^{mp} = \sigma_z^2 + k_Y \sigma_Y^2 + k_{m_j} \sigma_{\Delta mj}^2 \tag{32}$$

where L^{mp} denotes macroprudential losses and Θ refers to the vector of LTV policy parameters with respect to which the policymaker solves the optimization problem. σ_z^2, σ_Y^2 and $\sigma_{\Delta_{m_j}}^2$ are the asymptotic variances of a macroeconomic indicator of the choice of the regulator, $z_t = \{B_t/Y_t, B_t, q_t\}$; total output; and the LTV rule on loans of type/s $j = f, b$. The corresponding weight parameters satisfy $k_Y \geq 0$ and $k_{\Delta m_j} \geq 0$. Note that, while the class and specification of the loss function under consideration is typically used for policy analysis in the macroprudential literature (see, e.g., Angelini et al. 2014; Paoli and Paustian 2017), this paper does not attempt to draw conclusions on the welfare consequences of LTV rules or on optimal LTV policies by means of this exercise. Such aspects are only studied and discussed in the context of the welfare analysis presented in section 6.

Let $\Theta_1 = (m_{fx,1},\ m_{bx,1})$, $\Theta_2 = (m_{fx,2},\ m_{bx,2})$ and $\Theta_3 = (m_{fx,3},\ m_{bx,3})$ be vectors containing information on the values taken by the macroprudential LTV parameter values (i.e., m_{fx} and m_{bx}) under three policy scenarios that are compared against the baseline scenario of no countercyclical LTV limits (i.e., $m_{fx} = 0.00$ and $m_{bx} = 0.00$). Each of these LTV policy scenarios differs from one another in the parameter/s for which problem (32) is solved. In particular, $\widehat{\Theta}_1 = \left(m_{fx,1}^*,\ 0.00\right)$, $\widehat{\Theta}_2 = \left(0.00,\ m_{bx,2}^*\right)$ and $\widehat{\Theta}_3 = \left(m_{fx,3}^*,\ m_{bx,3}^*\right)$, where $\widehat{\Theta}_r$ refers to the specific vector of LTV policy parameter values under scenario $r = 1, 2, 3$, and parameter values that solve problem (32) under each scenario are denoted with an asterisk. In order to identify the optimal simple LTV rule/s within the class/es (30) and/or (31) that solve (32) under each of the three considered policy scenarios, it has been searched over the grid/s of parameter values $m_{bx}\,\{(-15.0) - 0.00\}$ and/or $m_{fx}\,\{(-15.0) - 0.00\}$, depending on the case.

For each policy scenario, table 3 reports the LTV policy parameter value/s that solve problem (32), the value taken by the minimized loss function (and its corresponding percentage change) as well as the standard deviation of the argument/s that enter the loss function. The first three columns of the table report the results of problem (32) under the assumption that $z_t = B_t/Y_t$ and each of them differ from one another in the values taken by weight parameters k_Y and k_{m_j}. The last two columns report the results of the same problem under the assumption that $z_t = \{B_t, q_t\}$,

$k_Y = 0$ and $k_{m_j} = 0$, for $j = f, b$.[28]

The main findings can be summarized as follows. The results reported in the first column underscore that, if the value/s of k_{m_j} is/are sufficiently high, the dynamic LTV rule on loans to borrowers is comparatively more effective in minimizing losses. This is only due to the fact that the optimized degree of responsiveness of m_b - and, thus, the required volatility in such LTV rule - is notably lower than that of m_f. In fact, m_f is more effective in stabilizing the credit-to-GDP ratio and total output than m_b. In line with the findings presented in section 4, rather than stabilizing it, a countercyclical LTV limit on loans to households actually destabilizes the total output.[29] Under the assumption that $k_{m_j} = 0$, for $j = f, b$, a countercyclical LTV rule on REIF loans is comparatively more effective in minimizing losses and complementing it with a countercyclical LTV limit on residential mortgages is not only unnecessary for the purpose of the macroprudential authority but may actually be counterproductive if $k_Y > 0$ (see the second and third columns of table 3). The fourth column reports the main results for the case in which $z_t = B_t$, $k_Y = 0$ and $k_{m_j} = 0$, which make even clearer that m_f is more effective in taming the credit cycle than m_b, whose capacity to stabilize lending is very limited and comes at the cost of amplifying the business cycle. The fifth column of table 3 displays the results of solving problem (32) under the assumption that $z_t = q_t$, $k_Y = 0$ and $k_{m_j} = 0$. In line with the results presented in figures 3 and C.1, a countercyclical LTV limit on residential mortgages does not have any kind of effectiveness in smoothing property prices and the best the macroprudential authority can do under such objective function is to have a countercyclical LTV rule on loans to REIFs in place.

6 Welfare Analysis

This section adopts a normative approach to investigate the welfare implications of the two types of LTV limits in this environment and optimal LTV policy rules. In order to do so, 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:

$$\arg\max_{\Theta} V_0 = \zeta_s V_0^s + \zeta_b V_0^b, \tag{33}$$

where $V_0^{\varkappa} = E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U\left(Z_{\varkappa,t}, \widetilde{N}_{x,t}\right)$ is the expected life-time utility function of household type $\varkappa = s, b$; $\zeta_{\varkappa}$ denotes the utility weight of agent class $\varkappa = s, b$; and Θ refers to the vector of policy

[28] Problem (32) has been solved numerically by means of the *osr* (i.e., optimal simple rule) command in dynare (see Adjemian et al. 2011).

[29] See table 2 for the value taken by the standard deviation of quarterly GDP under the baseline calibration (i.e., in the absence of countercyclical LTV limits).

parameters with respect to which the objective function is maximized. Problem (33) is subject to all the competitive 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:

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U \left(Z_{\varkappa,t}^A, \widetilde{N}_{x,t}^A \right) = E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t U \left[\left(1 + \lambda_{\varkappa}\right) Z_{\varkappa,t}^B, \widetilde{N}_{x,t}^B \right], \tag{34}$$

where superscripts A and B refer to the alternative policy scenario and the baseline case, respectively.

In order to assign values to ζ_s and ζ_b, we rely on two alternative but complementary criteria that are typically used in the literature. Welfare weighting criterion "A" solves problem (33) by further assuming that $\zeta_x = 0.5$, for $\varkappa = s, b$. That is, this criterion assigns the same weight to each of the two agent types.[30] Welfare criterion "B" goes one step further in treating both types of agents equally and solves (33) by further assuming that $\zeta_x = (1 - \beta_x)$, for $\varkappa = s, b$. That ensures the same utility weights across households discounting future utility at different rates.[31] For reporting purposes, welfare weights are normalized, $\widehat{\zeta}_x = \dfrac{(1 - \beta_x)}{[(1 - \beta_s) + (1 - \beta_b)]}$, such that $\widehat{\zeta}_s + \widehat{\zeta}_b = 1$ also under welfare criterion "B".

Figure 6 plots the individual and social welfare effects of changing parameter value m_{fx} for $x_t = \{Y_t, q_t, B_t\}$ under welfare criteria "A" and "B". There is a range of negative m_{fx} values for which both agent types are better off and which is limited due to the trade-offs they face. The workings of countercyclical LTV limits on REIFs induce two main effects that allow for understanding these welfare implications. First, the smoothing effect on lending to REIFs transmits to the rest of the economy and contributes to stabilizing key aggregates that directly give utility to patient and impatient households (i.e., consumption, housing services, and hours worked) along the lines described in section 5.1.

Second, limiting the activity of REIFs in a countercyclical manner triggers a net negative level effect on REIFs' rental supply and borrowings. As REIF rental services become costlier, borrowers partially replace them with those supplied by savers. Due to the complementarities and imperfect substitutability between rental and owner-occupied housing services and between consumption of durables and that of non durables (expression 2), borrowers' demand for owner-occupied housing (and, thus, for lending) and aggregate consumption decrease (see figure C.3). If the degree of

[30] Since the population weights of savers and borrowers are implicitly assumed to be identical, this criterion is equivalent to assuming a utilitarian social welfare function.

[31] This is a welfare weighting criterion typically considered in the macro-finance literature to prevent an overweight of savers' welfare related to a higher discount factor (see, e.g., Lambertini et al. 2013; Alpanda and Zubairy 2017).

countercyclical responsiveness of the rule is sufficiently large, the downward adjustment in demand for total lending is such that the net impact on lenders' (i.e., savers') demand for consumption of durables and non-durables is negatively affected. Not surprisingly, the magnitude of the negative level effect induced by $m_{fx} < 0$ on lending to REIFs becomes more pronounced under $x_t = B_t$. Therefore, in this case the range of negative m_{fx} values for which a countercyclical LTV rule on REIF loans is welfare-improving is comparatively smaller and the optimal degree of policy responsiveness is lower.

The same analysis is carried out for the case of countercyclical LTV limits on residential mortgages. Figure 7 plots the individual and social welfare effects of changing the value of parameter m_{bx} for $x_t = \{Y_t, q_t, B_t\}$ under welfare criteria "A" and "B". In this case, welfare trade-offs faced by each household type are quite different and are also the consequence of volatility effects (illustrated in figures 3 and C.1) and level effects captured in figure C.4. As the degree of responsiveness of a countercyclical LTV limit on residential mortgages increases, holding debt and owner-occupied housing becomes costlier to borrowers. Despite the fact that borrowers partially replace the latter with rental housing services provided by savers and REIFs, such consequence adversely affects borrowers' welfare through housing services and consumption aggregators. Patient households benefit from such increase in demand for rental services directly, as providers, and indirectly, as owners of REIFs. Savers' levels of durables and non-durables consumption increase with the degree of responsiveness of the countercyclical LTV rule on residential mortgages. Such jump in consumption levels is favoured by a decline in net investment in physical capital, promoted by the fall in total lending and the complementarities between labor and physical capital (see figure C.4).

Not surprisingly, attainable savers' welfare gains under a countercyclical LTV rule on residential mortgages are larger under $x_t = \{Y_t, q_t\}$ than under $x_t = B_t$ since the origin of these welfare gains is in the increased borrowers' debt volatility, which is comparatively more moderate if the LTV policy rule responds to steady state deviations in total lending (see figure 7A). By the same token, the range of m_{bx} values for which a countercyclical LTV limit on residential mortgages is welfare increasing for impatient households is comparatively larger under $x_t = B_t$ since the volatility of impatient households' borrowings and real estate holdings is lower (see figure 7B).

Lastly, figure 8 displays the individual and social welfare effects of simultaneously changing parameter values m_{bx} and m_{fx}, for $x_t = Y_t$, under welfare criteria "A" and "B".[32] Despite the fact that $m_{fx} < 0$ is more effective in smoothing key economic aggregates - such as lending and real GDP - than $m_{bx} < 0$, the negative level effect induced by the former implies that attainable welfare gains generated by the latter are comparatively larger. Nonetheless, and arguably due to the different transmission channels through which they operate (see figures 3, 5, C.3 and C.4),

[32] See Appendix C for figures displaying the individual and social welfare effects of simultaneously changing parameter values m_{bx} and m_{fx}, for $x_{b,t} = \{q_t, B_t\}$ under welfare criteria "A" and "B" (i.e., figures C.5 and C.6).

there are complementarities between the two rules. Table 4 confirms these findings by reporting the corresponding optimized parameter values and welfare gains resulting from solving problem (33) for the two proposed welfare criteria and under four policy scenarios (i.e., $\widehat{\Theta}_1$, $\widehat{\Theta}_2$, $\widehat{\Theta}_3$ and $\widehat{\Theta}_4$).[33] Policy parameter vectors $\widehat{\Theta}_1$, $\widehat{\Theta}_2$, $\widehat{\Theta}_3$ coincide with those already considered in section 5.2. In contrast to $\widehat{\Theta}_3$, policy parameter vector $\widehat{\Theta}_4 = \left(m^*_{fx^*_f,4},\ m^*_{bx^*_b,4}\right)$ solves problem (33) by simultaneously optimizing not only with respect to the macroprudential policy parameter of both rules, but also with respect to the indicator entering the LTV rule on loans to REIFs, $x_{f,t} = \{Y_t, q_t, B_t\}$, and the one that is relevant for the LTV rule on loans to households, $x_{b,t} = \{Y_t, q_t, B_t\}$.

In order to identify the welfare-maximizing LTV rule/s within the class/es (30) and/or (31) that solve (32) under each of the four policy scenarios, it has been searched over the grid/s of parameter values $m_{bx}\,\{(-6.0) - 0.00\}$ and/or $m_{fx}\,\{(-6.0) - 0.00\}$, depending on the case.[34] For the case of policy parameter vector $\widehat{\Theta}_4$, it has also been searched over $x_{f,t} = \{Y_t, q_t, B_t\}$ and $x_{f,t} = \{Y_t, q_t, B_t\}$ resulting in $x^*_{f,t} = Y_t$ and $x^*_{b,t} = B_t$. While attainable welfare gains are larger under policy scenario $\widehat{\Theta}_2$ than under scenario $\widehat{\Theta}_1$ (for both, savers and borrowers), jointly optimizing with respect to m_{bx} and m_{fx} (i.e., scenario $\widehat{\Theta}_3$) under $x_t = \{Y_t, q_t\}$ allows for savers and borrowers to benefit from somewhat more sizable welfare gains. In addition, if macroeconomic indicators entering each of the rules can differ (i.e., scenario $\widehat{\Theta}_4$), attainable welfare gains for savers and borrowers are even larger.

The next section reveals that, under certain alternative but plausible specifications and parameterizations of the model, welfare gains induced by an optimal LTV rule on lending to REIFs and its complementarities with LTV limits on residential mortgages are significantly larger due to more moderate negative level effects.

7 Robustness Checks

This section investigates the robustness of the main welfare effects and trade-offs triggered by countercyclical LTV rules on loans to REIFs to changes in key parameter values and assumptions that have been chosen for empirically relevant purposes. First, we study the welfare implications of altering the value of certain parameters.[35] Parameter values η_r and η_c provide information about: (i) the degree of substitutability between rental services provided by savers and those provided by REIFs, and (ii) the market power institutional investors have in the segment of rental

[33] In each case, the model is solved by using second-order perturbation techniques in Dynare. 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. This approach ensures that the effects of aggregate uncertainty are taken into account.

[34] These grids of parameter values have been chosen on the basis of the welfare trade-offs identified in figures 6 and 7.

[35] Unless otherwise stated, these welfare implications are investigated under the assumption that $x_t = Y_t$.

housing markets operated by them, aspects for which empirical studies are not readily available. In particular, an increase in η_r and η_c fosters competition in the segment of the rental housing market operated by REIFs. That has positive welfare consequences for borrowers (i.e., renters) but also for savers, who benefit in their capacity as rental service providers and despite the lower dividends from REIFs (see figure 9). Interestingly, the optimal degree of responsiveness of this LTV rule - measured by m^*_{fx} - significantly increases with η_r and η_c (see figure 10). As the values of these two parameters rise: (i) the quantity of REIFs' rental services supplied in equilibrium increase along with demand for credit (as this segment of the rental market becomes more competitive), which improves the stabilization capacity of m_{fx}, and (ii) the negative level effect induced by a countercyclical LTV rule on REIF loans vanishes. As shown in figure C.7, if the elasticity of substitution between types of rental services is sufficiently high, REIFs' rental supply no longer decreases with the degree of responsiveness of the LTV policy rule. REIFs' rental prices tend to decrease with the degree of responsiveness of the LTV rule and so does borrowers' demand for aggregate housing services. Borrowers and savers' aggregate consumption increase with the degree of responsiveness of the LTV limit on REIF loans through the above outlined mechanisms. The same applies to total hours worked and output. Consequently, as η_r and η_c increase, the optimal degree of responsiveness of a countercyclical LTV rule on REIF loans increases and the complementarities between the two types of LTV rules under consideration become more tangible (see figure 11).[36]

Appendix C contains some additional figures on the welfare implications of the same policy rule when the values of other key parameters change. Figure C.8 captures the main welfare consequences of having a less tight LTV limit on commercial mortgages (i.e., increase in m_f). For any given negative value of parameter m_{fx}, attainable welfare gains are larger due to a more sizable stabilization capacity of LTV rules within the class (31).[37] Consequently, the optimal degree of countercyclical responsiveness of this LTV rule decreases with m_f.[38] Figures C.9 to C.11 display the welfare effects of changing parameter value m_{fx} for different values of key parameters η_b, ω_r, ω_c, A_{fb} and A_{fc}. Empirically-relevant changes in these parameter values affect welfare levels but do not lead to significant shifts in the optimal degree of countercyclical responsiveness of the LTV rule. As η_b (i.e., elasticity of substitution between property and rental housing services) increases, borrowers' demand for owner-occupied housing increases at the expense of rental services. Overall,

[36] in order to clearly show how the social welfare effects of simultaneously changing parameter values m_{bx} and m_{fx} vary with η_r and η_c, the corresponding grid/s of parameter values have been expanded to m_{bx} $\{(-6.0) - 3.0\}$ and m_{fx} $\{(-36.0) - 0.00\}$. Allowing for $m_{bx} > 0$ also permits us to confirm that, despite the destabilization effects of countercyclical LTV rules on loans to borrowers, these are socially preferred to procyclical rules of the same type.

[37] Note that the stabilization capacity of countercyclical LTV rules on lending to REIFs increases with the amount of debt held by fund managers.

[38] Recall from figure C.2 that the magnitude of the negative level effect induced by this class of LTV rules increases with the degree of countercyclical responsiveness of the rule.

borrowers' consumption of durables and non-durables increases since housing services become less costly due to a lower dependance on rental services provided by REIFs under monopolistic competition. This shift towards owner-occupied housing services adversely affects savers in their capacity as rental service providers and owners of REIFs. Social welfare levels increase with η_b since the first effect more than compensates the second one (see figure C.9). An increase in the weight of REIFs' rental services in the corresponding CES aggregators, ω_r and ω_c, leads to a substitution of savers' rental services with comparatively costlier REIFs' rental services which adversely affects borrowers' welfare. The net impact on savers' welfare levels is positive due to the increase in REIFs' profits (see figure C.10). Welfare levels attained by patient and impatient households increase with the productivity with which fund managers transform property housing into rental housing services, A_{fb} and A_{fc}. Borrowers benefit from that permanent increase in productivity by partially replacing savers' rental services with those provided by REIFs. Savers benefit from that in their capacity as REIFs' owners (see figure C.11).

Lastly, we investigate the welfare consequences of relaxing the assumption on the non-separability of individual preferences on the consumption of durables and non-durables, which is captured by expenditure CES aggregators (2) and (9) and reflected in households' objective functions, (1) and (7).[39] In particular, figure 12 plots the individual and social welfare effects of changing the value of parameter m_{fx} for $x_t = \{Y_t, q_t, B_t\}$ and welfare criteria "A" and "B" under the assumption that households' objective function is

$$E_0 \sum_{t=0}^{\infty} \beta_{\varkappa}^t \left[\frac{1}{1-\sigma_h} \left(C_{\varkappa,t} - \frac{\widetilde{N}_{\varkappa,t}^{1+\phi}}{(1+\phi)} \right)^{1-\sigma_h} + \gamma_t \log H_{\varkappa,t}^p \right], \tag{35}$$

where $\varkappa = s, b$ refers to the household type and $H_{\varkappa,t}^p = H_{s,t}^p$ if $\varkappa = s$ whereas $H_{\varkappa,t}^p = \widetilde{HX}_{b,t}$ if $\varkappa = b$. Attainable welfare gains are higher under separable preferences not due to the size and transmission mechanisms through which the smoothing effect operates (which are virtually identical to those that apply under non-separable preferences), but to a less sizable negative level effect. As shown in figure C.12, the separability between the preferences on consumption of durables and those on non-durables implies that these two variables no longer comove. Non-durables consumption decreases less or even increase with the degree of countercyclical responsiveness of the LTV rule on REIF loans. As a consequence, hours worked and total output increase with this degree of

[39] Beyond the importance of assuming that households consume a basket of durables and non-durables of the type (2) and (9) 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 in their houses. That is, there are complementarities between the two types of consumption. However, most of macro models assume preferences on the consumption of these two broad types of goods are separable.

responsiveness for a certain relevant range of m_{fx} values, which contributes to a more moderate decline (or to even an increase) in the demand for lending and housing.

8 Conclusion

Based on recent empirical studies, the paper incorporates real estate institutional investors and rental housing markets in a two-sector DSGE model populated by two types of households; savers (landlords) and borrowers (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 leakages in existing macroprudential regulation. The countercyclical response of already existing LTV limits on residential mortgages triggers a reallocation of credit towards the REIF sector that may destabilize financial and business cycles. By way of contrast, countercyclical LTV limits on lending to REIFs are particularly effective in taming such cycles. Nevertheless, due to the different mechanisms through which they operate and to the quantitative importance of the non-trivial level effects they generate, both types of policy rules are welfare-improving and jointly induce more sizable welfare gains than in isolation.

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 in practice in order to improve the effectiveness and stabilization capacity of the macroprudential toolkit through the mechanisms outlined in the paper and which are still not in place: Countercyclical LTV limits on non-bank lending and (dynamic) limits on REIFs' leverage. The Central Bank of Ireland (2021) has recently proposed to adopt the latter in Ireland. Moreover, the quantitative analysis notes that such quantity regulation would allow for reference (competitive) 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.

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Table 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
η_b	Elast, of subst. property - rental housing	1	Standard
$\eta_r; \eta_c$	Elast. of subst. rental RE varieties	2	Standard
m_b	LTV ratio on residential mortgages	0.8	Standard
m_f	LTV ratio on commercial mortgages	0.6	Standard
δ_h	Depreciation rate of RE	0.010	Iacoviello & Neri (2010)
$\delta_0^c; \delta_0^h$	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	0.9906	$B_b/(Y) = 2.1291$
γ	Housing share in Cons. aggregator	0.163	$C/Y = 0.7607$
α	Capital share in non-RE production	0.148	$I/Y = 0.2119$
θ	Capital share in RE production	0.012	$qIH/Y = 0.1176$
ω_n	Weight in labor supply aggregator	0.408	$(qH)/(4Y) = 2.802$
$\omega_r; \omega_c$	REIFs' weight in rental RE aggregator	0.426	$H_f^r/H \approx 0.050$
ω_b	Rental RE weight in RE aggregator	0.429	$X/H = 0.3269$
C. Second moments			
ϕ_k	Capital adj. cost param.	9.80	$\sigma_I \ / \ \sigma_Y = 2.642$
σ_γ	Std. preference shock	0.023	$\sigma_q \ / \ \sigma_Y = 2.429$
σ_{Ax_s}	Std. X_s productivity shock	0.099	$\sigma_C \ / \ \sigma_Y = 0.748$
σ_{Ax_f}	Std. X_f productivity shock	0.001	$\sigma_{B_f} \ / \ \sigma_Y = 6.099$
σ_{Ah}	Std. IH productivity shock	0.010	$\sigma_{IH} \ / \ \sigma_Y = 2.797$
σ_{Ac}	Std. Y_c productivity shock	0.0011	$\sigma_Y = 2.138$

Note: Parameters in A are set to standard values in the literature. Parameters in B are calibrated to match key steady state ratios. Parameters in C are calibrated to match second moments of selected macroeconomic aggregates. Abreviations HH, LTV, RE and REIFs refer to households, loan-to-value ratio, real estate and real estate investment funds, respectively.

Table 2: Calibration targets

Variable	Description	Model	Data
A. First moments			
C/Y	Total consumption-to-GDP ratio	0.7730	0.7607
I/Y	Gross fixed capital formation-to-GDP ratio	0.2270	0.2119
$B_b/(Y)$	HH loans-to-GDP ratio	2.0034	2.1291
$(qH)/(4Y)$	Housing wealth-to-GDP ratio	2.9251	2.8018
qIH/Y	Total construction-to-GDP ratio	0.1170	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	0.3221	0.3269
B. Second moments			
σ_{B_f} / σ_Y	Std. REIFs loans	5.0726	6.099
σ_q / σ_Y	Std. property housing prices	1.1339	2.429
σ_{qIH} / σ_Y	Std. housing investment	3.0853	2.797
σ_I / σ_Y	Std. investment	2.0718	2.642
σ_C / σ_Y	Std consumption	0.7494	0.748
σ_Y	Std(GDP) x 100	2.7434	2.138

Note: All series in Euros are seasonally adjusted and deflated. With regards to the computation of the standard deviation targets, we have linearly detrended the corresponding series after having taken their log value. The standard deviation (Std.) of GDP is in quarterly percentage points. Data targets have been constructed from euro area quarterly data for the period 2002:I-2018:II. Data sources are Eurostat and ECB

Table 3: Macroprudential losses and optimal simple LTV rules

		$k_Y = 0.5$; $k_{m_j} = 0.1^{(1)}$	$k_Y = 0.5$; $k_{m_j} = 0$	$k_Y = 0$; $k_{m_j} = 0$	$z_t = B_t$	$z_t = q_t$
A.$\{m_{fx}\}$						
	$Loss\ Variation^{(2)}$	(-45.2513)	(-60.9154)	(-61.9086)	(-70.6369)	(-28.2496)
	$Loss^{(3)}$	0.7283	0.5199	0.4915	0.5603	0.0715
	$\sigma_z^{(4)}$	7.3637	7.0024	7.0029	7.4714	2.6476
	σ_Y	2.4222	2.3152	2.3179	2.2228	2.1022
	σ_{m_f}	20.0202	26.9179	26.7461	33.0345	41.3478
	$m_{fx}^{(5)}$	-5.938	-8.487	-8.419	-11.0358	-14.998
B. $\{m_{bx}\}$						
	$Loss\ Variation$	(-51.5831)	(-52.3241)	(-54.1130)	(-61.4517)	(0.0000)
	$Loss$	0.6441	0.6342	0.5921	0.7357	0.0996
	σ_z	7.7258	7.7247	7.7246	8.6017	3.1108
	σ_Y	2.8158	2.8167	2.8168	2.8377	2.7434
	σ_{m_b}	3.7698	3.8163	3.8211	4.9294	0.0000
	m_{bx}	-1.254	-1.270	-1.271	-1.635	-0.000
C.$\{m_{fx}, m_{bx}\}$						
	$Loss\ Variation$	(-54.1722)	(-60.9127)	(-61.9175)	(-70.6023)	(-28.2476)
	$Loss$	0.6096	0.5200	0.4914	0.5610	0.0715
	σ_z	7.3585	7.0025	7.0048	7.4827	2.6476
	σ_Y	2.6535	2.3189	2.3365	2.2656	2.1022
	σ_{m_f}	8.4797	26.7184	25.7243	30.6083	4.1348
	σ_{m_b}	2.5484	0.0313	0.1652	0.3706	0.0000
	m_{fx}	-2.267	-8.408	-8.019	-9.975	-14.998
	m_{bx}	-0.909	-0.013	-0.069	-0.161	-0.000

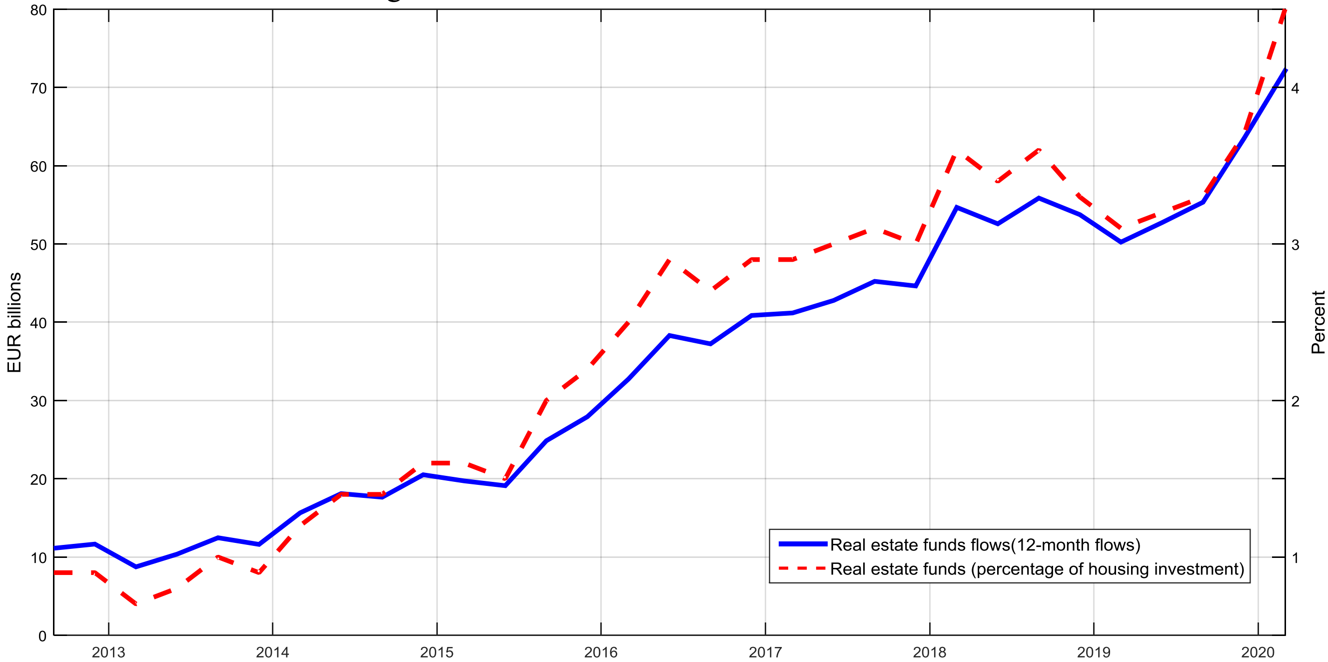
Note:(1) Key information on the parameterization and/or specification of the objective function of the macroprudential authority. Problem (32) has been solved numerically by means of the osr (i.e., optimal simple rule) command in dynare. (2) Percentage change in the value of the loss function under the policy scenario associated to the optimal simple LTV rule, with respect to the baseline scenario. (3) The value of the loss is multiplied by 100. (4) Standard deviations in quarterly percentage points. (5) Value of the policy parameter/s that solve the optimization problem of the macroprudential authority.

Table 4: Welfare gains and optimal LTV rules

	Savers	Borrowers	Social
A. $\{m_{fx}\}$			
I. Welf criterion "A" (i.e., $\zeta_{\varkappa} = 0.5$)			
(i) $m_{fY} = -3.14$	0.0165	0.0198	0.0181
(ii) $m_{fq} = -1.89$	0.0114	0.0078	0.0096
(iii) $m_{fB} = -0.66$	0.0135	0.0107	0.0121
II. Welf criterion "B" (i.e., $\zeta_{\varkappa} = 1 - \beta_{\varkappa}$)			
(i) $m_{fY} = -3.16$	0.0165	0.0198	0.0187
(ii) $m_{fq} = -1.82$	0.0113	0.0079	0.0091
(iii) $m_{fB} = -0.64$	0.0134	0.0107	0.0116
B. $\{m_{bx}\}$			
I. Welf criterion "A" (i.e., $\zeta_{\varkappa} = 0.5$)			
(i) $m_{bY} = -2.44$	0.0777	0.0788	0.0783
(ii) $m_{bq} = -1.64$	0.0616	0.0676	0.0646
(iii) $m_{bB} = -6.00$	0.0301	0.1885	0.1093
II. Welf criterion "B" (i.e., $\zeta_{\varkappa} = 1 - \beta_{\varkappa}$)			
(i) $m_{bY} = -2.09$	0.0598	0.0929	0.0814
(ii) $m_{bq} = -1.43$	0.0507	0.0761	0.0673
(iii) $m_{bB} = -6.00$	0.0301	0.1885	0.1335
C. $\{m_{fx}, m_{bx}\}$			
I. Welf criterion "A" (i.e., $\zeta_{\varkappa} = 0.5$)			
(i) $m_{fY} = -2.51; m_{bY} = -2.53$	0.0855	0.0977	0.0916
(ii) $m_{fq} = -1.57$; $m_{bq} = -1.66$	0.0672	0.0752	0.0712
(iii) $m_{fB} = 0.00$; $m_{bB} = -6.00$	0.0301	0.1885	0.1093
(iv) $m_{fY} = -0.66$; $m_{bB} = -6.00$	0.0308	0.1901	0.1104
II. Welf criterion "B" (i.e., $\zeta_{\varkappa} = 1 - \beta_{\varkappa}$)			
(i) $m_{fY} = -2.62; m_{bY} = -2.17$	0.0692	0.1106	0.0962
(ii) $m_{fq} = -1.55$; $m_{bq} = -1.45$	0.0574	0.0827	0.0739
(iii) $m_{fB} = 0.00$; $m_{bB} = -6.00$	0.0301	0.1885	0.1335
(iv) $m_{fY} = -0.67$; $m_{bB} = -6.00$	0.0308	0.1901	0.1348

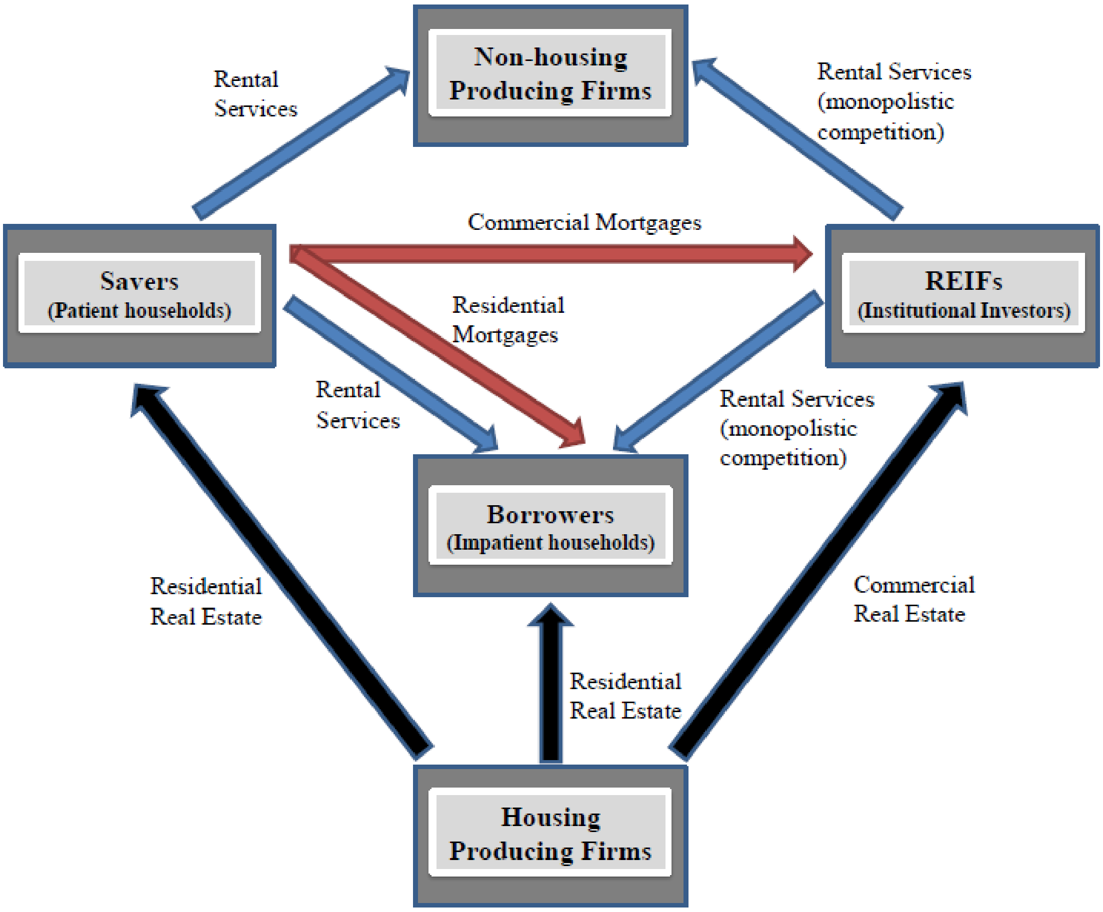
Note: Second-order approximation to the welfare gains associated to the CBDC interest rate rules and the corresponding optimized policy parameter for each of the two proposed welfare criteria. Welfare gains are expressed in percentage permanent consumption.

Figure 1: Real estate funds flows in the euro area



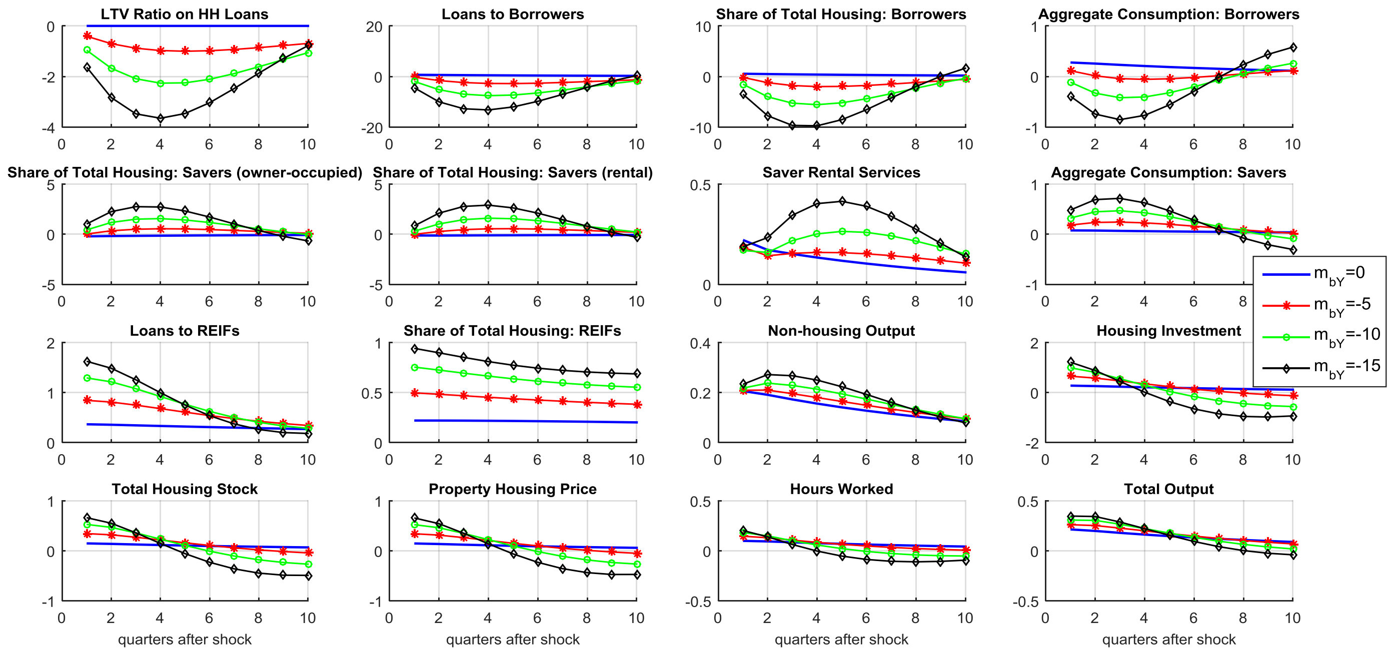
Note: This figure reports real estate funds flows (12-month flows) in the euro are both, in absolute terms and as a percentage of aggregate housing investment in the euro area. Time series are at quarterly frequency and have been plotted for the period 2012:III-2020:I. The figure is based on Battistini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

Figure 2: Flows in real estate and credit markets



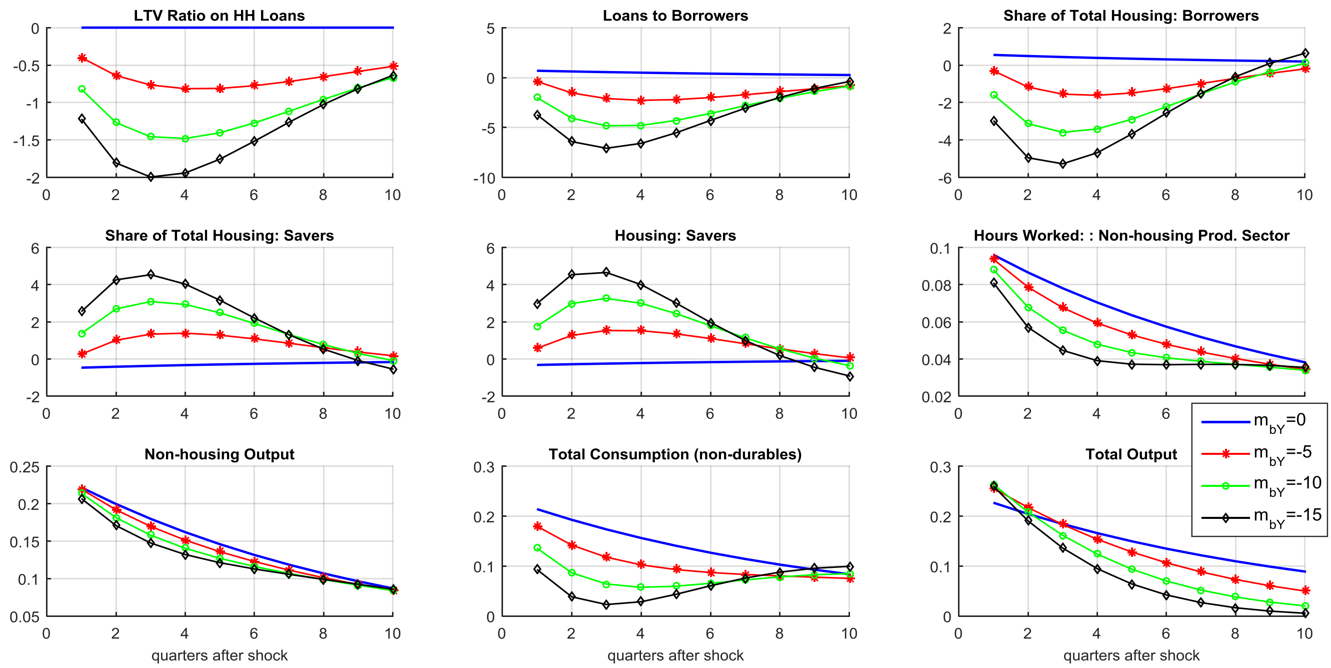
Notes: Black arrows indicate the direction of supply in property markets. Blue arrows refer to the direction of supply in rental housing markets. Red arrows make reference to the direction of supply in mortgage markets.

Figure 3: Transmission (m_{bY}). Impulse-responses to a positive non-housing technology shock



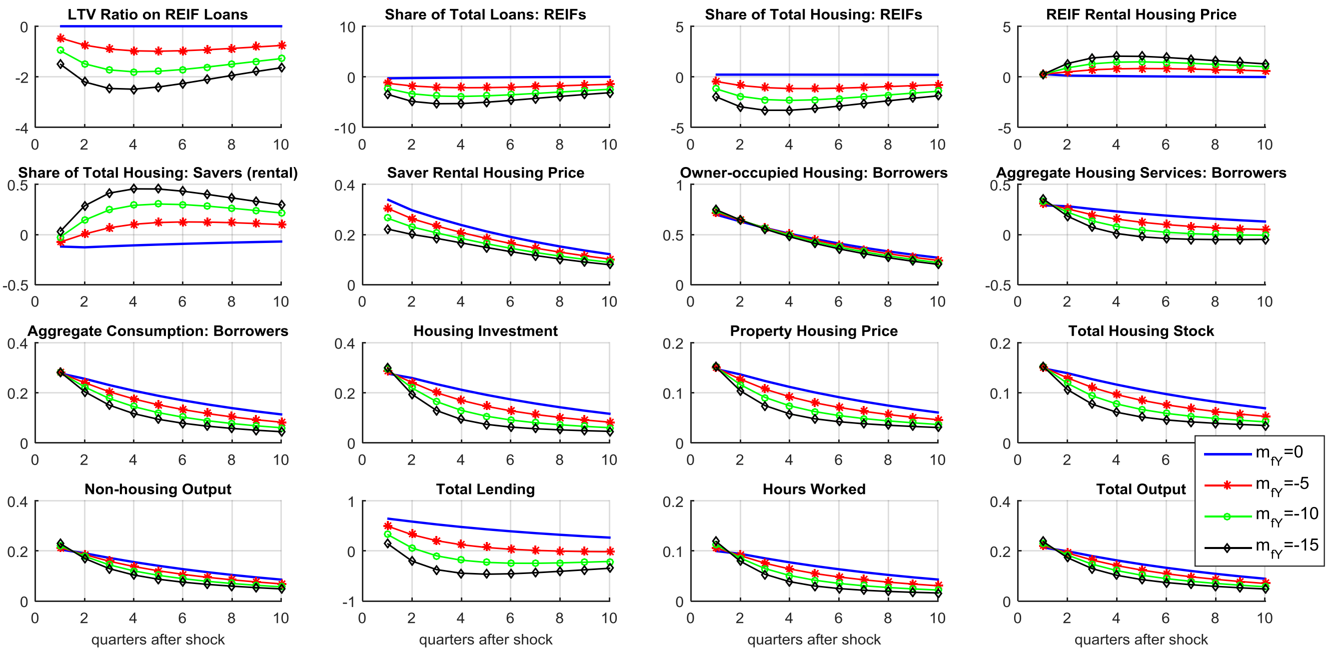
Notes: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario (i.e., m_{fY}=0 and m_{bY}=0). The starred, dotted, and diamond lines make reference to alternative macroprudential policy scenarios under which LTV parameter m_{bY} is equal to-5, -10 and -15, respectively.

Figure 4: Transmission (m_{bY}). The model without REIFs and rental housing markets



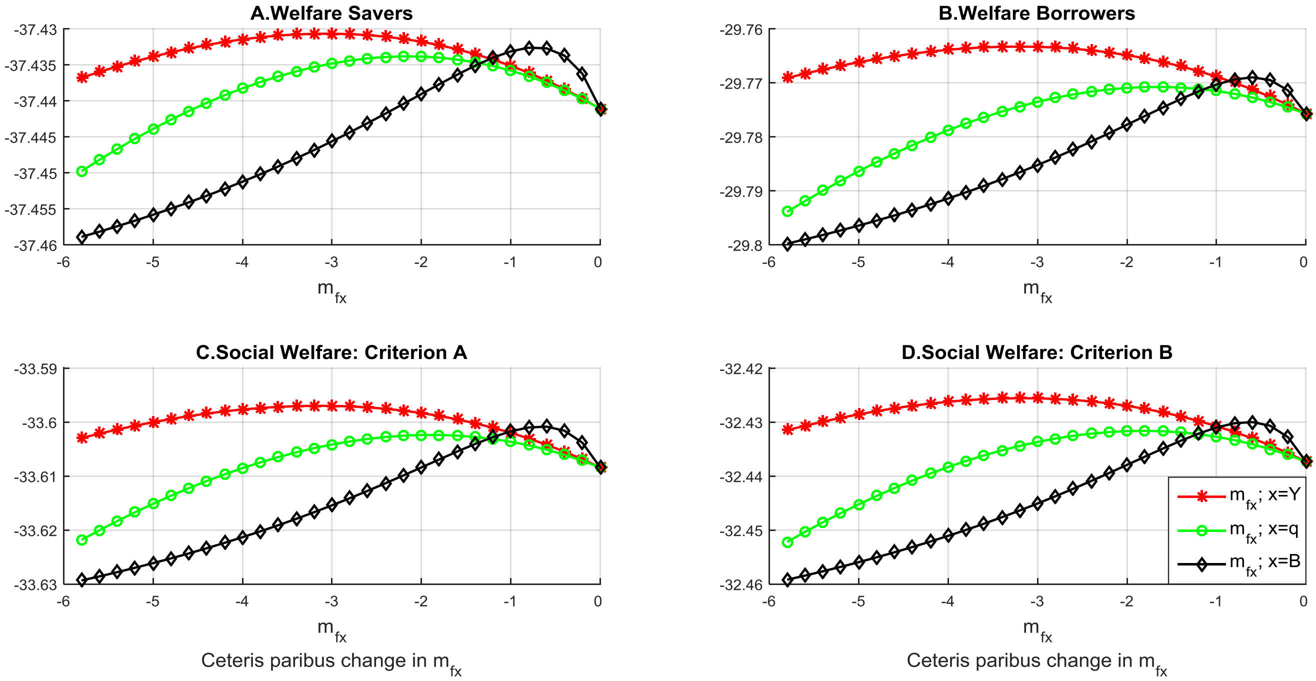
Notes: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario (i.e., m_{fY}=0 and m_{bY}=0). The starred, dotted, and diamond lines make reference to alternative macroprudential policy scenarios under which LTV parameter m_{bY} is equal to-5, -10 and -15, respectively.

Figure 5: Transmission (m_{fY}). Impulse-responses to a positive non-housing technology shock



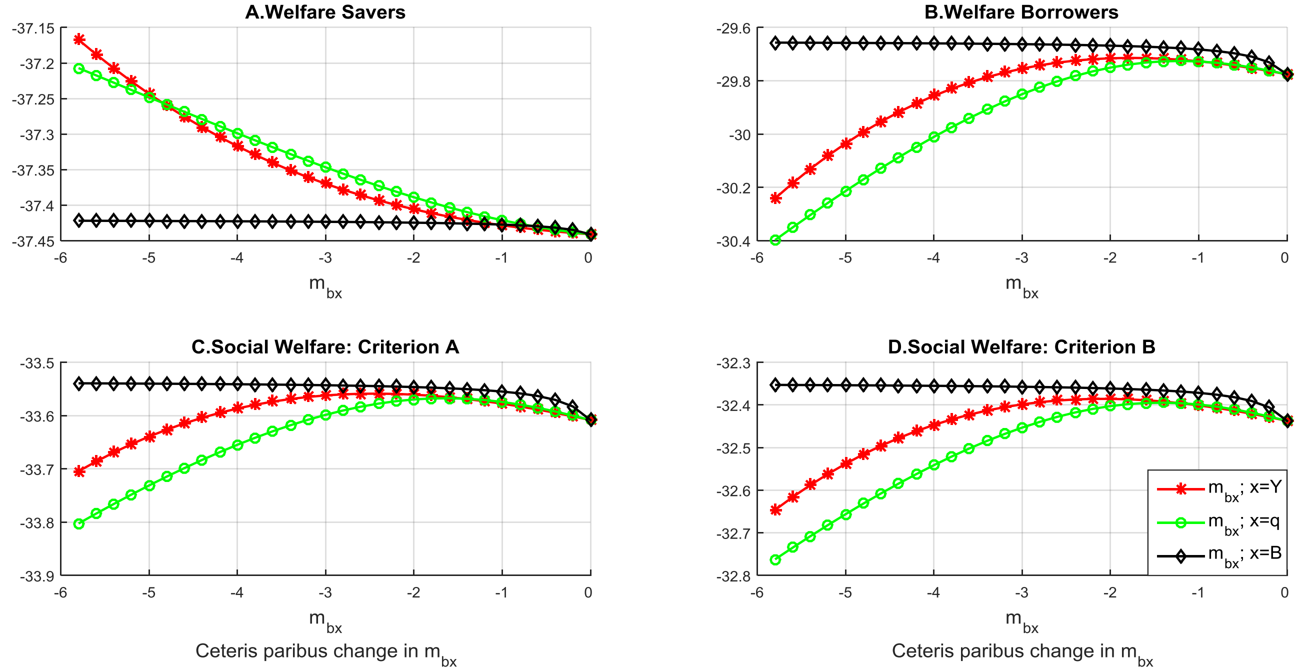
Notes: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario (i.e., m_{fY}=0 and m_{bY}=0). The starred, dotted, and diamond lines make reference to alternative macroprudential policy scenarios under which LTV parameter m_{fY} is equal to-5, -10 and -15, respectively.

Figure 6: Welfare effects of dynamic LTV policy rules on lending to REIFs



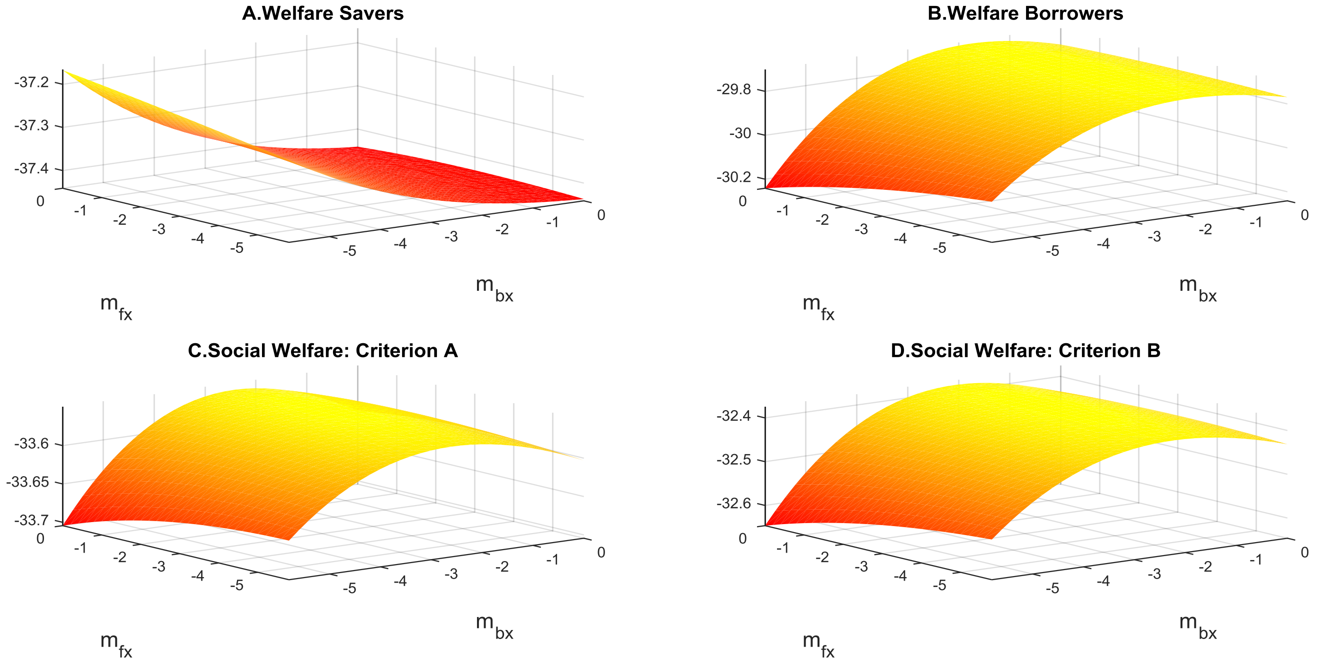
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria “A” and “B” as a function of macroprudential policy parameter m_{fx}. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator “x” is equal to Y, q, and B, respectively.

Figure 7: Welfare effects of dynamic LTV policy rules on lending to households



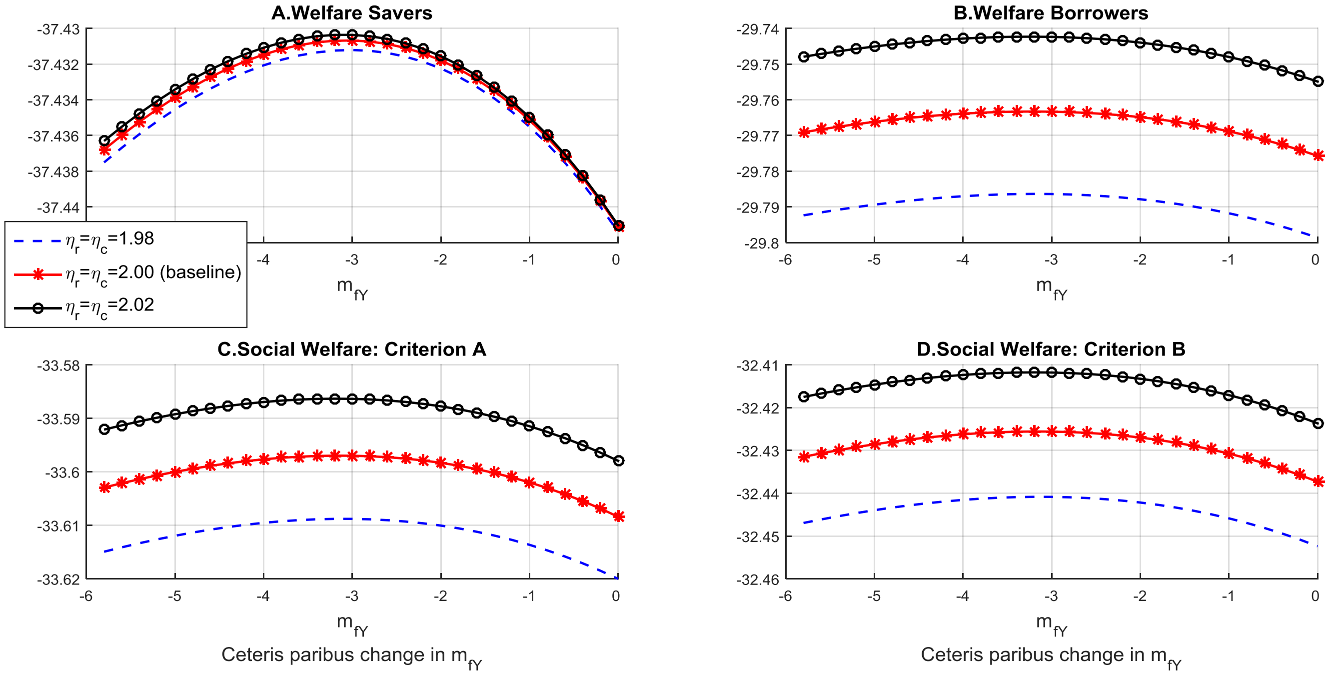
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of macroprudential policy parameter m_{bx}. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator "x" is equal to Y, q, and B, respectively.

Figure 8: Welfare effects of dynamic LTV policy rules on lending to REIFs and households (x=Y)



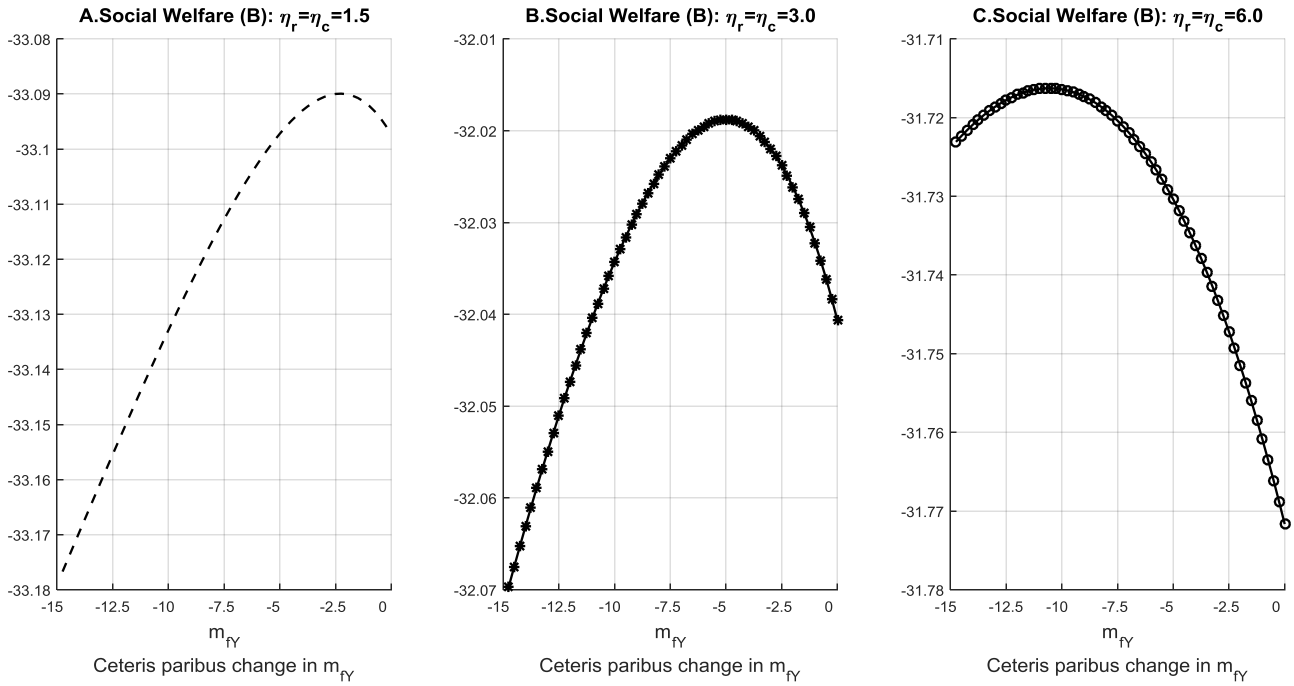
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of macroprudential policy parameters m_{fx} and m_{bx} under the assumption that macroeconomic indicator "x" is equal to Y.

Figure 9: Robustness checks: η_r, η_c (welfare effects of ceteris paribus changes in m_{fY})



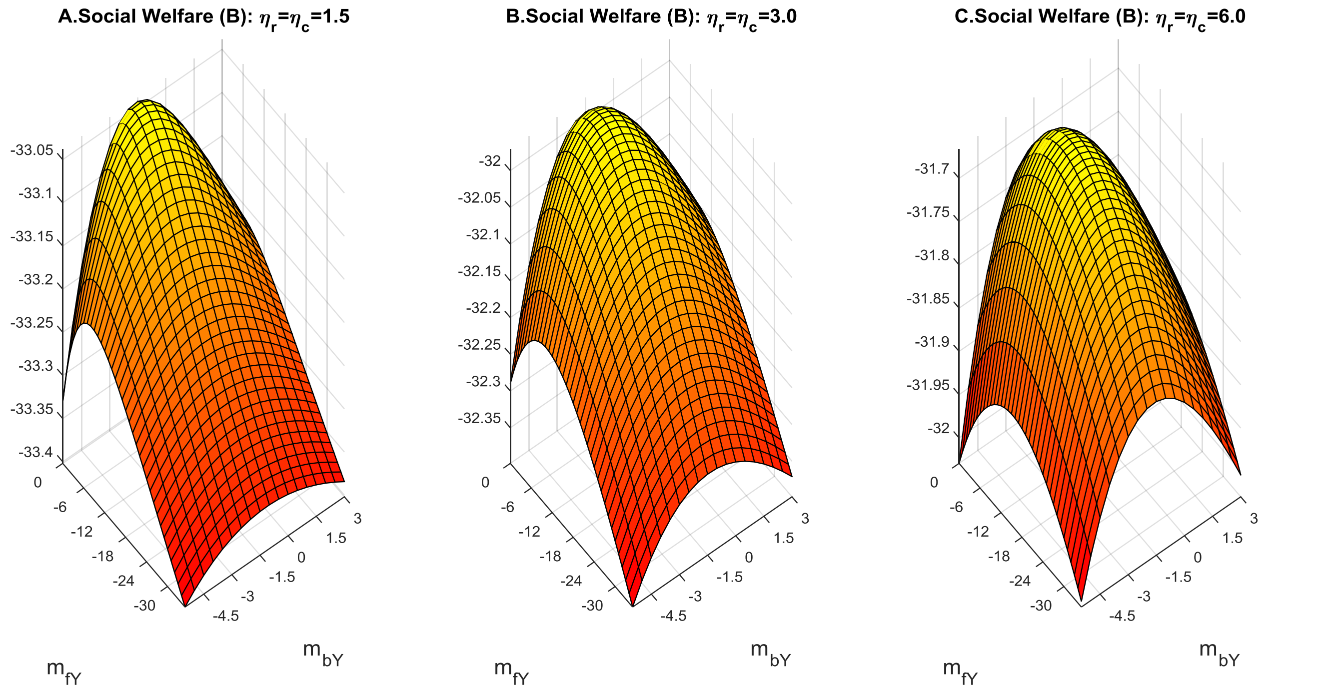
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of policy parameter m_{fY}, for alternative values of parameters η_r and η_c. The starred line refers to the baseline calibration whereas the dashed and dotted lines relate to alternative parameterization scenarios.

Figure 10: Robustness checks: η_r, η_c & the welfare trade-off (welfare effects of ceteris paribus changes in m_{fY})



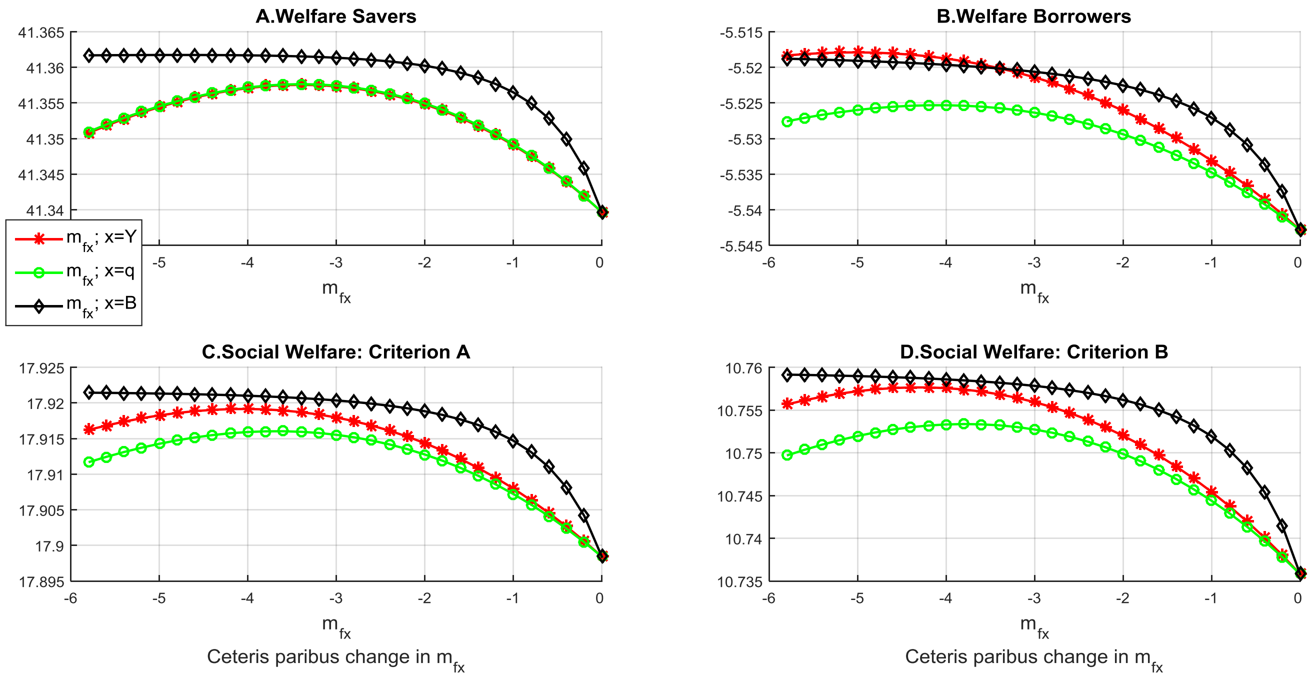
Notes: Second-order approximation to the unconditional social welfare under welfare criterion "B" as a function of policy parameter m_{fY}, for alternative values of parameters η_r and η_c.

Figure 11: Robustness checks: η_r, η_c & the welfare trade-off (welfare effects of ceteris paribus changes in m_{fY} and m_{bY})



Notes: Second-order approximation to the unconditional social welfare under welfare criterion "B" as a function of policy parameters m_{fY} and m_{bY} for alternative values of parameters η_r and η_c.

Figure 12: Robustness checks: Separable preferences (welfare effects of ceteris paribus changes in m_{fx})



Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of macroprudential policy parameter m_{fx}, under the assumption that preferences on consumption of durables and non-durables are separable. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator "x" is equal to Y, q, and B, respectively.

A 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.

B Equations of the Model

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

B.1 Patient Households

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

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

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

$$\widetilde{N}_{s,t} = \left[\omega_n^{1/\varepsilon} \left(N_{s,t}^c\right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N_{s,t}^h\right)^{(1+\varepsilon)/\varepsilon}\right]^{\varepsilon/(\varepsilon+1)}, \quad \text{(B.3)}$$

$$K_{s,t}^c = (1-\delta_t^c)K_{s,t-1}^c + I_t^c, \quad \text{(B.4)}$$

$$K_{s,t}^h = (1-\delta_t^h)K_{s,t-1}^h + I_t^h, \quad \text{(B.5)}$$

$$\delta_t^c\left(u_t\right) = \delta_0^c + \delta_1^c(u_t^c - 1)^2 + \frac{\delta_2^c}{2}\left(u_t^c - 1\right)^2, \quad \text{(B.6)}$$

$$\delta_t^h\left(u_t\right) = \delta_0^h + \delta_1^h(u_t^h - 1)^2 + \frac{\delta_2^h}{2}\left(u_t^h - 1\right)^2, \quad \text{(B.7)}$$

$$X_{s,t} = A_{s,t}H_{s,t-1}^r. \quad \text{(B.8)}$$

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

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

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

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

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

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

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

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

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

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

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

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

B.2 Impatient Households

The representative impatient household chooses the trajectories of demand for loans $B_{b,t}$, labor supply in each of the two production sectors, $N^c_{b,t}$ and $N^h_{b,t}$, consumption $C_{b,t}$, owner-occupied housing services, $H^p_{b,t}$, rental housing services provided by savers under perfect competition, $X_{sb,t}$, and rental housing services provided by institutional investors under monopolistic competition, $x_{fb,t}(i)$, $\forall i \in [0,1]$, that maximize its objective function subject to the following restrictions:

$$C_{b,t} + q_t \left[H^p_{b,t} - (1-\delta_h) H^p_{b,t-1} \right] + P_{s,t} X_{sb,t} + \int_0^1 p_{fb,t}(i)\, x_{fb,t}(i)\, di + R_{b,t-1} B_{b,t-1} = W^c_t N^c_{bt} + W^h_t N^h_{b,t} + B_{b,t}, \tag{B.18}$$

$$\widetilde{N}_{b,t} = \left[\omega_n^{1/\varepsilon} \left(N^c_{b,t} \right)^{(1+\varepsilon)/\varepsilon} + (1-\omega_n)^{1/\varepsilon} \left(N^h_{b,t} \right)^{(1+\varepsilon)/\varepsilon} \right]^{\varepsilon/(\varepsilon+1)}, \tag{B.19}$$

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

$$\widetilde{HX}_{b,t} = \left[\omega_b^{1/\eta_b} \left(\widetilde{X}_{b,t} \right)^{(\eta_b-1)/\eta_b} + (1-\omega_b)^{1/\eta_b} \left(H^p_{b,t} \right)^{(\eta_b-1)/\eta_b} \right]^{\eta_b/(\eta_b-1)}, \tag{B.21}$$

$$\widetilde{X}_{b,t} = \left[\omega_r^{1/\eta_r} \left(x_{fb,t}\right)^{(\eta_r-1)/\eta_r} + (1-\omega_r)^{1/\eta_r} \left(X_{sb,t}\right)^{(\eta_r-1)/\eta_r}\right]^{\eta_r/(\eta_r-1)}, \tag{B.22}$$

$$B_{b,t} \leq m_{b,t} E_t \left(\frac{q_{t+1}}{R_{bt}} H^p_{b,t}\right). \tag{B.23}$$

The resulting optimality conditions read

$$\lambda_{b,t} = (1-\gamma_t)\frac{Z_{b,t}}{C_{b,t}} \left(Z_{b,t} - \frac{\widetilde{N}_{b,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h}, \tag{B.24}$$

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

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

$$\begin{aligned} \lambda_{b,t}\left[q_t - E_t\left(m_{b,t}\frac{q_{t+1}}{R_{b,t}}\right)\right] &= \\ = \ \gamma_t \frac{Z_{b,t}}{\widetilde{HX}_{b,t}} \left(Z_{b,t} - \frac{\widetilde{N}_{b,t}^{1+\phi}}{(1+\phi)}\right)^{-\sigma_h} &\left[(1-\omega_b)\frac{\widetilde{HX}_{b,t}}{H^p_{b,t}}\right]^{1/\eta_b} + \beta_b E_t\left[q_{t+1}\lambda_{b,t+1}\left(1-\delta_h - m_{b,t}\right)\right], \end{aligned} \tag{B.27}$$

$$P_{s,t} = \frac{\gamma_t}{(1-\gamma_t)} \frac{C_{b,t}}{\widetilde{HX}_{b,t}} \left[\omega_b \frac{\widetilde{HX}_{b,t}}{\widetilde{X}_{b,t}}\right]^{1/\eta_b} \left[(1-\omega_r)\frac{\widetilde{X}_{b,t}}{X_{sb,t}}\right]^{1/\eta_r}, \tag{B.28}$$

$$p_{fb,t}(i) = \frac{\gamma_t}{(1-\gamma_t)} \frac{C_{b,t}}{\widetilde{HX}_{b,t}} \left[\omega_b \frac{\widetilde{HX}_{b,t}}{\widetilde{X}_{b,t}}\right]^{1/\eta_b} \left[\omega_r \frac{\widetilde{X}_{b,t}}{x_{fb,t}(i)}\right]^{1/\eta_r}. \tag{B.29}$$

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

B.3 Non-housing Producing Firms

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

$$Y_{c,t} = A_{c,t}(u^c_t K^c_{t-1})^{\alpha} \widetilde{X}^{\nu}_{c,t} N_t^{c(1-\alpha-\nu)}, \tag{B.30}$$

$$\widetilde{X}_{c,t} = \left[\omega_c^{1/\eta_c} \left(x_{fc,t}\right)^{(\eta_c-1)/\eta_c} + (1-\omega_c)^{1/\eta_c} \left(X_{sc,t}\right)^{(\eta_c-1)/\eta_c}\right]^{\eta_c/(\eta_c-1)}. \tag{B.31}$$

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:

$$W_t^c = (1-\alpha-\nu)\frac{Y_{c,t}}{N_t^c}, \tag{B.32}$$

$$r_t^c = \alpha\left(\frac{Y_{c,t}}{u_t^c K_{t-1}^c}\right), \tag{B.33}$$

$$P_{s,t} = \nu\frac{Y_{c,t}}{\widetilde{X}_{c,t}}\left[(1-\omega_c)\frac{\widetilde{X}_{c,t}}{X_{sc,t}}\right]^{1/\eta_c}, \tag{B.34}$$

$$p_{fc,t} = \nu\frac{Y_{c,t}}{\widetilde{X}_{c,t}}\left[\omega_c\frac{\widetilde{X}_{c,t}}{x_{fc,t}}\right]^{1/\eta_c}. \tag{B.35}$$

B.4 Housing Producing Firms

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

$$IH_t = A_{h,t}(u_t^h K_{t-1}^h)^{\theta} N_t^{h(1-\theta)}. \tag{B.36}$$

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

$$W_t^h = (1-\theta)\frac{q_t IH_{,t}}{N_t^h}, \tag{B.37}$$

$$r_t^h = \theta\left(\frac{q_t IH_t}{u_t^h K_{t-1}^h}\right). \tag{B.38}$$

B.5 Real Estate Fund Managers

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

$$\Pi_{f,t}+R_{b,t}B_{f,t-1}+q_t\left[H_{fb,t}^r + H_{fc,t}^r - (1-\delta_h)\left(H_{fb,t-1}^r + H_{fc,t-1}^r\right)\right] = B_{f,t}+ P_{fb,t}X_{fb,t}+ P_{fc,t}X_{fc,t}+J_{f,t}, \tag{B.39}$$

$$B_{f,t} \leq m_{f,t}E_t\left[\frac{q_{t+1}}{R_{b,t}}\left(H_{fr,t}^r + H_{fc,t}^r\right)\right], \tag{B.40}$$

$$X_{fb,t} = \overline{A}_{fb,t}H_{fb,t-1}^r, \tag{B.41}$$

$$X_{fc,t} = \overline{A}_{fc,t}H_{fc,t-1}^r. \tag{B.42}$$

The resulting optimality conditions read:

$$\Pi_{f,t}^{-1}\left[q_t - m_{f,t}E_t\left(\frac{q_{t+1}}{R_{b,t}}\right)\right] = \Lambda_{t,t+1}^{e}E_t\left\{\Pi_{f,t+1}^{-1}\left[P_{fr,t+1}\overline{A}_{fr,t+1}q_{t+1}(1-\delta_h - m_{f,t})\right]\right\}, \tag{B.43}$$

$$\Pi_{f,t}^{-1}\left[q_t - m_{f,t}E_t\left(\frac{q_{t+1}}{R_{b,t}}\right)\right] = \Lambda_{t,t+1}^{e}E_t\left\{\Pi_{f,t+1}^{-1}\left[P_{fc,t+1}\overline{A}_{fc,t+1}q_{t+1}(1-\delta_h - m_{f,t})\right]\right\}. \tag{B.44}$$

B.6 Real Estate Fund Retailers

The representative fund retailer maximizes her objective function. After having imposed a symmetric equilibrium, the first order conditions yield:

$$p_{fb,t} = \frac{\eta_r}{(\eta_r - 1)}P_{fb,t}, \tag{B.45}$$

$$p_{fc,t} = \frac{\eta_c}{(\eta_c - 1)}P_{fc,t}. \tag{B.46}$$

B.7 Macroprudential Authority

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

$$m_{b,t} = \rho_b m_{b,t-1} + (1-\rho_b)m_b + (1-\rho_b)\, m_{bx}(\frac{x_t}{x} - 1), \tag{B.47}$$

$$m_{f,t} = \rho_f m_{f,t-1} + (1-\rho_f)m_f + \left(1-\rho_f\right) m_{fx}(\frac{x_t}{x} - 1). \tag{B.48}$$

B.8 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:

$$Y_t = C_{,t} + I_{c,t} + I_{h,t} + q_t IH_t + \Phi_c(K_t^c) + \Phi_h(K_t^h). \tag{B.49}$$

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

$$N_t^c = N_{s,t}^c + N_{b,t}^c, \tag{B.50}$$

$$N_t^h = N_{s,t}^h + N_{b,t}^h. \tag{B.51}$$

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

$$K_{s,t}^{c} = K_{t}^{c}, \tag{B.52}$$

$$K_{s,t}^{h} = K_{t}^{h}. \tag{B.53}$$

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

$$B_t = B_{b,t} + B_{f,t}. \tag{B.54}$$

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

$$X_{s,t} = X_{sb,t} + X_{sc,t}, \tag{B.55}$$

$$X_{fb,t} = x_{fb,t}, \tag{B.56}$$

$$X_{fc,t} = x_{fc,t}. \tag{B.57}$$

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

$$H_t = H_{s,t}^{p} + H_{s,t}^{r} + H_{b,t}^{p} + H_{fb,t}^{r} + H_{fc,t}^{r}, \tag{B.58}$$

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

$$H_t = (1 - \delta_h) H_{t-1} + IH_t. \tag{B.59}$$

B.9 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:

$$\log A_{c,t} = \rho_{Ac} \log A_{c,t-1} + e_{Ac,t}, \;\; e_{Ac,t} \sim N(0, \sigma_{Ac}), \tag{B.60}$$

$$\log A_{h,t} = \rho_{Ah} \log A_{h,t-1} + e_{Ah,t}, \;\; e_{Ah,t} \sim N(0, \sigma_{Ah}), \tag{B.61}$$

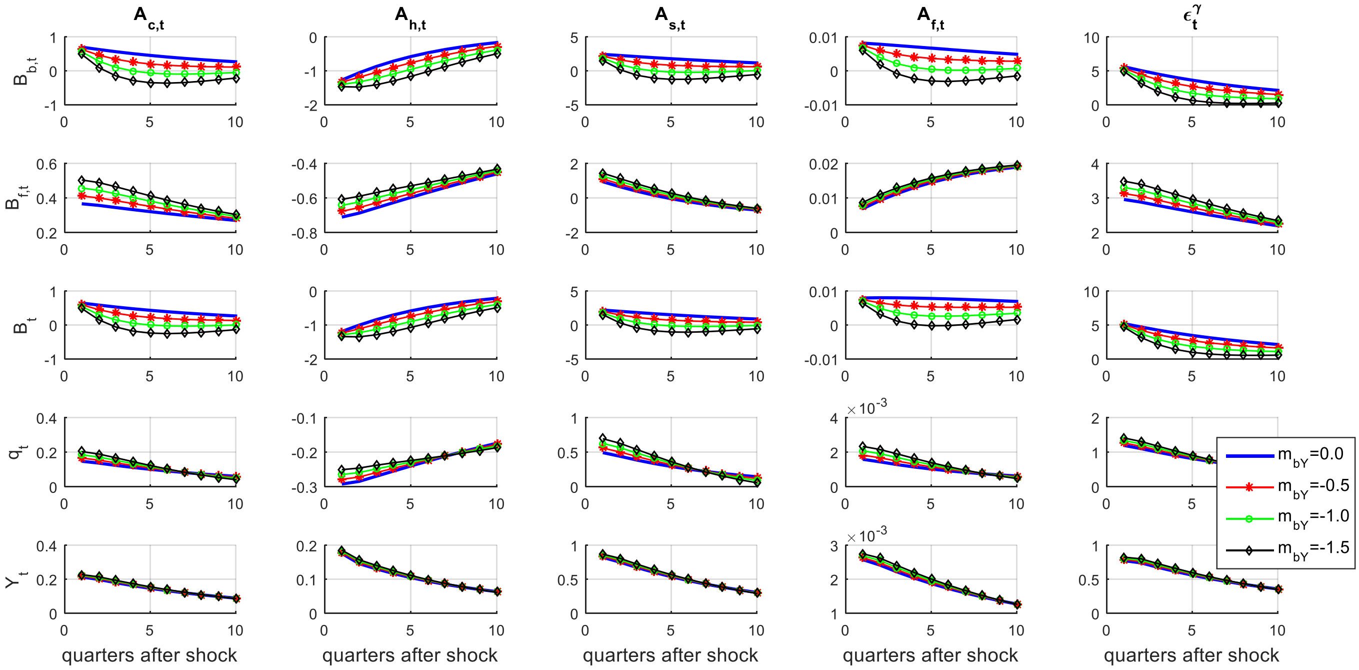
$$\log A_{s,t} = \rho_{As} \log A_{s,t-1} + e_{As,t}, \;\; e_{As,t} \sim N(0, \sigma_{As}), \tag{B.62}$$

$$\log A_{f,t} = \rho_{Af} \log A_{f,t-1} + e_{Af,t}, \;\; e_{Af,t} \sim N(0, \sigma_{Af}), \tag{B.63}$$

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

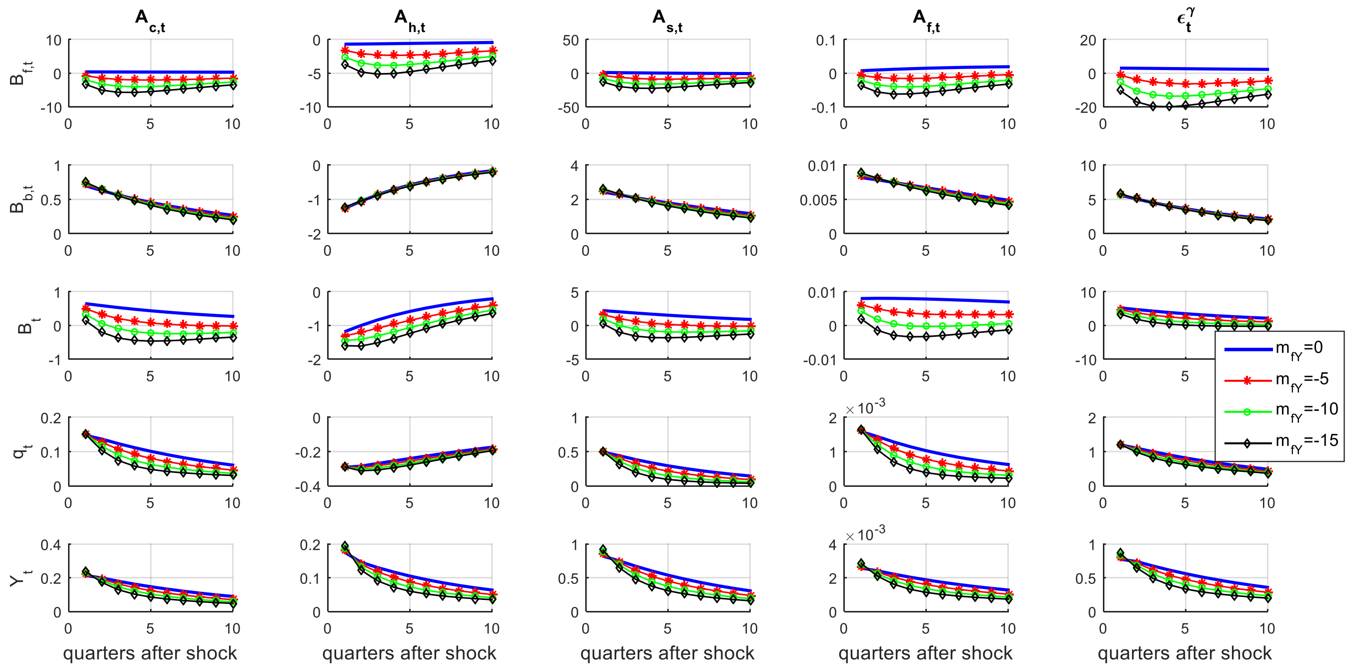
C Complementary Figures

Figure C.1: Stabilization capacity (m_{bx}). Impulse-responses to all shocks



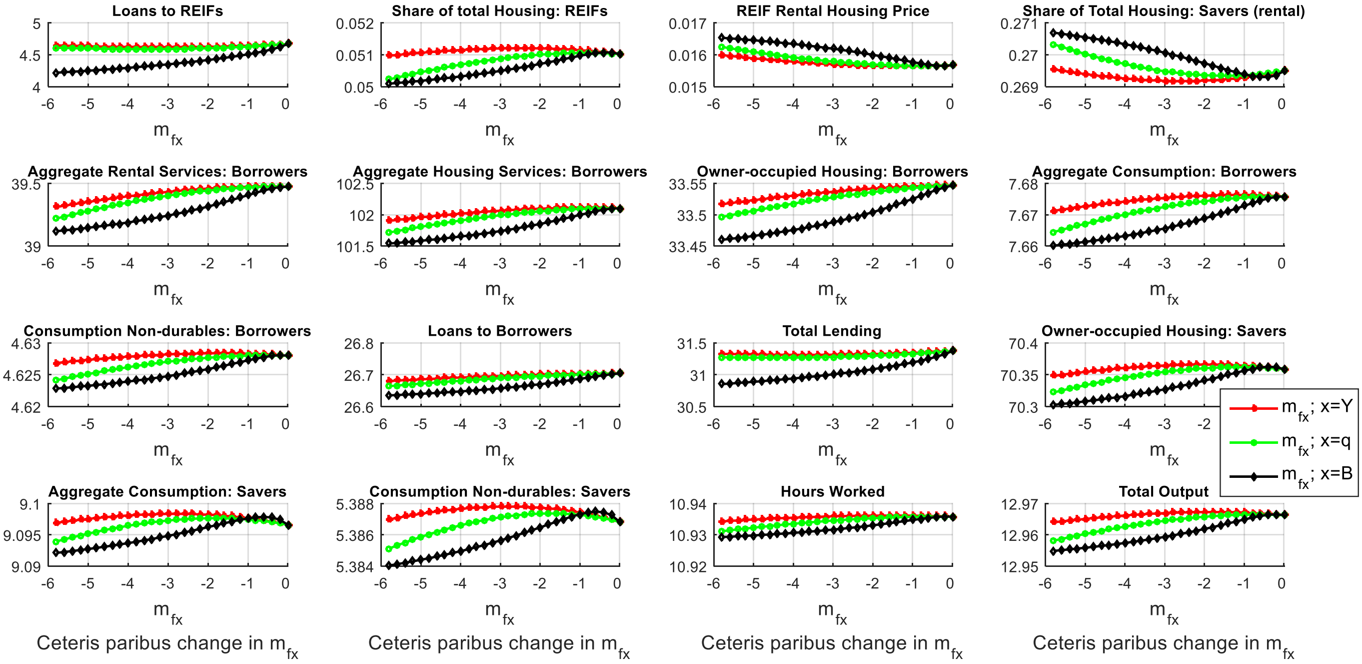
Notes: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario (i.e., m_{fY}=0 and m_{bY}=0). The starred, dotted and diamond lines make reference to alternative macroprudential policy scenarios under which LTV parameter m_{bY} is equal to -0.5; -1.0; and -1.5, respectively.

Figure C.2: Stabilization capacity (m_{fY}). Impulse-responses to all shocks



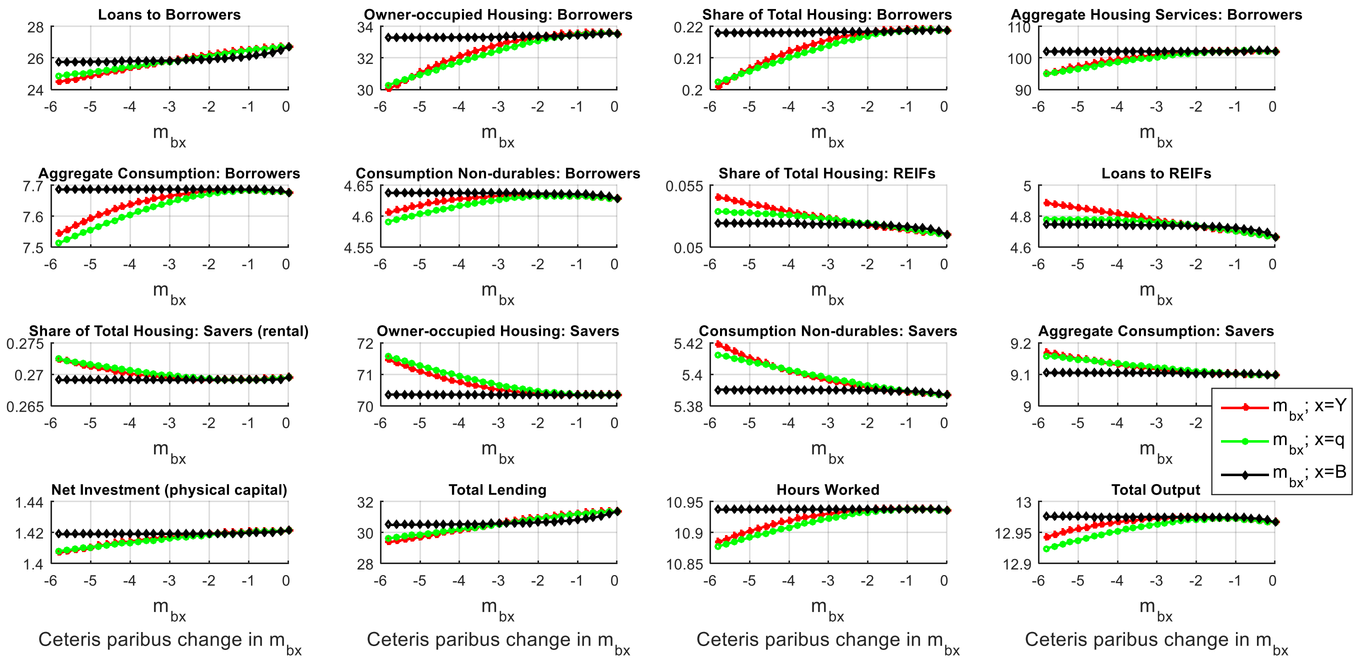
Notes: Variables are expressed in percentage deviations from the steady state. The solid line refers to the baseline scenario (i.e., m_{fY}=0 and m_{bY}=0). The starred, dotted, and diamond lines make reference to alternative macroprudential policy scenarios under which LTV parameter m_{fY} is equal to-5, -10 and -15, respectively.

Figure C.3: Level effects of dynamic LTV policy rules on lending to REIFs



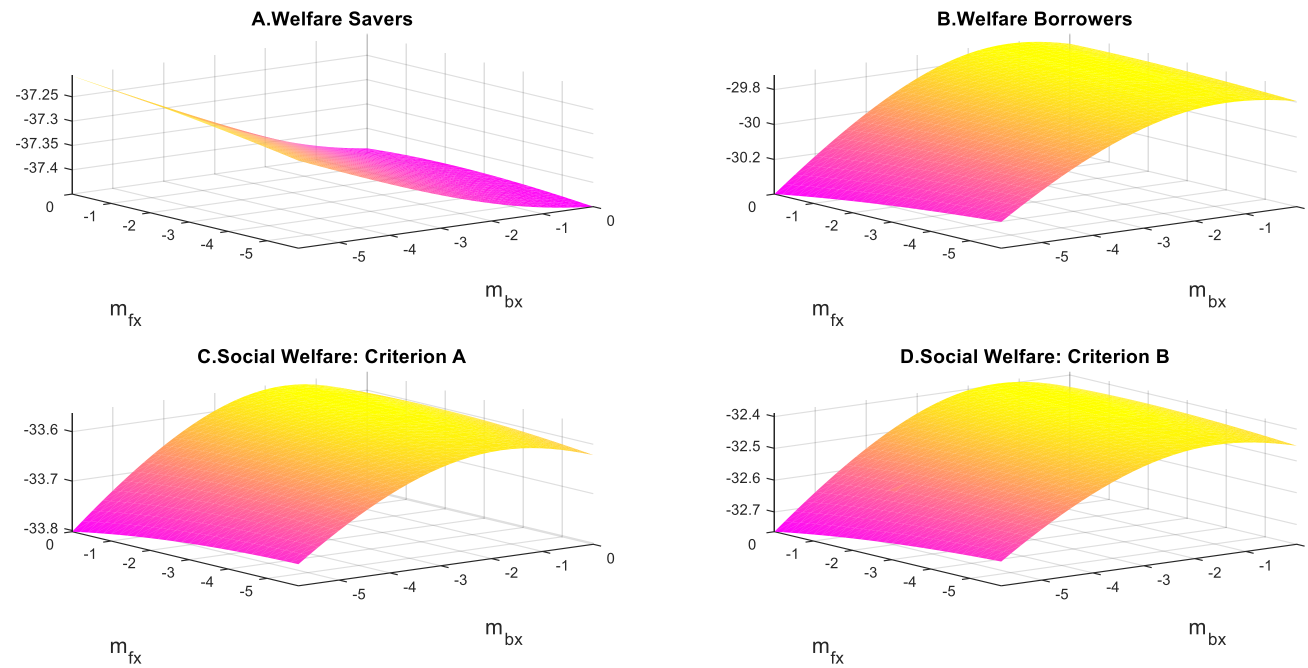
Notes: Second-order approximation to the stochastic mean of key selected variables as a function of macroprudential policy parameter m_{fx}. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator "x" is equal to Y, q, and B, respectively.

Figure C.4: Level effects of dynamic LTV policy rules on lending to borrowers



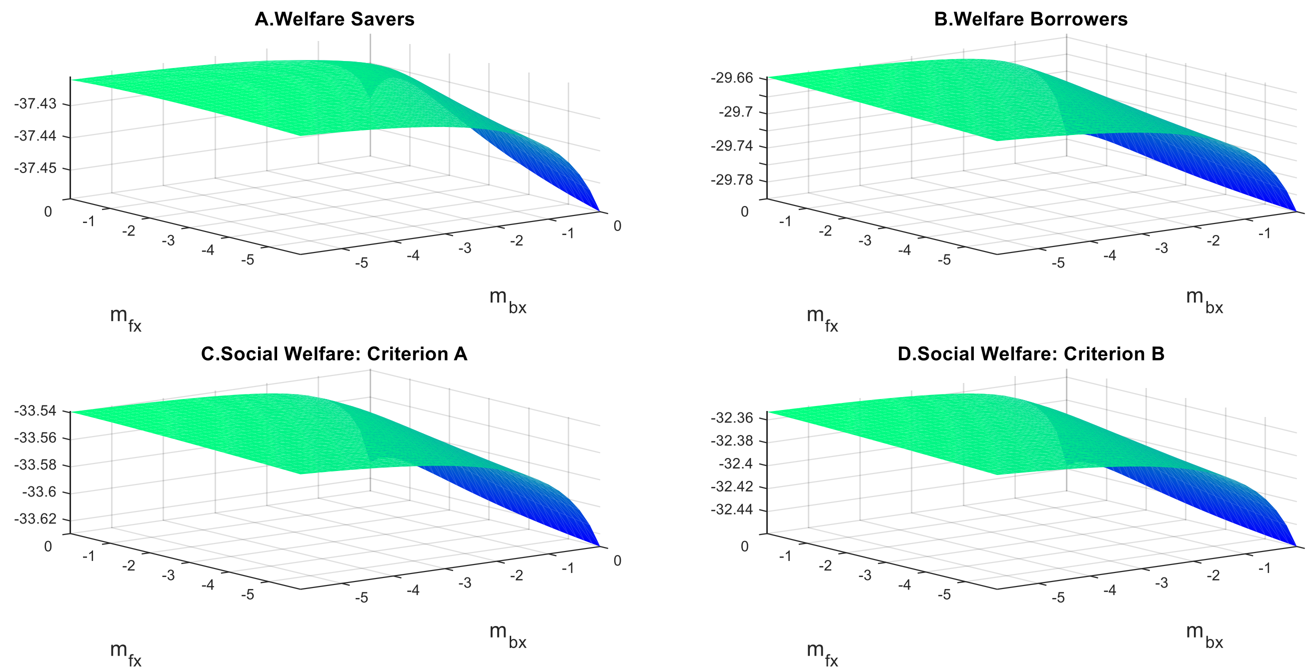
Notes: Second-order approximation to the stochastic mean of key selected variables as a function of macroprudential policy parameter m_{bx}. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator "x" is equal to Y, q, and B, respectively.

Figure C.5: Welfare effects of dynamic LTV policy rules on lending to REIFs and households (x=q)



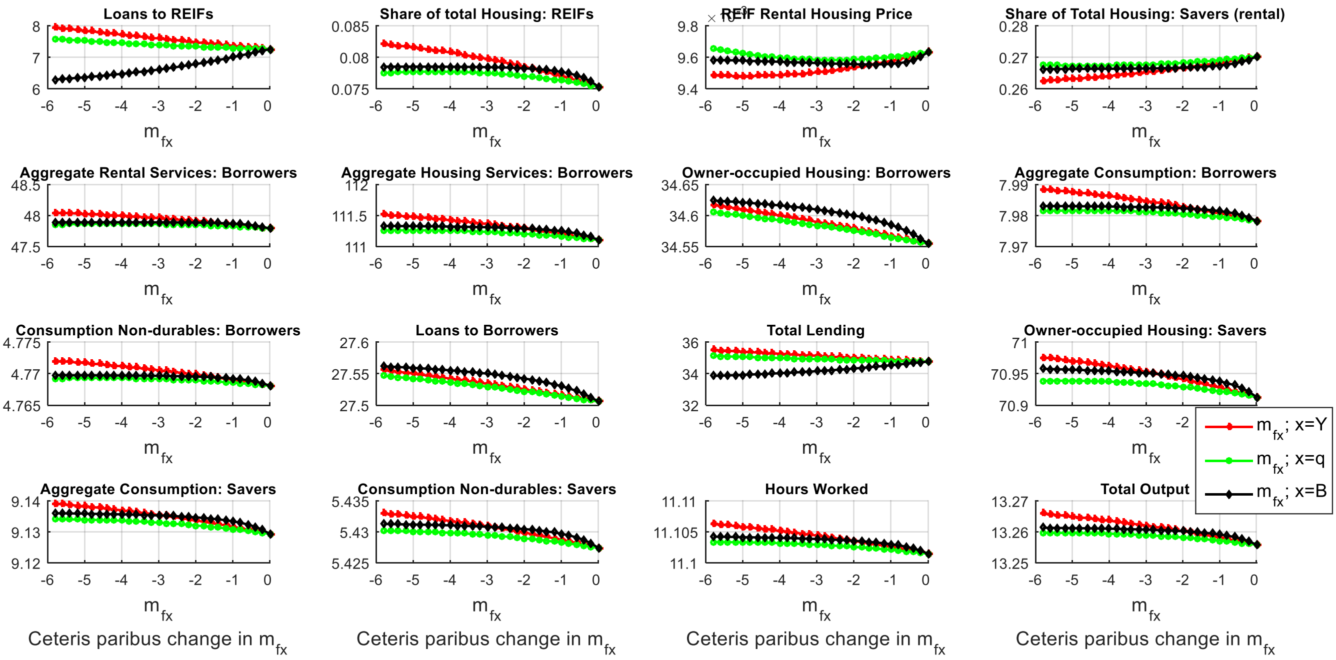
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria “A” and “B” as a function of macroprudential policy parameters m_{fx} and m_{bx} under the assumption that macroeconomic indicator “x” is equal to q.

Figure C.6: Welfare effects of dynamic LTV policy rules on lending to REIFs and households (x=B)



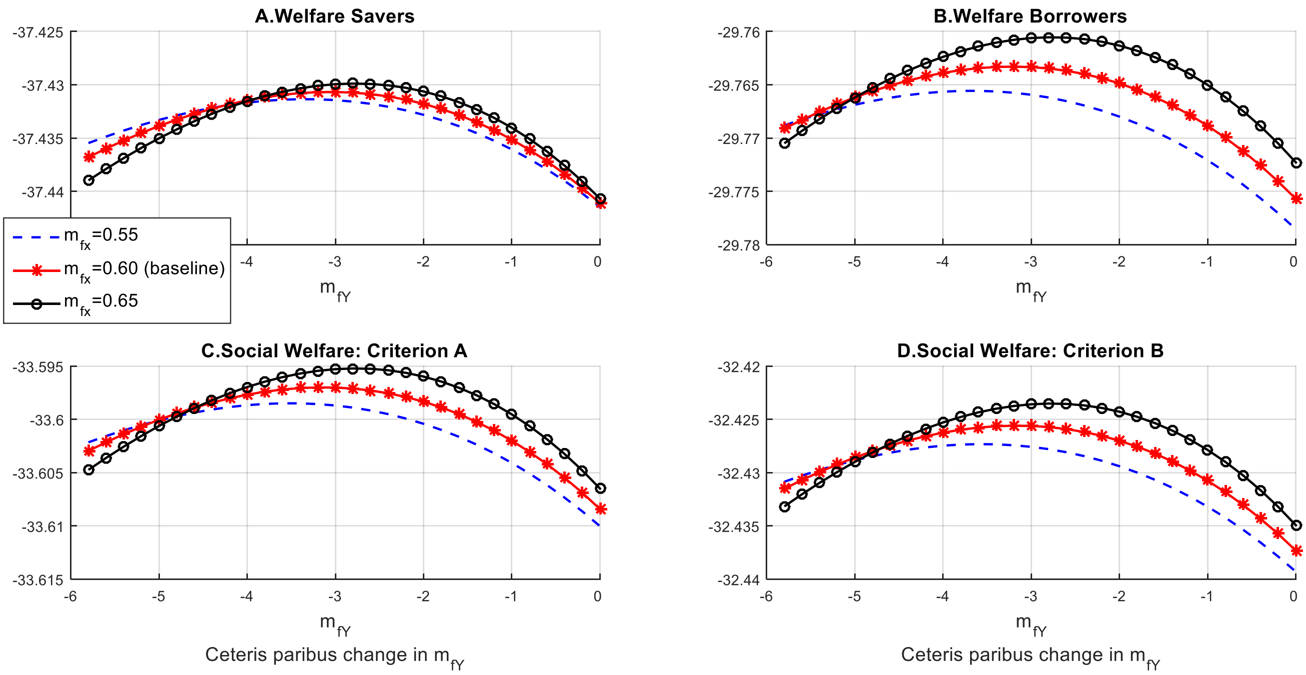
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria “A” and “B” as a function of macroprudential policy parameters m_{fx} and m_{bx} under the assumption that macroeconomic indicator “x” is equal to B.

Figure C.7: Level effects of dynamic LTV policy rules on lending to REIFs ($\eta_r = \eta_c = 6.0$)



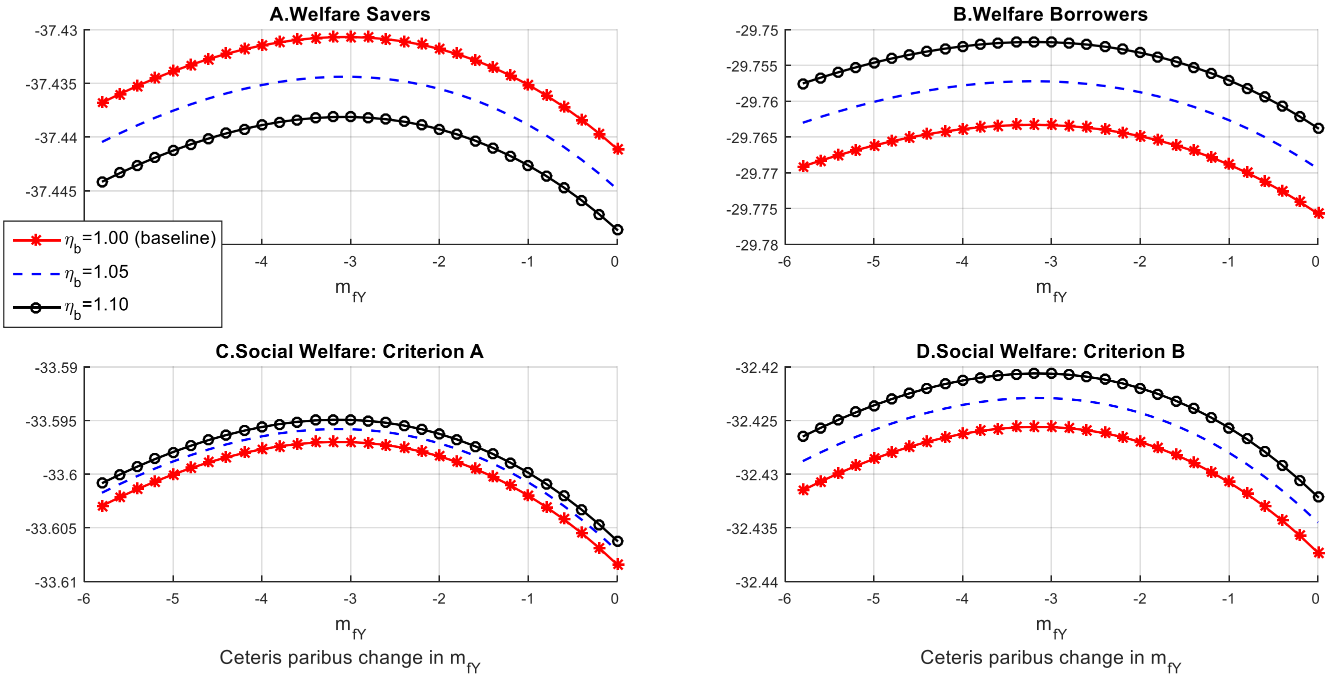
Notes: Second-order approximation to the stochastic mean of key selected variables as a function of macroprudential policy parameter m_{fx}, under the assumption that $\eta_r = \eta_c = 6.0$. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator "x" is equal to Y, q, and B, respectively.

Figure C.8: Robustness checks: m_f (welfare effects of ceteris paribus changes in m_{fY})



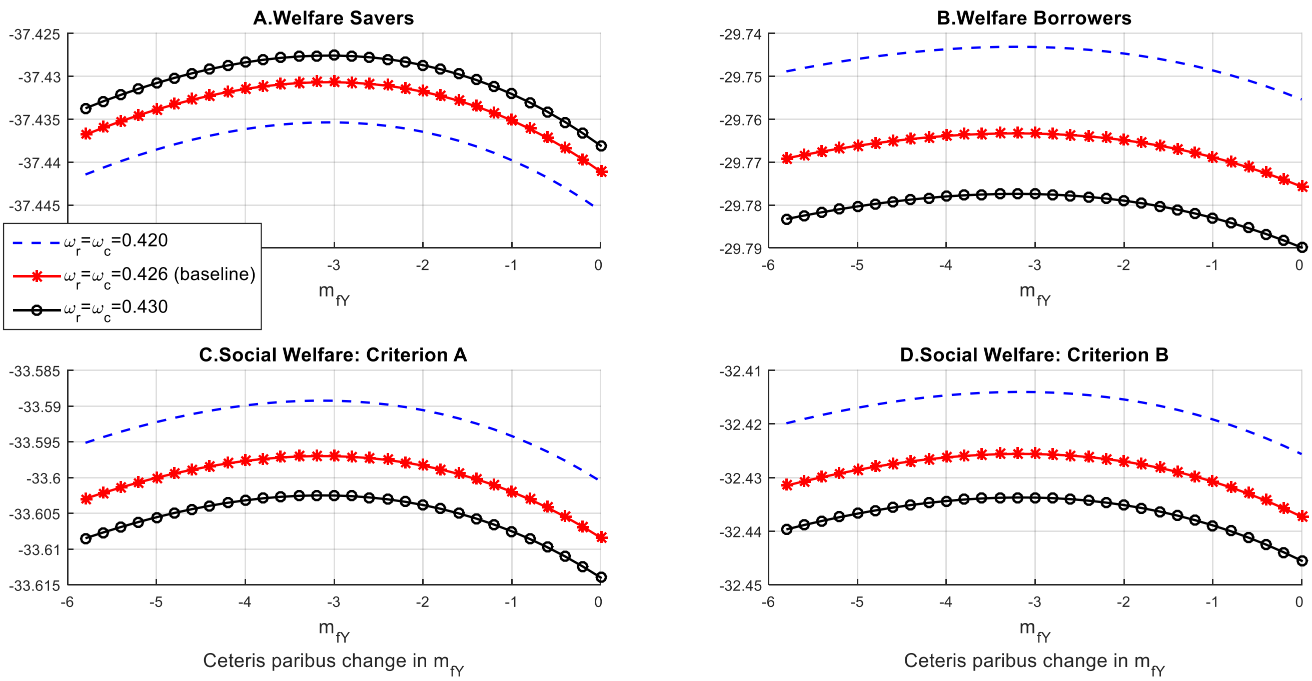
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" under as a function of policy parameter m_{fY}, for alternative values of parameter m_f. The starred line refers to the baseline calibration whereas the dashed and dotted lines relate to alternative parameterization scenarios.

Figure C.9: Robustness checks: η_b (welfare effects of ceteris paribus changes in m_{fY})



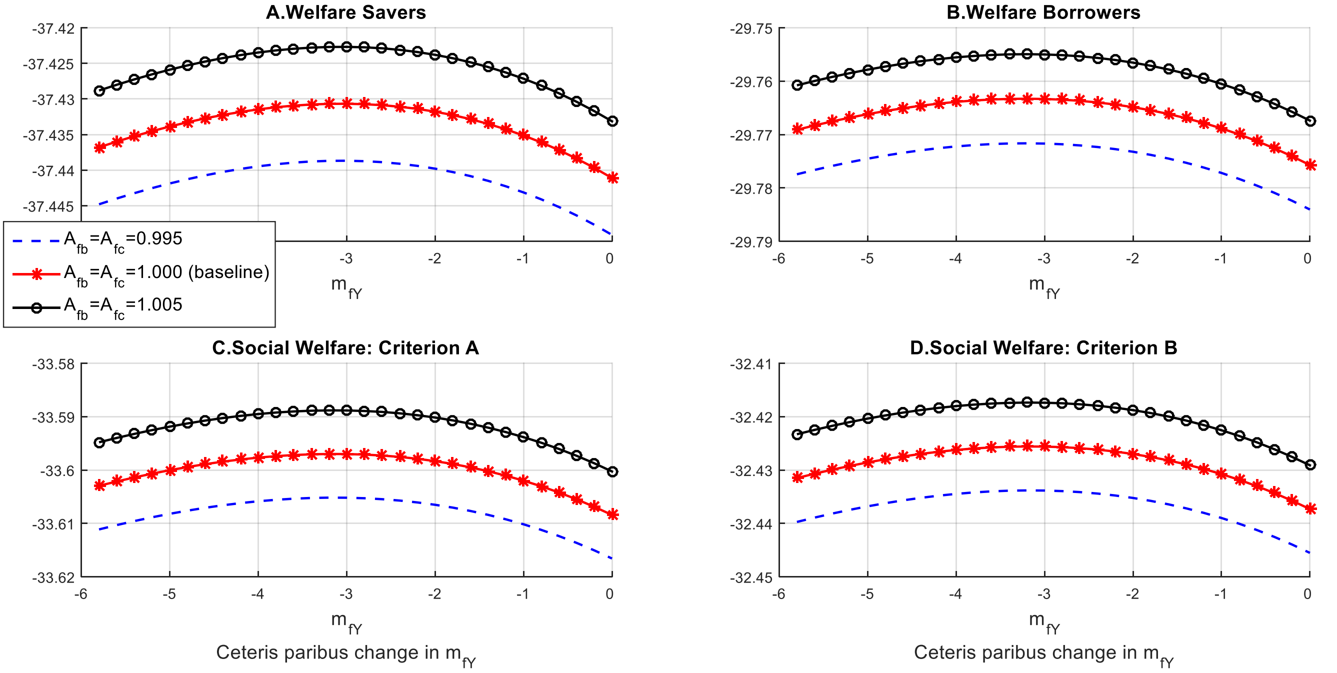
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of policy parameter m_{fY}, for alternative values of parameters η_b. The starred line refers to the baseline calibration whereas the dashed and dotted lines relate to alternative parameterization scenarios.

Figure C.10: Robustness Checks: ω_r, ω_c (welfare effects of ceteris paribus changes in m_{fY})



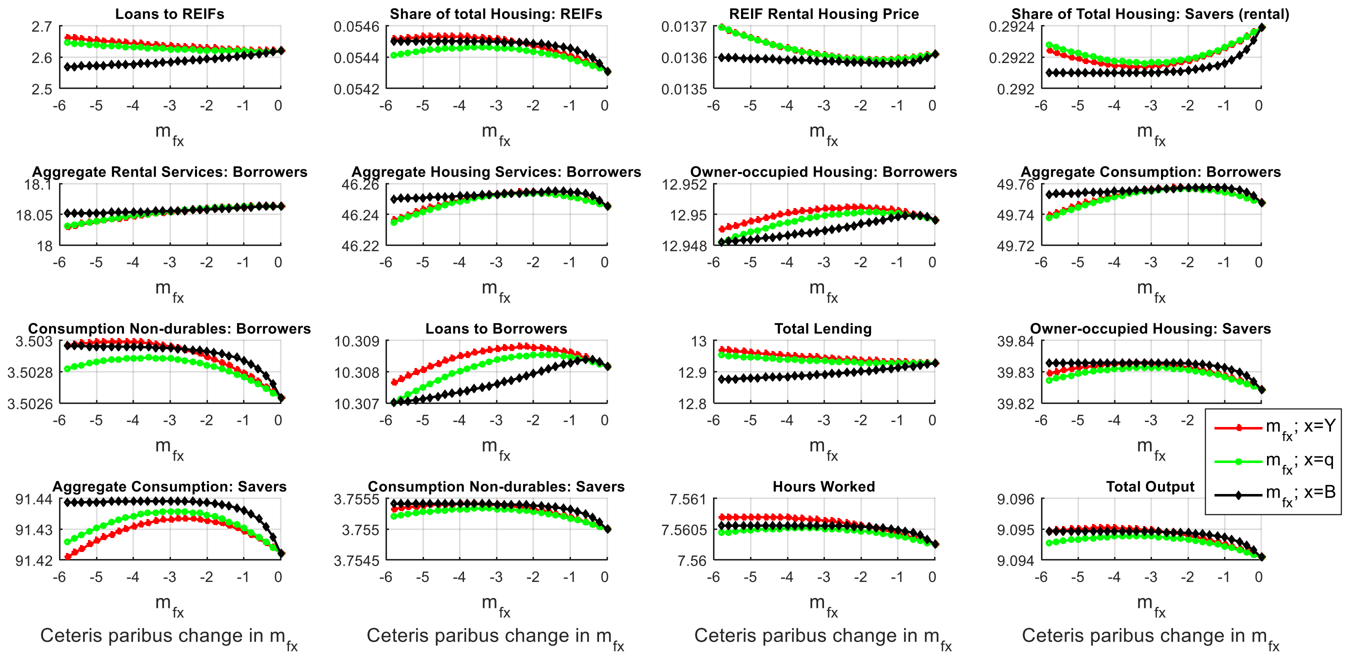
Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria "A" and "B" as a function of policy parameter m_{fY}, for alternative values of parameters ω_r and ω_c. The starred line refers to the baseline calibration whereas the dashed and dotted lines relate to alternative parameterization scenarios.

Figure C.11: Robustness checks: A_{fb}, A_{fc} (welfare effects of ceteris paribus changes in m_{fY})



Notes: Second-order approximation to the unconditional welfare of savers and borrowers as well as to the unconditional social welfare under welfare criteria “A” and “B” as a function of policy parameter m_{fY}, for alternative values of parameters A_{fb} and A_{fc}. The starred line refers to the baseline calibration whereas the dashed and dotted lines relate to alternative parameterization scenarios.

Figure C.12: Level effects of dynamic LTV policy rules on lending to REIFs (Separable preferences)



Notes: Second-order approximation to the stochastic mean of key selected variables as a function of macroprudential policy parameter m_{fx}, under the assumption that preferences on consumption of durables and non-durables are separable. The starred, dotted and diamond lines relate to macroprudential policy scenarios under which macroeconomic indicator “x” is equal to Y, q, and B, respectively.

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