Bank of Israel **Research Department**

Assessing the Impact of Monetary and Macroprudential Policies on Israel's Housing Market: A DSGE Model Approach[1]

Alex Ilek[*], Nimrod Cohen, and Yaakov Chen-Zion*****

Discussion Paper 2024.14
November 2024

Bank of Israel - **http://www.boi.org.il**

[*] Alex Ilek – Research Department, Bank of Israel. Email: alexei.ilek@boi.org.il

[**] Nimrod Cohen– Research Department , Bank of Israel. Email: **nimrod.cohen@boi.org.il**

[***] Yaakov Chen-Zion – Research Department, Bank of Israel. Email: **yaakov.chen-zion@boi.org.il**

[1] We want to thank Oren Levintal for his discussion, and Eliezer Borenstein, Alon Benyamini, Yoav Friedman, Sigal Ribon, Yossi Yakhin, and all other participants in the Bank of Israel Research Department seminar for their helpful comments and suggestions.

חטיבת המחקר, בנק ישראל ת"ד 780 ירושלים 91007

Research Department, Bank of Israel. POB 780, 91007 Jerusalem, Israel

השפעתן של מדיניות מוניטרית ומאקרו-יציבותית על שוק הדיור בישראל: ניתוח באמצעות מודל DSGE

אלכס אילק, נמרוד כהן ויעקב חן ציון

תקציר

אנחנו מפתחים מודל DSGE המבוסס על יסודות מיקרו-כלכליים, המותאם לכלכלת ישראל. המודל כולל את שוק דיור – הן את שוק הבעלות והן את שוק השכירות. מטרתנו העיקרית היא לבחון את ההשפעות של מדיניות מוניטרית ומקרו-יציבות על שוק הדיור, ובמיוחד על מחירי הדירות. במודל, מדיניות מקרו-יציבות מיוצגת על ידי מגבלה ליחס הלוואה-לערך דירה (LTV), מדד מקובל הן בספרות והן בפרקטיקה. ממצאינו מצביעים על כך שמדיניות מוניטרית מרסנת מורידה את מחירי הדירות בעוד שמחירי השכירות הריאליים עולים. מדיניות מקרו-יציבות אינה פוגעת ביכולת המדיניות המוניטרית להשיג את יעדיה העיקריים. מדיניות מקרו-יציבות מחמירה (LTV נמוך יותר) מפחיתה באופן משמעותי את החוב ואת יחס הבעלות לשכירות במשק, אך מעלה במעט את מחירי הדירות ומחירי השכירות הריאליים; ממצא זה מאתגר את הספרות הקיימת (במסגרת מודלים DSGE), ואנו מייחסים את הפער להיעדר שוק שכירות (ומשקיעי נדל״ן) במודלים אלו. תובנות אלו מצביעות על כך שבעוד כלים מקרו-יציבותיים יכולים לסייע בניהול היציבות הפיננסית, יש להעריך בזהירות את השפעתם על מחירי הדירות לצד כלים מוניטריים אחרים.

Assessing the Impact of Monetary and Macroprudential Policies on Israel's Housing Market: A DSGE Model Approach

Alex Ilek, Nimrod Cohen and Yaakov Chen-Zion

Abstract

We develop and calibrate a micro-founded DSGE model, tailored to the Israeli economy, based on key stylized facts about the Israeli economy. The model includes the housing market, both ownership and rental, and heterogeneous households. Macroprudential policy is represented by policy regarding the Loan-to-Value (LTV) ratio, a common measure in both literature and practice. Our primary objective is to examine the effects of monetary and macroprudential policies on the housing market, especially on housing prices. Our findings suggest that contractionary monetary policy pushes home prices downward while real rent prices rise. Macroprudential policy does not undermine monetary policy's ability to achieve its primary goals, although it introduces a slight distributional effect. Tighter macroprudential policy (lower LTV) significantly reduces debt and the ownership-to-rent ratio in the economy, but slightly increases home prices and real rent prices. This challenges the existing DSGE model literature, and we attribute this discrepancy to the absence of a rental market (and real estate investors) in those models. These insights indicate that while macroprudential tools can help manage financial stability, their effect on home prices must be carefully assessed alongside other monetary measures.

JEL classification: R21, E12, E32, E52, E61.

Keywords: housing market, monetary policy, macroprudential policy, ownership-to-rent ratio, heterogeneous households.

1. Introduction

In this paper, we seek to understand the impact of monetary policy and macroprudential policy on the Israeli housing market and the broader economy. Our main questions are:

1. What is the transmission of monetary policy to the Israeli housing market and the economy, and what are the main channels?
2. Does a tighter macroprudential policy—represented by a lower loan-to-value (henceforth, LTV) ratio restriction—influence the effectiveness of monetary policy in achieving its primary goals?
3. How does the LTV policy influence the housing market, in the short and long run?

For this purpose, we build a structural micro-founded Dynamic Stochastic General Equilibrium (DSGE) model, which is advantageous for analyzing policy questions. Structural models allow the establishment of causal relationships between different variables, by explicitly modeling the micro-founded relationships between economic factors. Thus, one can understand how changes in one variable affect others and the system dynamics, which is crucial for policy analysis. Moreover, this model allows us to analyze counterfactual scenarios, such as "what if" questions, and helps in understanding the potential benefits and drawbacks of alternative policy options. In other words, the model serves as *our laboratory* for policy experiments, especially macroprudential policy measures, which are rare and thus difficult to conduct purely through empirical analysis.

The Israeli housing market has two interrelated submarkets—ownership and rental, a distinction that is fundamental to policy analysis. Thus, our research includes a comprehensive analysis based on a micro-founded DSGE model, which includes both of these market segments. Additionally, the model includes two types of households—lenders and borrowers **with collateral constraints** (tied to the dwelling values, as in Iacoviello (2005)). Finally, the model was adjusted to fit the specific characteristics of the Israeli economy.

We analyze the dynamics of key variables of interest, focusing specifically on monetary and macroprudential policies. We also explore the interaction between these two policies, as we inquire whether tighter macroprudential policy influences the effectiveness of monetary policy.

The frequency of monetary and macroprudential policies differs. Monetary policy, which targets business cycles, is implemented frequently (e.g., monthly) and has a broad impact on the entire economy, including both the rental and ownership housing markets. In contrast, macroprudential policy focuses on financial cycles and ensuring long-term financial stability, and is implemented infrequently, typically once every couple of years. According to Drehmann et al. (2012), financial cycles can range from 8 to 20 years, while business cycles typically last between 2 and 8 years. Moreover, macroprudential policy is specific, such as LTV regulation, which has a direct impact on volume of credit.

Our results align with the literature, showing that altering the LTV ratio through macroprudential policy does not hinder the effectiveness of monetary policy in achieving its main objectives. However, it does lead to a slight distributional effect, reflecting household heterogeneity. We find that a stricter LTV policy substantially lowers debt and ownership among borrowers, but its impact on home prices is minimal. This contrasts with existing DSGE model literature, which suggests that a lower LTV ratio significantly reduces home prices. We argue that this discrepancy arises from a critical element absent in earlier models but incorporated in ours.

The structure of the paper is as follows: Section 2 provides a brief literature review, Section 3 presents important stylized facts of the Israeli housing market, Section 4 describes the model, Section 5 details the model calibration, Section 6 analyzes monetary and macroprudential policies, and Section 7 concludes.

2. Literature Review

Some empirically oriented studies have investigated the impact of monetary policy on the Israeli housing market. Yakhin and Gamrasni (2021) and Nagar and Segal (2014) estimated a long-run equilibrium relationship between home prices, rents, interest rates, and other variables. They also explained short-run dynamics of rent and home prices by using a Vector-error-correction model. Both found empirically that in the short run, a rise in the monetary interest rate lowers home prices but raises rents, which they interpret as an ownership-rent substitution effect.

Several studies have examined the impact of macroprudential policy in Israel. Benchimol et al. (2022) investigated the effects of domestic macroprudential policy measures on bank credit in Israel, using individual bank panel data. They found that macroprudential policy measures significantly reduce credit growth, particularly in mortgages, and influence the transmission of monetary policy to banking credit. However, the impact on home prices was not analyzed. Ribon (2023) found that after macroprudential innovation there is immediately a slight and statistically insignificant increase in home prices, but later a decrease, which becomes statistically significant only after one year.[1]

Laufer and Tzur-Ilan (2021) analyzed the impact of a macroprudential measure implemented in October 2010, when the Israeli banking regulator mandated higher capital provisions for mortgages with LTV ratios above 60%, leading to increased interest rates for these loans and prompting borrowers to reduce their LTV ratios below 60%. Using microdata they found that this macroprudential policy measure led to a roughly 3% decrease in home prices. Buitron and Denis (2014) reported that while macroprudential policies in Israel have reduced the volume of transactions in the housing market and reduced new housing loans, there is no evidence that they have helped to restrain home prices.

Although these data-driven models successfully characterize some features of the Israeli economy, they do not consider household heterogeneity, financial frictions, and general equilibrium effects. More importantly, they suffer from the Lucas critique, as the estimated parameters are in reduced form, capturing past policy measures and the public's response to these measures. To analyze policy impact appropriately, a micro-founded DSGE model is needed.

The international literature on DSGE models that include housing is vast. Iacoviello (2005) and Aoki et al. (2004) introduced the financial accelerator effect, where borrowing is limited by LTV restrictions and dwellings serve as collateral. They demonstrate that LTV restrictions amplify and propagate the effects of monetary policy shocks on housing investments, home prices, and consumption.

Some studies have examined the impact of macroprudential policy on home prices using DSGE models. For example, Funke et al. (2018) developed a DSGE model with housing for New Zealand, demonstrating that macroprudential policies may reduce home prices. Studies by Bruneau et al. (2018) for Canada and by Lee and Song (2015) for Korea show similar results. However, these results are not consistent with empirical studies, which found a smaller impact. Cerutti et al. (2017) investigated the impact of macroprudential policies, such as an LTV ratio cap, on home prices and credit across 119 countries. Their findings indicated that LTV policies significantly

[1] Ribon (2023) used a dummy variable to represent macroprudential (MP) measures (assuming permanent MP measures). However, this variable covered all MP measures, not just those in the housing market.

curbed household credit growth. The impact on home prices was slightly negative but not statistically significant in advanced economies. We conjecture that the inconsistency between the results from the DSGE models and the empirical studies may be due to the absence of the rental market in the DSGE models. As we demonstrate in Section 6.3, including the rental market leads to different results regarding the effect of macroprudential policy on home prices.

In our DSGE model, we assume that households perceive ownership and renting as (imperfect) substitutes, as in Sun and Tsang (2017). However, the supply of rentals in our model differs significantly from that in Sun and Tsang (2017). In their model, fitted to the US, financially constrained firms provide rental supply, whereas in our model, suitable for Israel, the suppliers of rental services are financially unconstrained households (investors).

Several studies have examined the impact of macroprudential policy on the effectiveness of monetary policy. This issue is closely related to the institutional setup of macroprudential policy and its interactions with monetary policy (Malovaná et al. (2023)). Funke et al. (2018) find that under different LTV ratios, the effectiveness of monetary policy remains unchanged. Cozzi et al. (2021) investigate how varying leverage ratios of banks influence the sensitivity of inflation and output to monetary policy shocks. They found that the responses were similar across different leverage ratios. These findings suggest that any gains from the coordination of monetary and macroprudential policy are likely to be small.[2] In Section 6.2, we examine how different LTV ratios impact the effectiveness of monetary policy. We assess this effectiveness not only with respect to aggregate variables—output and inflation—but also with respect to the individual responses of the two types of households.

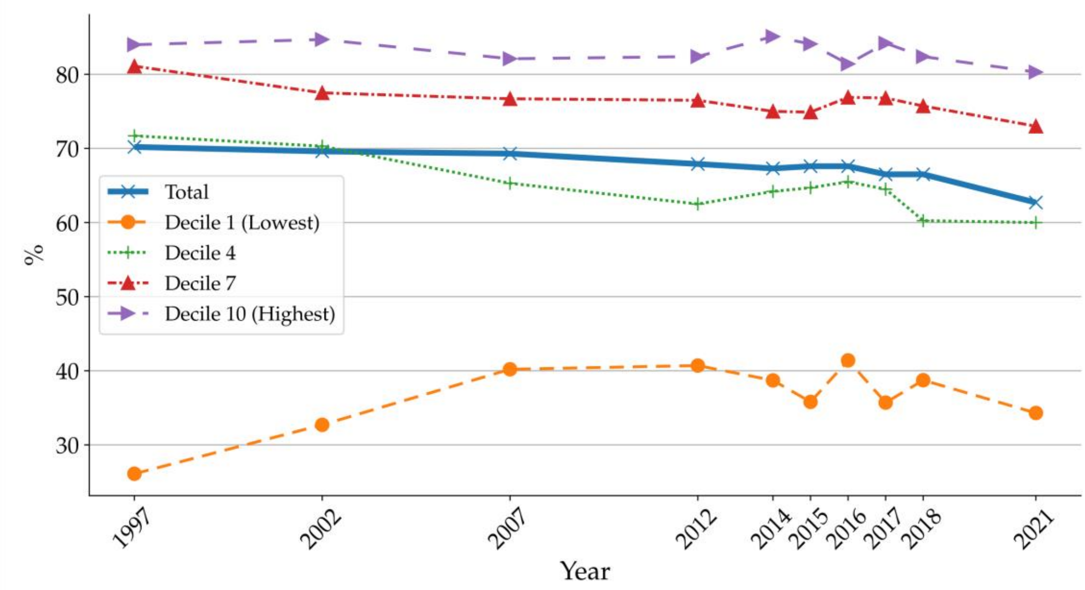
3. Stylized facts of the Israeli housing market

In this section, we present important stylized facts of the Israeli housing market, which will serve as guidance for structuring our model, with special attention to policy and housing market structure.

[2] These results contradict the findings of Quint and Rabanal (2014); Bekiros et al. (2020); Bosshardt et al. (2023); Cairó and Sim (2023), who found that macroprudential policies can complement monetary policy and vice versa.

First, based on Fig. 1 we note that there are significant disparities in home ownership rates across different income deciles. For the lowest (poorest) income decile, only 35% of households are homeowners. This is probably due to financial constraints, as evident by the small share of mortgages (14%) for the two lowest income deciles (Fig. 2).[3]

Figure 1: Share of owner-occupied households by selected income decile (1997-2021)



Source: Authors' Analyses. Data: CBS. Net-income per standardized person.

In contrast, more than 80% of households in the highest (wealthiest) income decile are homeowners. Among them, only 33% have mortgages, indicating that most of them finance their homes with their own resources. It is worth noting that about 15% of wealthy households choose to rent their dwellings, which can be interpreted as a revealed preference rather than a financial constraint.

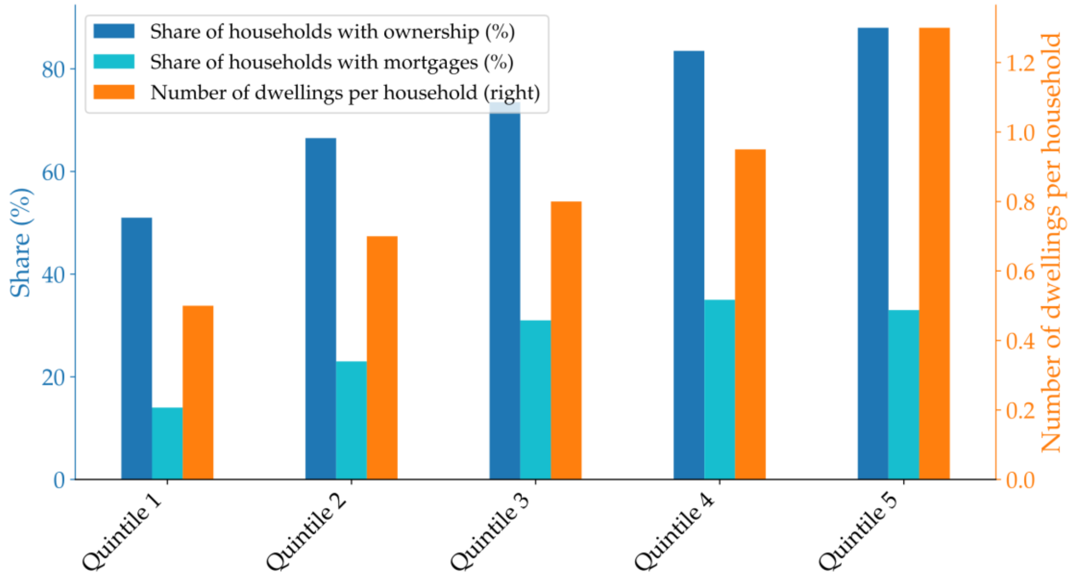
Analytically, Proposition 4 (Section 4.5) demonstrates that even when home ownership preferences are the same across all households, the lower ownership-rent ratio of borrower (financially constrained) households compared to lender (financially unconstrained) households is due to the existence of financial constraints.

The data also show that wealthy (high-income) households own, on average, one or more dwellings (Fig. 2). We thus conclude that they are the "investors" in the housing market, supplying rental dwellings to the market. This is one

[3] As income increase the share of households with mortgage is higher, which is robust phenomena worldwide.

of the unique features of the Israeli housing market, and we incorporate it into the model.

Figure 2: Share of households with mortgages by income decile (left y-axis), and Number of dwellings per household by income decile (right y-axis) (2018)



Source: Author's Analyses based on Stein-Kapach (2019) and Kosman (2021)

Next, we discuss an important measure of the mortgage market – the LTV ratio. The average LTV ratio in Israel is low compared to other developed countries (Laufer and Tzur-Ilan (2021)). Furthermore, the LTV ratio is significantly affected by macroprudential policy, which was activated from around 2010 (Benchimol et al. (2022)).

Data from OECD countries (Hoenselaar et al. (2021)), depicted in Fig. 3, show that countries with more permissive LTV restrictions tend to have a higher percentage of homeowners with mortgages (out of total population) on average. Additionally, as shown in Fig. 4, countries with a higher proportion of homeowners with mortgages tend to have higher mortgage leverage, which constitutes a sizable portion of household debt. The takeaway is that as leverage restrictions are relaxed, a larger proportion of households may take out mortgages and become homeowners, resulting in higher overall leverage.

Figure 3: LTV restriction and share of households' with mortgages

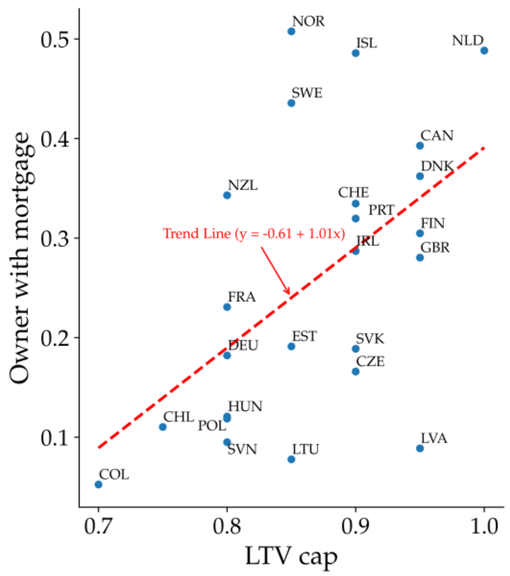
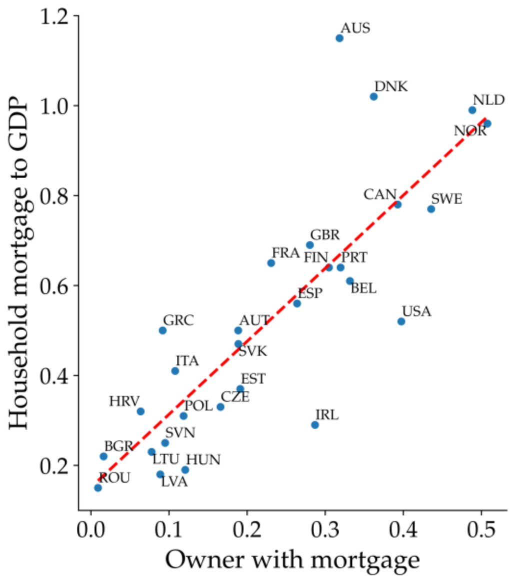


Figure 4: Share of households with mortgages vs. mortgage leverage (with respect to GDP)



Source: Authors' Analyses. Data: OECD

In addition, there is a high degree of nominal rigidity in rental prices in Israel. Based on a sample from 2010–2015, Raz-Dror (2019) found that rent contracts are signed for at least one year, on average. Ribon and Sayag (2013) found that the average period for price changes among different components of the CPI in Israel is less than one year. This indicates that price rigidity in rent prices is higher than other components of the CPI. This finding for Israel aligns with the economic literature, which also finds a higher level of nominal price rigidity in rental prices relative to other prices (Genesove (2003); Shimizu et al. (2010); Verbrugge et al. (2017)).

4. The Model

The model contains two representative household categories, lenders (patient) and borrowers (impatient), which **have collateral constraints**; housing retailers who provide final rental properties in the housing market; companies that produce consumer goods (excluding housing services); commercial banks functioning as financial intermediaries; and a central bank responsible for implementing monetary and macroprudential policies.

The lenders' (patient) discount factor is higher than that of the borrowers (impatient), which generate savings and debt respectively. In equilibrium, the debt of borrowers equals the savings of lenders.

Although Israel is a small open economy, we have modeled it as a closed economy because the global engagement of Israel's economy has a limited impact on the housing sector—our primary focus. Additionally, Israeli households generally obtain mortgages only from the local banking system. In this model, domestic banks gather funds from lenders at a risk-free interest rate through deposits and then extend mortgages to borrowers, adding a credit spread.

We assume that the supply of dwellings is exogenous and fixed, meaning that fluctuations in the housing market are solely attributable to shifts in the demand for ownership and rental properties from both types of households. The assumption that the supply of dwellings is exogenous aligns well with the Israeli context for two reasons: (1) the workforce involved in constructing new houses in Israel predominantly consists of foreign and Palestinian workers, with a minimal proportion of Israeli workers[4]; and (2) the allocation of land for new housing construction is controlled by Israeli authorities and is not subject to free market dynamics.

The model encompasses both the ownership and rental housing markets, with the two being imperfectly substitutable. Demand in these markets originates from two distinct household categories: 1. borrowers, who are **constrained** by LTV restriction, and 2. lenders, who are financially **unconstrained** and act as investors by supplying rental properties. Both household types generate demand for nonhousing consumption goods and provide labor to firms.

Real estate investors offer rental houses by leasing them to renters, subject to price rigidity. Firms produce consumption goods (exclude housing) using labor (without capital) and operate in monopolistic competition subject to price rigidity. The central bank conducts monetary policy using a monetary interest rate, and macroprudential policy using LTV restrictions. In the model, there is no fiscal policy.

[4] This is in contrast to the approach taken by Sun and Tsang (2017), where domestic households must decide on their labor contribution to new home production. In our model, labor input decisions are confined to the production of consumption goods.

4.1 Households

Households' utility function includes consumption C_t (excl. housing), housing H_t and labor N_t. We assume the utility function of the following form:

$$U(C_t, H_t, L_t) = z_t \Gamma_C log(C_t - \zeta C_{t-1}) + j_t log(H_t) - \frac{1}{1+\theta} N_t^{1+\theta}.$$

Where, ζ, is a degree of habit in consumption, and z_t and j_t are preference shocks to consumption and housing, respectively. We define a housing bundle that consists of ownership, $h_{o,t}$, and rent, $h_{r,t}$:

$$H(h_{o,t}, h_{r,t}) = \left[\gamma h_{o,t}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma) h_{r,t}^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where $\varepsilon > 1$ is the intratemporal elasticity of substitution between rent and ownership, and γ, 0< γ <1 is a relative weight of ownership.

4.1.1 Borrowers

Borrowers—or to be more precise, households with collateral constraints—are subject to an LTV constraint, in the following form:

$$\frac{B'_t}{q_t h'_{o,t}} \leq LTV_t, \qquad (1)$$

where B'_t is the level of (CPI-indexed) new-issued debt, $q_t h'_{o,t}$ is the value of dwellings purchased by the borrowers, $h'_{o,t}$ is the number of housing units purchased for ownership, and q_t is the (real) price of one housing unit.

The LTV constraint is imposed by macroprudential policy on new-issued debt, is subject to shocks reflecting new regulations, and is exogenous to the households (see detailed discussion in Section 4).

In the following policy analysis, we assume the LTV constraint is always binding under both monetary and macroprudential tightening policies. First, we calibrate the model to provide a strong incentive for impatient agents to borrow. Specifically, their discount factor ensures that impatient households are close to the borrowing limit, allowing for accurate linearization around a steady state with a binding borrowing limit (Iacoviello (2005); Iacoviello and Neri (2010); Sun and Tsang (2017)). Second, the LTV constraint is already binding in the steady state, even before these policies are implemented, and the shocks we analyze will further tighten the constraint. Our calibration of the LTV ratio in the steady state is 66% and it is derived from the Israeli data, ensuring that it is binding (see Section 5 and Cohen and Ilek (2024)[5].We calibrate the share of borrowers to be 31.2% of the population, representing households for whom the borrowing constraint is binding or nearly binding, as detailed in Section 5 and Cohen and Ilek (2024).

The budget constraint is expressed in real terms, meaning that it is in terms of consumption (excluding housing) (P_t^c):

$$C_t' + q_t h_{o,t}' + r_t h_{r,t}' + R_{t-1}^L B_{t-1}' = B_t' + q_t h_{o,t-1}' + w_t' N_t' \quad (2)$$

where on the left side: C_t' is consumption (excl. housing), $q_t h_{o,t}'$ is the expenditure on dwellings purchased for ownership, $r_t h_{r,t}'$ is the expenditure on rental services (r_t is the real price of rental services and $h_{r,t}'$ is the amount of rental services), $R_{t-1}^L B_{t-1}'$ is the payment on debt from the previous period, and R_{t-1}^L is the gross real interest rate on mortgages. we neglect transaction cost of purchased or sold dwellings, as well as their depreciation.

On the right side: B_t' is the amount of new (real) debt, $q_t h_{o,t-1}'$ is the value of dwellings purchased for ownership in period t-1 and then sold in period t, and $w_t' N_t'$ is income from labor. We also assume that the borrowers do not receive any dividends, because they do not own any firms. We also assume that there are no taxes because there is no government in the model.

The gross mortgage interest rate is defined as $R_t^L = R_t + \omega_t$,, where R_t denotes the risk-free real interest rate, and ω_t is a (positive) spread. This spread stems from the risk considerations of commercial banks (Benigno et al. (2020) and Ilek and Cohen (2023)). For a given leverage, higher perceived risk aversion on the part of banks will result in a higher spread. Accordingly, we formulate the spread's dependence on leverage as follows:

$$\omega_t - \omega = \alpha(LTV_t - LTV) + u_t^\omega, \quad (3)$$

The spread's deviation from its steady-state level is a function of the leverage's deviation from its steady-state level, with elasticity α. Where u_t^ω is a supply shock to the spread. If macroprudential policy does not change the minimum required LTV, such that $LTV_t = LTV$ for all t, then $\omega_t = \omega + u_t^\omega$.

In the Israeli mortgage market, there are several types of mortgages, such as 'Prime', which is unindexed and tied to the Bank of Israel interest rate, typically with a fixed spread of about 1.5 percentage points. According to Ilek and Cohen (2023), empirical data from Israel indicate that the spread for other mortgage types is affected by the borrowers' leverage levels.

[5] This document is available upon request

Here we present the first-order conditions of borrowers (see Supplementary materials for details):

(a) $C_t': \lambda_t' = \Gamma_c' \left(\frac{z_t'}{C_t' - \zeta^c C_{t-1}'} - \beta' \zeta^c \frac{z_{t+1}'}{C_{t+1}' - \zeta^c C_t'} \right)$

(b) $h_{o,t}': j_t' \frac{\gamma' h_{o,t}'^{-\vartheta}}{\gamma' h_{o,t}'^{1-\vartheta} + (1-\gamma') h_{r,t}'^{1-\vartheta}} = \lambda_t' q_t - \beta' \lambda_{t+1}' q_{t+1} - \mu_t' LTV_t q_t$

where $\vartheta = \frac{1}{\epsilon}$. The lagrangian multiplier associated with the LTV constraint in Eq. (1) is μ_t'.

(c) $h'_{r,t}: j_t' \frac{(1-\gamma') h_{r,t}'^{-\vartheta}}{\gamma' h_{o,t}'^{1-\vartheta} + (1-\gamma') h_{r,t}'^{1-\vartheta}} = \lambda_t' r_t$

(d) $B_t': \mu_t' = \lambda_t' - \beta' \lambda_{t+1}' R_t^L$

(e) $N_t': N_t'^{\varrho} = \lambda_t' w_t'$

4.2 Lenders (Unconstrained households)

Lenders function in dual roles: as consumers and as investors. As consumers, they demand goods, rental services, and home ownership; they supply labor; and they value leisure. As investors, they buy properties as investments and rent them to renters. Notably, investors do not gain direct utility from investment properties, viewing them instead as a financial tool.

The budget constraint of lenders (in real terms of P_t^c):

$$C_t + q_t(h_{o,t} + h_{inv,t}) + kq_t(h_{o,t} + h_{inv,t}) + r_t h_{r,t} + R_{t-1} B_{t-1} = B_t + q_t(h_{o,t-1} + h_{inv,t-1}) - q_t(h_{o,t-1} + h_{inv,t-1}) + p_t^m h_{inv,t} + w_t N_t + Div_t, \quad (4)$$

where $h_{o,t}$ represents the quantity of houses purchased for ownership, and $h_{inv,t}$ represents the quantity of houses purchased for investment purposes (with all investors being identical). Investors lease out $h_{inv,t}$ dwellings to retailers as an intermediate good at a nominal price P_t^m ($P_t^m = p_t^m P_t^c$) at the start of period t, and reclaim the dwellings at the end of period t. Therefore, only investors are subject to capital gains or losses when reselling in period t+1. It is important to recognize that r_t signifies the real price of rental services in the economy, which typically differs from p_t^m, since p_t^m is the price of the intermediate housing good for retailers. Lenders receive dividends from three sources: firms producing consumer goods, commercial banks, and retailers of dwellings.

The first-order conditions of the lenders are given below (see Appendix A for details):

(a) C_t: $\lambda_t = \Gamma_c\left(\frac{z_t}{C_t - \zeta^c C_{t-1}} - \beta\zeta^c \frac{z_{t+1}}{C_{t+1} - \zeta^c C_t}\right)$

(b) $h_{o,t}$: $j_t \frac{\gamma h_{o,t}^{-\vartheta}}{\gamma h_{o,t}^{1-\vartheta} + (1-\gamma) h_{r,t}^{1-\vartheta}} = \lambda_t q_t$

(c): $h_{r,t}$: $j_t \frac{(1-\gamma) h_{r,t}^{-\vartheta}}{\gamma h_{o,t}^{1-\vartheta} + (1-\gamma) h_{r,t}^{1-\vartheta}} = \lambda_t r_t$

(d) B_t: $\lambda_t = \beta\lambda_{t+1} R_t$

(e) N_t: $N_t^{\varrho} = \lambda_t w_t$

(f) $h_{inv,t}$: $\lambda_t (p_t^m - q_t) = -\beta\lambda_{t+1} q_{t+1}$

It is possible to represent Eq.(f) as follows:

$$q_t = p_t^m + sdf_{t,t+1} q_{t+1},$$

Thus, the price of the dwelling is determined by current and future payoffs received by the households from the dwelling retailers:

$$q_t = E_t \sum_{i=0}^{\infty} s\,df_{t,t+i} p_{t+i}^m,$$

where $sdf_{t,t} \equiv 1$, $sdf_{t,t+i} \equiv \prod_{l=1}^{i} s\,df_{t+l}$ for $i > 0$, $sdf_{t,t+1} = \beta \frac{\lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor of the lenders. This formula is typically used to relate home prices to rent prices in the economy. However, in our model, it is determined by the price of intermediate rental dwellings leased by retailers (see Section 4.3). The discrepancy between the two prices arises from the existence of price rigidity in rent prices (see Proposition 1 in Section 4.5 and Eq. (5) in Section 4.3).

4.3 Retailers

The objective of this section is to generate nominal rigidity in rental prices, a phenomenon observed in the Israeli market as shown by Raz-Dror (2019). This rigidity is characterized by the significantly lower volatility of rental prices than of home prices. A comparison between Raz-Dror (2019) and Ribon and Sayag (2013) indicates that rental prices exhibit greater nominal rigidity than consumer goods prices. This phenomenon is not exclusive to Israel. It is also observed globally (see Sun and Tsang (2017), Genesove (2003), Shimizu et al. (2010), and Verbrugge et al. (2017)). To that end, we introduce a model of monopolistic competition in the rental market with price rigidity.

Retailers lease dwellings from investors for one period at a nominal price P_t^m, and the dwellings are then used as intermediate rental properties. The final product of rental dwellings in the economy, Y_t^{rent}, is a composite of a continuum of mass unity of differentiated rental dwellings that uses intermediate rental dwellings from investors as the sole input (that is, $h_{inv,t}(j) = Y_{f,t}$, where $Y_{f,t}$ is the amount of dwellings of retailer f, and $h_{inv,t}(j)$ is the intermediate rental dwellings of investor j). The final product of Y_t^{rent} for rental dwellings is:

$$Y_t^{rent} = \left[\int_0^1 \left(Y_{f,t}\right)^{\frac{\eta_r-1}{\eta_r}} dj\right]^{\frac{\eta_r}{\eta_r-1}},$$

where η_r is the elasticity of substitution between differentiated rental dwellings.

Demand for differentiated retail dwelling f is given:

$$Y_{f,t} = \left(\frac{P_{f,t}^{rent}}{P_t^{rent}}\right)^{-\eta_r} Y_t^{rent},$$

where the (nominal) price of Y_t^{rent} is given as:

$$P_t^{rent} = \left[\int_0^1 \left(P_{f,t}^{rent}\right)^{1-\eta_r} dj\right]^{\frac{1}{1-\eta_r}}.$$

Differentiated retail firms face price rigidity à la Rotemberg (1982), leading to a Philips curve of rent prices.

We begin by presenting the expected profit that retailer 'f' aims to obtain:

$$\max E_t \sum_{i=0}^{\infty} s\,df_{t,t+i} \Bigg[P_{f,t+i}^{rent} Y_{f,t+i} - P_{t+i}^{m} Y_{f,t+i}$$
$$- \frac{\Theta}{2} \left(\frac{P_{f,t+i}^{rent}}{P_{f,t+i-1}^{rent}} - \pi^{1-\phi} \left(\frac{P_{t+i-1}^{rent}}{P_{t+i-2}^{rent}} \right)^{\phi} \right)^2 P_{t+i}^{rent} Y_{t+i}^{rent} \Bigg],$$

where π is the steady-state inflation rate (excl. rental services), ϕ is the degree of indexation to past inflation of rental services and Θ defines the cost associated with changing price. $sdf_{t,t} \equiv 1$, $sdf_{t,t+i} \equiv \prod_{l=1}^{i} s\,df_{t+l}$ for $i > 0$, $sdf_{t,t+1} = \beta \frac{\lambda_{t+1}}{\lambda_t}$, the stochastic discount factor of the lenders (owners of retailer's firm).

The first-order condition with regard to price $P_{f,t}^{rent}$ yields a nonlinear Philips curve for nominal rental prices (see Appendix A for details):

$$\frac{p_t^m}{r_t} = \frac{\eta_r - 1}{\eta_r} + \frac{\Theta}{\eta_r} \pi_t^{rent} \left(\pi_t^{rent} - (\pi)^{1-\phi} (\pi_{t-1}^{rent})^{\phi} \right)$$
$$- sdf_{t,t+1} \frac{\Theta}{\eta_r} \pi_{t+1}^{rent} \left(\pi_{t+1}^{rent} - (\pi)^{1-\phi} (\pi_t^{rent})^{\phi} \right), \qquad (5)$$

where $\pi_t^{rent} = \frac{r_t}{r_{t-1}} \pi_t^c$.

In the steady state, the final (real) price of rental services (r) is higher than the intermediate (real) rent price (p^m) by a markup of ($r = \frac{\eta_r}{\eta_r - 1} p^m$). Retailers' dividends, in real terms, are transferred to the lenders:

$$Div_t^{retail} = r_t Y_t^{rent} - p_t^m Y_t^{rent} - \frac{\Theta}{2} \left(\pi_t^{rent} - (\pi)^{1-\phi} (\pi_{t-1}^{rent})^{\phi} \right)^2 r_t Y_t^{rent},$$

where $Y_t^{rent} = h_{inv,t}$ (see proof in Appendix A).

4.4 Market clearing

The total number of dwellings acquired for investment by the lenders matches the supply of the final rental dwelling product.

$$h_{inv,t} = h_{r,t} + h'_{r,t} = Y_t^{rent}. \qquad (6)$$

The total number of dwellings the in the economy, available for both rent and ownership, is constant.

$$h_{o,t} + h'_{o,t} + h_{r,t} + h'_{r,t} = h.$$

Total savings are equal to total debt.

$$B_t + B'_t = 0$$

4.5 What determines the ownership-to-rent ratio?

Here, we introduce several propositions describing the factors that determine the ownership-to-rent ratio of lenders and borrowers.

Proposition 1:

With price flexibility and monopolistic competition in the rental housing market, the ownership-to-rent ratio among lenders in any period (and in steady state) is determined by their preferences and the markup.

Proof:

We again present the Philips curve for the rental prices (see Eq. (5) from Section 2.2):

$$\frac{p_t^m}{r_t} = \frac{\eta_r - 1}{\eta_r} + \frac{\Theta}{\eta_r}\pi_t^{rent}\left(\pi_t^{rent} - (\pi)^{1-\phi}(\pi_{t-1}^{rent})^{\phi}\right)$$

$$- sdf_{t,t+1}\frac{\Theta}{\eta_r}\pi_{t+1}^{rent}\left(\pi_{t+1}^{rent} - (\pi)^{1-\phi}(\pi_t^{rent})^{\phi}\right).$$

We can see that the ratio $\frac{p_t^m}{r_t}$ is neither equal to 1 nor constant. Nonetheless, with price flexibility and monopolistic competition, $\Theta = 0, \eta_r > 1$, we obtain:

$$r_t = \mathcal{F}p_t^m,$$

where $\mathcal{F} = \frac{\eta_r}{\eta_r - 1}$ is a markup.

From the first-order conditions of the lenders (Eqs. (b) and (c) in Section 2.1.2.)

$$\frac{h_{o,t}}{h_{r,t}} = \left(\frac{1-\gamma}{\gamma}\left[\frac{q_t(1+k)}{r_t} - sdf_{t,t+1}\frac{q_{t+1}(1-k)}{r_t}\right]\right)^{-\varepsilon}.$$

If we plug in $r_t = \mathcal{F}p_t^m$ we obtain:

$$\frac{h_{o,t}}{h_{r,t}} = \left(\frac{1-\gamma}{\gamma}\frac{1}{\mathcal{F}}\left[\frac{q_t(1+k)}{p_t^m} - sdf_{t,t+1}\frac{q_{t+1}(1-k)}{p_t^m}\right]\right)^{-\varepsilon}.$$

From Eq. (f) in Section 2.1.2., we have:

$$\frac{q_t}{p_t^m}(1+k) - sdf_{t,t+1}\frac{q_{t+1}}{p_t^m}(1-k) = 1.$$

Thus, for any time t as well in the steady state, the ownership-to-rent ratio is determined by preferences and markup in the rental market:

$$\frac{h_{o,t}}{h_{r,t}} = \frac{h_o}{h_r} = \left(\frac{\gamma}{1-\gamma}\mathcal{F}\right)^{\varepsilon}.$$

Proposition 2:

With price flexibility and a fully competitive rental housing market, the ownership-to-rent ratio among lenders in any period is determined solely by their preferences.

Proof:

In a fully competitive rental housing market, $\mathcal{F} \to 1$, the following condition holds (using the previous equation):

$$\frac{h_{o,t}}{h_{r,t}} = \left(\frac{\gamma}{1-\gamma}\right)^{\varepsilon}.$$

Proposition 3:

A lower LTV ratio, indicating tighter macroprudential policy, results in a *lower* ownership-to-rent ratio for *borrowers* in the steady state.

Proof:

From Eqs. (b)-(c) in Section 4.1.1., we derive the ownership–to-rent ratio of the *borrowers* in the steady state:

$$\frac{h_o'}{h_r'} = \left[\frac{1-\gamma'}{\gamma'}\left(\frac{q}{r}(1+\mathrm{k}) - sdf'\frac{\mathrm{q}}{\mathrm{r}}(1-\mathrm{k}) - \frac{\mathrm{q}}{r}\frac{\mu'}{\lambda'}LTV\right)\right]^{-\varepsilon}$$

Taking the derivative with regard to LTV yields:

$$\frac{\partial\left(\frac{h_o'}{h_r'}\right)}{\partial LTV} = \varepsilon\frac{q}{r}\frac{\mu'}{\lambda'}\left[\frac{1-\gamma'}{\gamma'}\left(\frac{q}{r}(1+k) - sdf'\frac{q}{r}(1-k) - \frac{q}{r}\frac{\mu'}{\lambda'}LTV\right)\right]^{-\varepsilon-1} > 0$$

The derivative is positive, meaning that a higher LTV constraint leads to a higher ownership–to-rent ratio. This result arises because the terms outside the brackets are positive ($\frac{q}{r}, \frac{\mu'}{\lambda'}$ >0) and are not affected by the LTV in the steady state (see Appendix A). The expression within the brackets is also positive, otherwise, the ownership–to-rent ratio ($\frac{h_o'}{h_r'}$) would be negative.

Proposition 4:

In the steady state, the ownership-to-rent ratio for borrowers is lower than that for lenders, given identical preferences, due to the LTV ratio constraint.

Proof:

The ownership-to-rent ratio of the lenders in steady state:

$$\frac{h_o}{h_r} = \left(\frac{1-\gamma}{\gamma}\frac{\mathrm{q}}{\mathrm{r}}[1+\mathrm{k} - sdf(1-k)]\right)^{-\varepsilon}$$

The ownership-to-rent ratio of the borrowers in steady state:

$$\frac{h_o'}{h_r'} = \left[\frac{1-\gamma'}{\gamma'}\frac{q}{r}\left(1+\mathrm{k} - sdf'(1-\mathrm{k}) - \frac{\mu'}{\lambda'}LTV\right)\right]^{-\varepsilon'}$$

Under assumption $\gamma' = \gamma, \varepsilon' = \varepsilon, k = 0$, we obtain:

$$\frac{h_o}{h_r} = \left(\frac{1-\gamma}{\gamma}\frac{\mathrm{q}}{\mathrm{r}}[1 - sdf)]\right)^{-\varepsilon} \; and \; \frac{h_o'}{h_r'} = \left[\frac{1-\gamma}{\gamma}\frac{q}{r}\left(1 - sdf' - \frac{\mu'}{\lambda'}LTV\right)\right]^{-\varepsilon}$$

In order for $\frac{h_o}{h_r} > \frac{h_o'}{h_r'}$ to hold, we need to prove that $1 - sdf < 1 - sdf' - \frac{\mu'}{\lambda'}LTV$.

Since $sdf = \beta$ and $sdf' = \beta'$, and after multiplying both sides by -1 we need to prove that:

$$\beta - \beta' > \left(1 - \frac{\beta'}{\beta} - \beta'\Psi\right)LTV$$

where $\frac{\mu'}{\lambda'} = 1 - \frac{\beta'}{\beta} - \beta'\Psi$ (see Appendix A).

This inequality always holds because the LHS is always greater than 1, while the RHS is always less than 1.

4.6 Firms

There is a continuum of monopolistically competitive firms indexed by $z \in [0,1]$. Each firm produces a differentiated intermediate good using labor $\bar{N}_t(z)$ with a Cobb–Douglas production function that is linear in labor. The share of each type of labor in the production function is assumed to be identical to the share in the population, τ, as in Benigno et al. (2020)). Additionally, there is no capital in production.[6]

$$Y_t(z) = A_t \bar{N}_t(z),$$

where $\bar{N}_t(z) = \left(N_t(z)\right)^{\tau}\left(N_t'(z)\right)^{1-\tau}$ is a Cobb-Guglass composite of both types of workers. The specification of the production function is the same as in Benigno et al. (2020). The specification of labor input $\bar{N}_t(z)$ is also similar to Sun and Tsang (2017), but the production function in that study also includes capital.

The differentiated-good firms sell their products in a monopolistic competition to a composite firm, producing the aggregate domestic good:

$$Y_t = \left(\int_0^1 Y_t(z)^{\frac{\eta_t - 1}{\eta_t}} dz\right)^{\frac{\eta_t}{\eta_t - 1}},$$

where η_t is the (time-varying) elasticity of substitution between the differentiated goods, thus serving as a "mark-up shock" to inflation π_t. The shock $\log(\eta_t)$ follows $AR(1)$ process.

The aggregate good Y_t is then sold in perfect competition at the price of $P_t^c = \left(\int_0^1 P_t^c(z)^{1-\eta_t} dz\right)^{\frac{1}{1-\eta_t}}$ and is used for private consumption.

Minimizing production costs by the composite firm implies the following demand functions for the differentiated goods:

$$Y_t(z) = \left[\frac{P_t^c(z)}{P_t^c}\right]^{-\eta_t} Y_t.$$

We assume nominal price rigidities à la Rotemberg (1982). Each firm z seeks to maximize its expected profits, and the discounting factor of profits depends on the ownership of the firms, which is assumed to belong to the lenders. This assumption is in line with Guerrieri and Iacoviello (2017).

The expected profits:

$$\max E_t \sum_{i=0}^{\infty} s\, df_{t,t+i} X_{t+i}(z),$$

where $X_t(z)$ is the nominal profit of firm z in $X_t(z) = P_t^c(z)Y_t(z) - W_tN_t(z) - W_t'N_t'(z) - \frac{\chi}{2}\left(\frac{P_t^c(z)}{P_{t-1}^c(z)} - (\pi)^{1-\varpi}\left(\frac{P_{t-1}^c}{P_{t-2}^c}\right)^{\varpi}\right)^2 P_t^cY_t$

and $sdf_{t,t} \equiv 1$, $sdf_{t,t+i} \equiv \prod_{l=1}^{i} s\,df_{t+l}$ for $i > 0$, $sdf_{t,t+1} = \beta\frac{\lambda_{t+1}}{\lambda_t}$, a stochastic discount factor of the lenders (owners of the firms). π is the steady-state inflation rate (excl. rentals), ϖ is the degree of indexation to past inflation (excl. rent)[6] and χ defines the cost associated with changing the price and is the source for price rigidity.

The first-order conditions with regard to price $P_t^c(z)$ yield the Philips curve:

$$\Gamma_t = \frac{\eta_t - 1}{\eta_t} + \frac{\chi}{\eta_t}\left(\pi_t^c - (\pi)^{1-\varpi}(\pi_{t-1}^c)^{\varpi}\right)\pi_t^c$$
$$-\frac{sdf_{t,t+1}\chi}{\eta_t}\left(\pi_{t+1}^c - (\pi)^{1-\varpi}(\pi_t^c)^{\varpi}\right)\frac{Y_{t+1}}{Y_t}\pi_{t+1}^c$$

where $sdf_{t,t+1} = \frac{\beta\lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor of the lenders, and Γ_t is a marginal cost.

The first-order conditions with regard to $N_t(z)$ and $N_t'(z)$ (see Appendix A for details) yields:

$$\Gamma_t = \frac{w_t}{\tau Y_t}N_t = \frac{w_t'}{(1-\tau)Y_t}N_t'$$

Dividends are transferred to the lenders:

$$Div_t = Y_t - w_tN_t - w_t'N_t' - \frac{\chi}{2}(\pi_t^c - (\pi)^{1-\varpi}(\pi_{t-1}^c)^{\varpi})^2Y_t$$

4.7 Commercial Banks (intermediates)

Commercial banks serve as intermediaries, accepting deposits from lenders and providing loans to borrowers. The spread-leverage relationship presented in Eq. (3), with parameter α, which is assumed to be chosen optimally by commercial banks to maximize their profits, is subject to possible default risk of the borrowers. While the maximum limit of LTV_t is determined exogenously by macroprudential policy.

[6] Similar to the assumption of indexation to past inflation in the Calvo price rigidity setting.

Bank profits in period t are transferred to lenders in period t+1, under the assumption that lenders are the sole owners of the banks.[7]

$$Div_t^b = X_{t-1}^b = B'_{t-1}(R_{t-1}^L - R_{t-1})$$

4.8 Monetary policy

The central bank's monetary policy follows a Taylor-type rule:

$$r_t^{CB} = \rho r_{t-1}^{CB} + (1-\rho)(r^{CB} + \theta_1(\pi_t - \pi) + \theta_2 \Delta y_t) + \epsilon_t^{CB}$$

where $\pi_t = \delta\pi_t^r + (1-\delta)\pi_t^C$ is the CPI inflation, calculated as the weighted average of the inflation of rental dwellings and the inflation of CPI (excl. rental dwellings) (with δ being the weight of rental dwellings in the CPI); Δy_t is the growth rate of GDP relative to the growth rate in the steady state; and ϵ_t^{CB} is a monetary shock.

5. Calibration

We calibrate our model parameters to align with the Israeli economy's distinct features (Table 1). The degree of habit formation parameter for consumption ζ is set at 0.5 for all households, a value that falls between the 0.62 from Argov et al. (2012) and the 0.1 from Ilek and Rozenshtrom (2018), (IL&R in Table 1). The disutility from labor parameter θ is set at 2.5, consistent with Ilek and Rozenshtrom (2018). The relative preference of housing, j_t, set in steady state to $j = 1$, while we test for robustness in the appendix the case of $j = 0.12$ as in Iacoviello and Neri (2010) and Sun and Tsang (2017). The elasticity of substitution between differentiated consumption goods ($\eta = 6$) is set to imply a steady state markup of 20%, consistent with Ilek and Rozenshtrom (2018). We apply the same elasticity value of 6 for the substitution between differentiated rental goods. This assumption suggests that firms have identical market power in both markets under monopolistic competition.

We assume a high elasticity of substitution between renting and owning (set at $\varepsilon = 10$) in the housing services aggregator function for both household types. We then adjust parameters $\gamma = 0.499$ and $\gamma' = 0.605$ to align with the observed ownership-to-rent ratios of 6 for lenders and 1.7 for borrowers. It is important to note that the lenders' ownership-to-rent ratio in the model is

[7] This simplifies the derivation of the economy's resource constraint.

also influenced by the 20% markup in the rental market, while the borrowers' ratio is affected by the steady state LTV ratio (see Section 4.5).

The two parameters—the share of constrained households (borrowers or impatient households) in the economy and their corresponding LTV ratio—are calibrated to reflect that, in reality, debt spans long periods rather than a single period as assumed in our model. We set the share of constrained households (1-τ) at 31.2%, based on Cohen and Ilek (2024). The corresponding effective LTV ratio is set at 66%, as calculated by the same study. Below, we explain this calibration.

Veteran debt holders, who are far from the debt limit, are unaffected by changes in the LTV ratios, unless seeking new debt or refinancing, so they are not classified as financially constrained. In contrast, households near the debt limit face difficulties in obtaining additional credit, and are classified as financially constrained. We calibrate the parameters of the model accordingly, based on a long-term survey (Cohen and Ilek (2024)). In practice, the model is calibrated so that debt limit affects about 31.2% of Israel's population. This group consists of two sub-groups:

1) Households unable to purchase a home due to insufficient equity (approximately 25% of the population). For them the effective LTV limit is around 75%.

2) Homeowners with existing mortgages who remain financially constrained (about 7% of the population). For them, the effective LTV limit is about 50% [8] if they wish to increase home-backed debt.

The effective LTV in the model is a weighted average of the limits for these two groups.

Lenders (patient households) have a discount factor $\beta = 0.99$, while borrowers (impatient households) have a discount factor $\beta' = 0.975$. These values have a tiny impact on dynamics but ensure that impatient households are sufficiently close to the borrowing limit, creating a strong enough impatience motive. This allows for accurate linearization around a steady state with a binding borrowing limit (Iacoviello (2005); Iacoviello and Neri (2010)).

Borrowers encounter a mortgage interest rate spread ω of 1.5% annually (0.375% quarterly), aligned with the average mortgage rate spread in Israel.

[8] Until 2024, the general-purpose loan limit backed by a home was 50%, but during "Operation Swords of Iron," it was temporarily raised to 70% (up to 200,000 ILS). For calibration, we use the 50% value.

We set the elasticity of the interest rate spread to leverage α at 0.02, following Ilek and Cohen (2023), indicating that a one percentage point rise in the LTV ratio results in a 0.02 percentage point increase in the spread.

The CPI inflation (excluding rent) indexation parameter ϖ is set at 0.3, which is between the 0.37 in Argov et al. (2012) and the zero in Ilek and Rozenshtrom (2018). We also apply the same indexation degree to nominal rent prices, $\phi = 0.3$. The price adjustment cost parameter for differentiated consumption goods firms χ, which affects the level of nominal rigidity in price setting, is set at 95, matching the value obtained in Ilek and Rozenshtrom (2018). The price adjustment cost parameter for rental services firms Θ is set at 311, based on stylized facts in Israeli rental market documented by Raz-Dror (2019)[9], indicating greater nominal rigidity in rental goods prices relative to consumption goods prices. This is consistent with empirical evidence from Raz-Dror (2019) and Ribon and Sayag (2013).

The inflation gap parameter θ_1 in the monetary policy rule is set at 2, implying a central bank's strong response to inflation deviations from its target, in line with the Taylor principle. This parameter is chosen to be between the 2.5 obtained in Argov et al. (2012) and the 1.5 from Ilek and Rozenshtrom (2018). The central bank's response to output growth θ_2 is set at 0.02, suggesting a more moderate response to output changes. The interest rate inertia parameter ρ is set at 0.75, reflecting significant smoothing in the interest rate. This inertia parameter aligns with Ilek and Rozenshtrom (2018) and is similar to Argov et al. (2012).

Finally, it is important to note that the steady-state levels of debt, the (risky) interest rate on debt, wages, and working hours are determined by the model's fundamental parameters. To assess the plausibility of their steady-state values, we observe that the model's payment-to-income (PTI) ratio aligns with empirical data, standing at approximately 25%.

Table 1: Calibration summary

Parameter	Description	Value	Reference
ζ^c	Habit in consumption for both HH	0.5	IL&R, Argov et al. (2012)
β	Discount factor of lenders	0.99	Literature

[9] The calculation of the parameter Θ is available from the authors upon request.

β'	Discount factor of borrowers	0.975	Literature
ω	Interest rate spread (in annual terms)	1.5%	Ilek and Cohen (2023)
α	Elasticity of interest rate spread to LTV	0.02	Ilek and Cohen (2023)
γ	Proportion of ownership in the housing bundle for lenders	0.499	Authors' calculations
γ'	Proportion of ownership in the housing bundle for borrowers	0.605	Authors' calculations
ϵ	Intratemporal elasticity of substitution between rent and ownership for both HH	10	Authors' calculations
$1\text{-}\tau$	Share of borrowers	31.2%	Cohen and Ilek (2024)
LTV	Loan-to-value ratio	66%	Cohen and Ilek (2024)
η	Elasticity of substitution between intermediate consumption goods	6	IL&R
η_r	Elasticity of substitution between intermediate rental dwellings	6	Authors' calculations
θ	Curvature of utility with regard to labor for both HH	2.5	IL&R
ϖ, ϕ	Degree of inflation indexation of consumption and rental prices	0.3	Argov et al. (2012) and authors' considerations
χ	Parameter of consumption price adjustment in cost function	95	IL&R
Θ	Parameter of rent price adjustment in cost function	311	Authors' calculations

θ_1	Reaction of CB policy rule to inflation gap	2	IL&R and Argov et al. (2012)
θ_2	Reaction if CB policy rule to output growth	0.02	IL&R and Argov et al. (2012)
ρ	Degree of smoothing in the CB interest rate rule	0.75	IL&R and Argov et al. (2012)
δ	Weight of rent in the CPI	25%	Data
π	Inflation target	2%	Official BOI target

6. Policy Analysis

In this section, we analyze the impact of monetary and macroprudential policies on the housing market.

We conducted some robustness tests for our result under different parameters, as described in Appendix 8.1. Additionally, we checked the robustness of our analysis using a nonlinear model based on a second-order Taylor approximation.

6.1 Impact of monetary policy on the housing market

The responses to a monetary policy (MP) shock, as depicted in Fig. 5 (blue line, representing the baseline case), are consistent with the conventional New-Keynesian model. Following a contractionary monetary policy shock of 1 p.p. (in annualized terms) the real interest rate increases, resulting in a simultaneous decline in real activity and inflation.

It is important to note that the increase in the real interest rate induces an intertemporal substitution effect (consistent with the Euler equation) among all households (both lenders and borrowers), resulting in a decrease in the demand for consumption (C, C') and housing rental services (h_r, h_r'). Moreover, both household types have negative labor income effects, as wages and hours declined (see Fig. A.6 in Appendix).

In addition, the investors' (unconstrained households) demand for rental property investment, h_{inv}, is decreasing. As a result, the total number of rented housing units $(h_r + h_r')$ must also decrease by the same amount, since the only housing supply available for rent is h_{inv} (see Eq. 6). Moreover, a decrease in the supply of rental housing leads to a higher real price of rent, r.

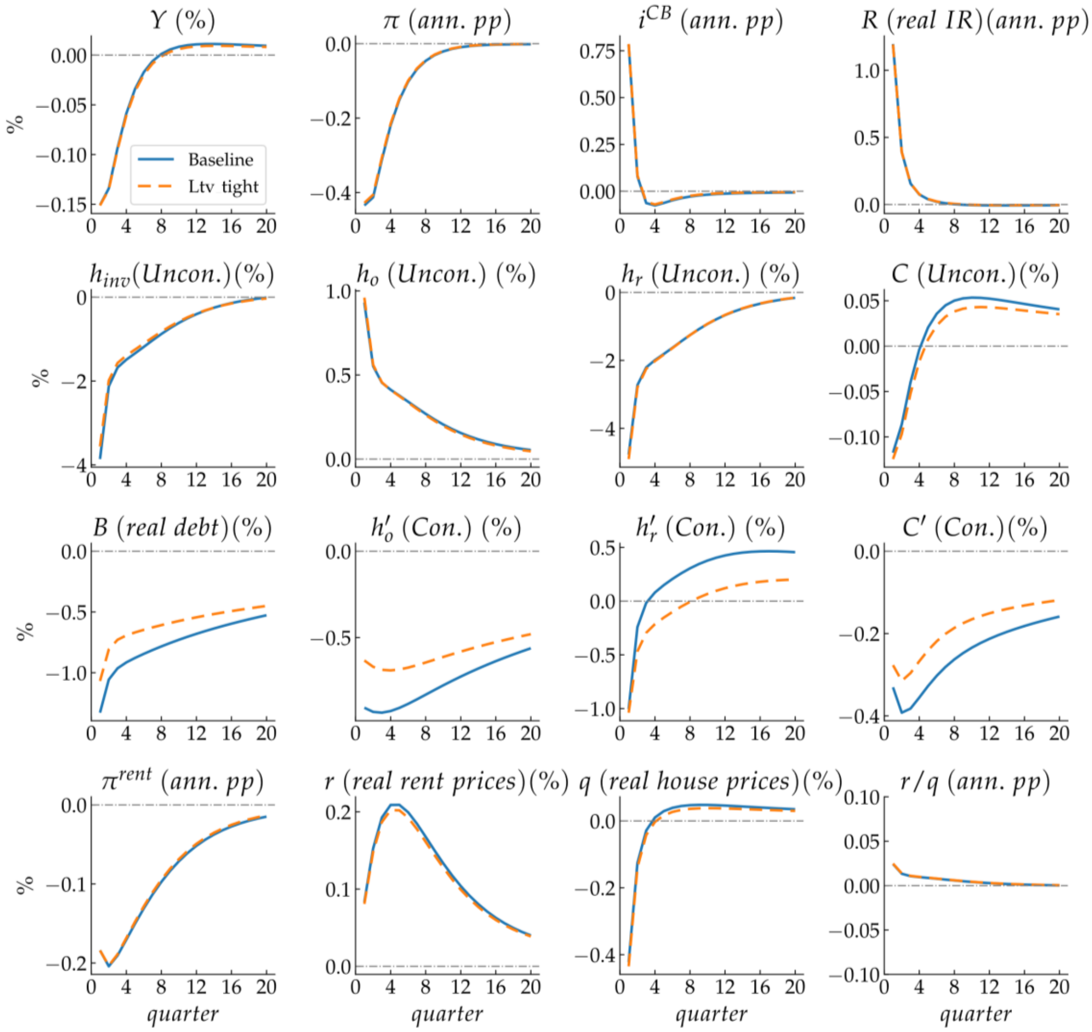
Furthermore, the housing market experiences a significant reduction in housing prices as valuations adjust to the higher interest rates. The escalation in interest rates also raises the mortgage rates, exhibiting a nearly one-to-one relationship. Mortgages therefore become more expensive, which pushes borrowers (financially constrained households) to reduce their debt burden and, consequently, to reduce their expenses and their home ownership. This makes the collateral constraint tighter and results in borrowers deleveraging their debt to meet the LTV constraint, further pushing down their expenses, and thus reducing ownership, rental, and consumption demand.

Notably, the rent to home price ratio (r/q), which represents the return on dwellings, increases, aligning with the higher interest rate.

Interestingly, lenders (unconstrained households) take advantage of the lower home prices and increase their home ownership, h_o. This is the only segment of the housing market that increases and clears the market.

As discussed, to meet the LTV constraint, borrowers decrease their home ownership, which could potentially result in increased demand for rentals (substitution effect between ownership and renting). However, this does not happen immediately but is delayed by four quarters. Two main factors discourage demand for rental housing services: (a) a general reduction in demand due to high real interest rates and the debt deleveraging process, and (b) higher real rent prices (supported by low general inflation, as a relative price effect). It is essential to emphasize that households may reduce both home ownership and renting, for instance by downsizing from a 4-room apartment to a 3-room apartment.

Figure 5: Response to a 1 p.p. MP shock, under a baseline LTV restriction of 66% (blue line) and under a tight LTV cap of 56% (orange dashed line)



Notes: Variables (in deviation from steady state): output, inflation, central bank rate, real interest rate, investment dwellings (to rent out), ownership by unconstrained households, renting by unconstrained households, consumption by unconstrained households, real debt, ownership by constrained households, renting by constrained households, consumption by constrained households, real rent prices, and real home prices. The y-axes denote percent deviation of each variable from its steady state in annualized terms, except for inflation and interest rates, which are in percentage point deviations.

Compared to the relevant literature, our findings align qualitatively with much of the existing research, including studies such as Sun and Tsang (2017). Nagar and Segal (2014) find that a permanent decrease of 1 p.p. in the monetary interest rate was found to lead to a 6.5 percent increase in nominal home prices over a two-year period. In our model, a comparable measure gives an increase of only approximately 1.6 percent in real terms, and 5.4 in nominal terms. In Yakhin and Gamrasni (2021), a 1 p.p. increase in short-term real rates decreases real home prices by 2 percent, where in our model the decrease is only 0.8 percent. We emphasize that this comparison is only to get an order of magnitude, since in our current examination we evaluate only the direct impact of a monetary policy shock.

6.2 The effectiveness of monetary policy under different levels of macroprudential policy tightness

An interesting question is whether monetary policy's effectiveness in achieving price stability and supporting real activity is affected by the tightness of macroprudential policy. This question is directly related to the debate on the coordination of monetary and macroprudential policies (see, e.g., Malovaná et al. (2023)). To investigate this question, we conduct an experiment by introducing a monetary policy shock under two different regulations: (a) a baseline LTV ratio of 66% (as analyzed above) and (b) a tighter LTV ratio of 56%. The latter represents a policy aimed at maintaining lower leverage in the economy, thereby reducing the severity of financial distress.

Fig. 5 displays the impulses under both scenarios (baseline and tight LTV cap), and it appears that the impulse dynamics of inflation and output are almost identical in both cases. *Thus, we conclude that macroprudential policy, in the form of LTV limits, does not change the effectiveness of monetary policy.*

These results are consistent with Funke et al. (2018) (Section 4.4.4), despite notable differences in model specifications and housing market assumptions, and with Cozzi et al. (2021) (Fig. 12), although they considered the leverage ratio of banks rather than households.

There is almost no difference in the reaction of unconstrained households (lenders) to the two levels of the LTV cap. This is true of both home prices and rent prices.

However, the reactions of constrained households (borrowers) differ. When the LTV cap is tighter, the initial level of debt (steady state level) is lower (by 35%, as discussed below). With the lower debt level, the increase in the interest rate has less of an effect. With a higher LTV cap (66%), borrowers have higher leverage, so the interest rate burden may result in significant deleveraging. In contrast, under the tight macroprudential policy with an LTV cap of 56%, the interest rate payments are more manageable. Consequently, financially constrained households experience a less severe decline in consumption and in home ownership, accompanied by a less severe decrease in credit.

In addition to the difference in debt levels (intensive margin), a lower LTV cap reduces the share of borrowers (extensive margin), because mortgages become less affordable. We estimate the corresponding reduction in the share of borrowers, , $1-\tau$, based on Israeli data (see Cohen and Ilek (2024)) and find a decrease of 3 to 4 percentage points. However, accounting for this effect does not alter any impulse responses. (The primary equation affected is that of labor composition, see Section 2.4.) Thus, we conclude that the entire contribution, which is minimal, stems from the initial debt level differences, as described.

We conjecture that the primary reason for the insensitivity of output (which is mostly equal to the sum of consumptions (excl. housing) of the two household types), inflation, and other key variables to monetary policy across different LTV ratios stems from the separability of the utility function between consumption and housing. This means that the marginal utility from consumption (excl. housing) is not directly affected by the amount of housing used for ownership and rent. For borrowers, this is critical because, as a result of a positive monetary shock under different LTV ratios, their demand for housing varies significantly (see Figure 5). If they had a nonseparable utility function, their demand for consumption (excl. housing) would have changed more significantly than in the basic case in Figure 5.

The insensitivity of the effectiveness of monetary policy to different LTV ratios could be due to the model's linearity (first-order Taylor approximation). We test whether this finding changes when we solve the model using a second-order Taylor approximation, and find that the result remains valid.

6.3 The Effect of LTV Ratio on Home Prices

The primary objective of macroprudential policy is to lessen the risk of future financial crises by controlling the level of debt in the economy. An intriguing question is whether such policy also influences home prices? Research findings vary, suggesting that the impact of macroprudential policy on home prices may depend on a country's specific housing market structure, making it difficult to draw definitive conclusions. Here, we examine the impact of macroprudential policy in the housing market using our model.

6.3.1 Short term effect

The LTV ratio shock demonstrates the impact of macroprudential policy that either tightens or loosens household borrowing capacity. Given the infrequency of macroprudential policy measures, we assume that the shock to the LTV ratio is (almost) permanent, approximated by a remarkably high inertia.[10] More specifically, we simulate a scenario where macroprudential policy lowers the maximum LTV ratio from 66% to 56% (almost) permanently. The share of borrowers is an exogenous parameter in the model, while in reality the LTV ratio shock may change the lender-borrower composition. Thus, we present here only the intensive borrowing margin.

Fig. 6 displays the impulse responses of the main variables to a permanent reduction of the LTV cap by 10 percentage points. It is evident that strict macroprudential (MP) policy significantly affects new debt, ownership, and rental conditions for borrowers (constrained households), yet its impact on home prices is minimal.

Several studies using DSGE models have assessed the impact of changing LTV ratios on home prices, and find that a permanent reduction in the LTV cap immediately decreases home prices.[11] However, as Fig. 6 shows, in our model we find that a reduction of 10 percentage points in LTV regulation leads to a marginal increase of 0.6% in home prices. We hypothesize that the reason for this difference is due to the lack of a rental market in those models (which serves as a high substitution to ownership), combined with the unique mechanism of the rental housing supply in Israel (Section 2 describes Israel's housing market).

The tight macroprudential policy—a reduction of 10 p.p. in the LTV cap—significantly reduces new debt by 40%. The elasticity of new debt to LTV exceeds one because borrowers' home ownership markedly drops by 30%. Consequently, a debt reduction of more than 10% is necessary to comply with the new LTV limit.

Since borrowers seek to reduce ownership, there is downward pressure on home prices. In models with ownership only, as described previously, home prices fall. However, the channel offsetting the initial downward pressure on home prices emerges when a rental market is included in the model. Given high substitutability between owning and renting, borrowers switch to renting, as shown by the increase in rent corresponding to the decrease in ownership (Figure 6). Now, facing high rental demand from borrowers, investors boost their demand for home purchases, resulting in a roughly 10% increase in investment (see Figure 6). This occurs as the return on investment in housing increases relative to the decline in interest rates on deposits.

[10] Similar to the approach in Alpanda and Zubairy (2017) Footnote 34, and Funke et al. (2018).
[11] When scaling all results to a 10 percentage point permanent reduction in LTV ratio caps, the studies suggest an immediate decrease in home prices as follows: 19% according to Funke et al. (2018), 1.2% according to Bruneau et al. (2018), 0.5% according to Lee and Song (2015).

Essentially, two opposing forces largely neutralize each other in affecting home prices: borrowers selling houses and moving to rentals, creating initial downward pressure on home prices, and investors then buying properties to meet the increased rental demand, driven by higher relative returns on investment. The slight rise in home prices can also be linked to a small endogenous reduction in the central bank (CB) interest rate (by 0.1 p.p.). Rental prices, facing upward demand pressure from borrowers. Consequently, lenders lower their rental demand.

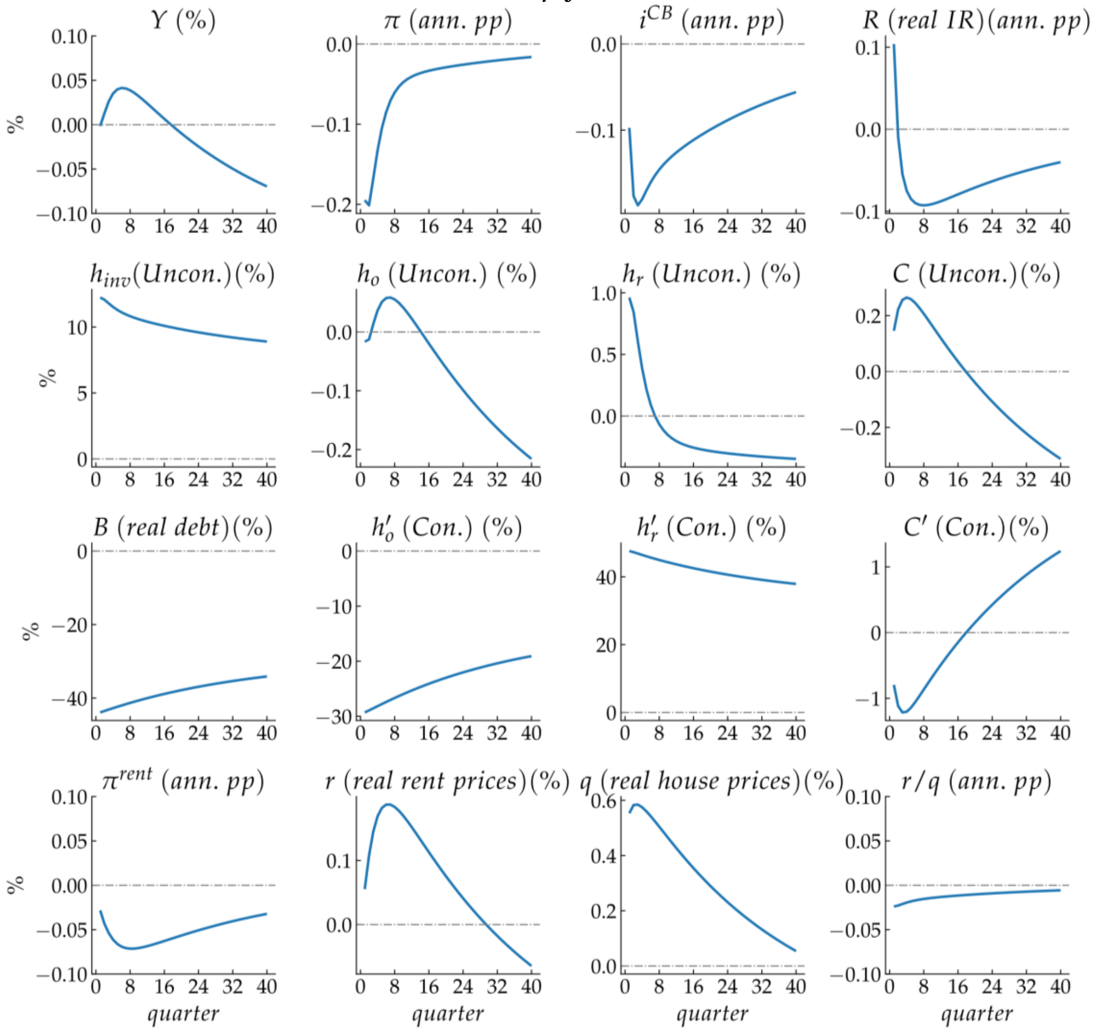
Figure 6 shows that tightening macroprudential policy (reductin the LTV cap) generates an immediate substitution effect between ownership and rent for borrowers. In contrast, tightening monetary policy (see Figure 5) results in a delayed substitution effect. This delay arises from the fact that tightening monetary policy also generates a negative income effect, which initially dominates the substitution effect.

One interesting result is the decline in inflation (excluding rentals), leading to a prolonged decrease in both the nominal and the real central bank interest rates (Figure 6). The decline in inflation (excluding rentals) stems from a reduction in firms' marginal costs. This occurs because, facing a reduction in consumption following significant deleveraging, borrowers try to compensate by working more. This generates a positive labor supply effect, resulting in lower wages and increased hours worked for borrowers. Since the elasticity of substitution between borrowers' and lenders' input is unitary (see Section 4.6), lenders' wages also decline, leading to a decrease in hours worked for lenders. The opposing labor supply responses of the two household types result in output remaining largely unchanged (Figure 6).

Our model-based theoretical result regarding a weak and even positive reaction of home prices to a decline in the maximum LTV ratio aligns with Cerutti et al. (2017) and Buitron and Denis (2014). Cerutti et al. (2017) found that a reduction in the maximum LTV ratio had an insignificant and slightly negative impact on home prices in advanced economies. Buitron and Denis (2014) reported that there is no empirical evidence that macroprudential policies in Israel have had a restraining effect home prices.

We conducted a robustness test for this result under a low degree of substitution between ownership and rent. The result remains largely unchanged (see Section 8.1) even though the substitution effect on home prices is much weaker than the baseline case, as it is outweighed by stronger accommodative monetary policy.

Figure 6: The impact of macroprudential policy that reduces the LTV cap from 66% to 56%



Note: All variables are presented as percentage deviations from their steady-state (SS) values. The LTV ratio is presented as an absolute percentage level.

6.3.2 Long-term effect

As observed earlier, the reduction in the maximum LTV ratio influenced the short-term dynamics of the rent-to-ownership price ratio and the ownership-to-rent ratio for both household types. We now conduct a comparative study where we permanently lower the maximum LTV limit. In Table 2, we compare two steady states of the economy: the baseline calibration with an LTV cap of 66%, and a scenario with tighter macroprudential policy featuring an LTV cap of 56%. We interpret modification of the LTV limit as emphasizing a structural shift in the economy rather than a dynamic policy action. We examine how a permanent decline in the LTV cap affects the level of debt and the composition between ownership and renting for two household types in the new steady state. However, we do not assess the impact of this permanent decline on the overall welfare of the economy, nor do we provide recommendations for the optimal LTV ratio.

In the steady state, the relative price of rent to ownership is determined by the lenders' discount factor and the rental market markup, not by the LTV ratio (Appendix A). Therefore, it is insightful to explore the changes in the ownership-to-rent ratio and other variables, excluding the price effect.

As expected, a stricter LTV restriction leads to significant 35% decline in new mortgages in the new steady state, resulting in a rent ratio that is 15.7% higher among borrowers. The elasticity of new debt to the LTV ratio is greater than one, as the value of homes purchased by borrowers declines. Therefore, to meet the new LTV cap, a reduction in debt exceeding 10% is required, as detailed in Eq. (1).

The rent ratio among lenders remains unchanged in the steady state (14.3%), as it is determined by their preferences and a markup in the housing market. Overall, the rent ratio in the economy increases from 16.8% to 18.6%, but this effect is solely via borrowers.

Propositions 1 and 3 in Section 4.5 analytically demonstrate a decline in the ownership-rent ratio of borrowers, without any change in the ownership-rent ratio of lenders, in response to a permanent reduction in the LTV cap.

Table 2's outcomes presume that LTV ratio changes do not affect the share of borrowers or other model parameters. While in practice, LTV changes might alter the proportion of borrowers (constrained households), our model does not account for an endogenous shift between the two groups (lenders to borrowers or vice-versa). Such a transition would also imply a change in preferences for lenders and borrowers, given their differing initial discount factors (β). The final two columns of Table 2 present outcomes assuming that a tighter macroprudential policy raises the fraction of constrained households from 32% to 35%, based on external calibration (see Cohen and Ilek (2024)). The results show a small deviation from the original scenario, while the share of constrained households remains constant.

Table 2: Comparative statistics – Steady-state levels of debt and ownership-to rent ratio under different LTV limits

	Baseline	Tight LTV	Change	Tight LTV*	Change*
Share of constrained households in the population, τ	31.2%	31.2%	-	35%	3.8%
LTV limit	66%	56%	-10%	56%	-10%
B			-35%		-27%
Rent ratio of lenders $\frac{h_r}{h_r+h_o}$	14.3%	14.3%	-	14.3%	-
Rent ratio of borrowers $\frac{h'_r}{h'_r+h'_o}$	36.8%	52.5%	15.7%	52.5%	15.7%
Rent ratio total $\frac{h_r+h'_r}{h}$	16.8%	18.6%	1.8%	19.1%	2.3%

7. Conclusions

The effectiveness of monetary and macroprudential policies is an important question for central banks. Our model of the Israeli economy shows that while a tighter macroprudential policy, represented by the LTV ratio cap, can significantly reduce debt levels and the ownership-to-rent ratio of borrowers, its impact on home prices is relatively minor and can even be positive. This finding contrasts with existing DSGE model literature, which typically suggests that a lower LTV ratio cap decreases home prices. We attribute this discrepancy to the absence of a rental market in those models, a key factor explaining housing market dynamics.

In our model, the presence of a rental market creates a mechanism where borrowers shift from ownership to renting, prompting investors to purchase more dwellings to meet the increased rental demand, thus counteracting the initial downward pressure on home prices. These insights are crucial for policymakers, indicating that while macroprudential tools can help manage financial stability, their effect on home prices must be carefully assessed alongside other monetary measures.

Furthermore, our analysis indicates that macroprudential policy does not undermine the central bank's ability to achieve its primary goals of price stability and supporting real activity, although it does introduce a slight distributional effect due to household heterogeneity.

We believe that our research not only enhances the understanding of Israel's housing market dynamics but also has implications for other economies implementing similar policies.

Reference

Alpanda, Sami and Sarah Zubairy (2017). “Addressing Household Indebtedness: Monetary, Fiscal or Macroprudential Policy?” *European Economic Review,* 92 (February): 47–73. https://doi.org/10.1016/j.euroecorev.2016.11.004.

Aoki, Kosuke, James Proudman, and Gertjan Vlieghe (2004). “House Prices, Consumption, and Monetary Policy: A Financial Accelerator Approach.” *Journal of Financial Intermediation*, 22.

Argov, Eyal, Emanuel Barnea, Alon Binyamini, Eliezer Borenstein, David Elkayam, and Irit Rozenshtrom (2012). “MOISE: A DSGE Model for the Israeli Economy.” Discussion Paper Series, 2012.06. Bank of Israel Research Department. https://doi.org/10.2139/ssrn.2168191.

Bekiros, Stelios, Rachatar Nilavongse, and Gazi Salah Uddin (2020). “Expectation-Driven House Prices and Debt Defaults: The Effectiveness of Monetary and Macroprudential Policies.” *Journal of Financial Stability,* 49 (August):100760. https://doi.org/10.1016/j.jfs.2020.100760.

Benchimol, Jonathan, Inon Gamrasni, Michael Kahn, Sigal Ribon, Yossi Saadon, Noam Ben-Ze’ev, Asaf Segal, and Yitzchak Shizgal (2022). “The Interaction between Domestic Monetary Policy and Macroprudential Policy in Israel.” *Economic Modelling* 112 (July):105872. https://doi.org/10.1016/j.econmod.2022.105872.

Benigno, Pierpaolo, Gauti B. Eggertsson, and Federica Romei (2020). “Dynamic Debt Deleveraging and Optimal Monetary Policy.” *American Economic Journal: Macroeconomics,* 12(2): 310–350. https://doi.org/10.1257/mac.20160124.

Bosshardt, Joshua, Marco Di Maggio, Ali Kakhbod, and Amir Kermani (2023). “The Credit Supply Channel of Monetary Policy Tightening and Its Distributional Impacts.” Working Paper. Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w31464.

Bruneau, Gabriel, Ian Christensen, and Césaire Meh (2018). “Housing Market Dynamics and Macroprudential Policies.” *Canadian Journal of Economics,* 51(3): 864–900. https://doi.org/10.1111/caje.12346.

Buitron, Carolina Osorio, and Stephanie Denis (2014). “The Housing Market in Israel.” IMF Country Report No. 14/48. International Monetary Fund.

Cairó, Isabel and Jae Sim (2023). “Monetary Policy and Financial Stability.” *Journal of Economic Dynamics and Control,* 157 (December):104764. https://doi.org/10.1016/j.jedc.2023.104764.

Cerutti, Eugenio, Stijn Claessens, and Luc Laeven (2017). “The Use and Effectiveness of Macroprudential Policies: New Evidence.” *Journal of Financial Stability,* 28 (February):203–224. https://doi.org/10.1016/j.jfs.2015.10.004.

Cohen, Nimrod and Alex Ilek (2024). “An Estimate of the Share of Financially Constrained Households in Israel (Hebrew).” Unpublished Memo. Bank of Israel.

Cozzi, Guido, Matthieu Darracq Paries, Peter Karadi, Jenny Körner, Christoffer Kok, Falk Mazelis, Kalin Nikolov, Elena Rancoita, Alejandro Van Der Ghote, and Julien Weber (2021). “Macroprudential Policy Measures: Macroeconomic Impact and Interaction with Monetary Policy.” ECB Working Paper Series 2376. https://doi.org/10.2139/ssrn.3541732.

Drehmann, Mathias, Claudio E. V. Borio, and Kostas Tsatsaronis (2012). “Characterising the Financial Cycle: Don’t Lose Sight of the Medium Term!” BIS Working Papers 380. Bank for International Settlements. https://www.bis.org/publ/work380.htm.

Funke, Michael, Robert Kirkby, and Petar Mihaylovski (2018). “House Prices and Macroprudential Policy in an Estimated DSGE Model of New Zealand.” *Journal of Macroeconomics,* 56 (June):152–171. https://doi.org/10.1016/j.jmacro.2018.01.006.

Genesove, David (2003). “The Nominal Rigidity of Apartment Rents.” *The Review of Economics and Statistics,* 85 (4): 844–853. https://doi.org/10.1162/003465303772815763.

Guerrieri, Luca and Matteo Iacoviello (2017). “Collateral Constraints and Macroeconomic Asymmetries.” *Journal of Monetary Economics,* 90 (October):28–49. https://doi.org/10.1016/j.jmoneco.2017.06.004.

Iacoviello, Matteo (2005). “House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle.” *American Economic Review,* 95 (3): 739–764. https://doi.org/10.1257/0002828054201477.

Iacoviello, Matteo and Stefano Neri (2010). “Housing Market Spillovers: Evidence from an Estimated DSGE Model.” *American Economic Journal: Macroeconomics,* 2 (2): 125–64. https://doi.org/10.1257/mac.2.2.125.

Ilek, Alex and Nimrod Cohen (2023). “A Semi-Structural Model with Household Debt for Israel.” Discussion Paper Series, 2023.03. Bank of Israel Research Department. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4368479.

Ilek, Alex and Irit Rozenshtrom (2018). “The Term Premium in a Small Open Economy: A Micro-Founded Approach.” *International Review of Economics & Finance,* 57 (September): 333–352. https://doi.org/10.1016/j.iref.2018.02.002.

Kosman, Liran (2021). “Housing Ownership Data by Deciles in Israel.” The Knesset Research and Information Center, Israel.

Laufer, Steven and Nitzan Tzur-Ilan (2021). “The Effect of LTV-Based Risk Weights on House Prices: Evidence from an Israeli Macroprudential Policy.” *Journal of Urban Economics,* 124 (July):103349. https://doi.org/10.1016/j.jue.2021.103349.

Lee, Junhee and Joonhyuk Song (2015). “Housing and Business Cycles in Korea: A Multi-Sector Bayesian DSGE Approach.” *Economic Modelling,* 45 (February): 99–108.

https://doi.org/10.1016/j.econmod.2014.11.009.
Malovaná, Simona, Martin Hodula, Zuzana Gric, and Josef Bajzík (2023). "Macroprudential Policy in Central Banks: Integrated or Separate? Survey among Academics and Central Bankers." *Journal of Financial Stability,* 65 (April):101107. https://doi.org/10.1016/j.jfs.2023.101107.
Nagar, Weitzman and Guy Segal.(2014). "What Explains the Developments in Home Prices and Rents in Israel between 1999 and 2010?" *Israel Economic Review,* 12(1): 115–161.
Quint, Dominic and Pau Rabanal (2014). "Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro Area." *International Journal of Central Banking,* 10(2).
Raz-Dror, Ofer (2019). "The Changes in Rent in Israel during the Years of the Housing Crisis 2008–2015." *Israel Economic Review,* 17(1). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3481727.
Ribon, Sigal (2023). "The Interaction between Macroprudential and Monetary Policies and the Housing Market – A VAR Examination for Israel." Discussion Paper Series, 2023.11. Bank of Israel Research Department. https://boiwebrepec.azurefd.net/RePEc/boi/wpaper/WP_2023.11.pdf.
Ribon, Sigal and Doron Sayag (2013). "Price Setting Behavior in Israel An Empirical Analysis Using Microdata." Discussion Paper Series, 2013.07. Research Department Bank of Israel.
https://boi.org.il/media/m41lhbv0/dp1307e.pdf.
Shimizu, Chihiro, Kiyohiko G. Nishimura, and Tsutomu Watanabe (2010). "Residential Rents and Price Rigidity: Micro Structure and Macro Consequences." *Journal of the Japanese and International Economies,* 24(2): 282–299. https://doi.org/10.1016/j.jjie.2009.12.006.
Stein-Kapach, Nardit (2019). "Ownership of Financial Assets by Households Findings from the Longitudinal Survey 2018 (Hebrew Only)." Central Bureau of Statistics.
Sun, Xiaojin and Kwok Ping Tsang (2017). "What Drives the Owner-Occupied and Rental Housing Markets? Evidence from an Estimated DSGE Model." *Journal of Money, Credit and Banking,* 49(2–3): 443–468. https://doi.org/10.1111/jmcb.12385.
van Hoenselaar, Frank, Boris Cournède, Federica De Pace, and Volker Ziemann (2021). "Mortgage Finance across OECD Countries." OECD Economics Department Working Papers 1693. Paris: OECD. https://doi.org/10.1787/f97d7fe0-en.
Verbrugge, Randal, Alan Dorfman, William Johnson, Fred Marsh III, Robert Poole, and Owen Shoemaker (2017). "Determinants of Differential Rent Changes: Mean Reversion versus the Usual Suspects." *Real Estate Economics,* 45(3): 591–627. https://doi.org/10.1111/1540-6229.12145.
Yakhin, Yossi and Inon Gamrasni (2021). "The Housing Market in Israel: Long-Run Equilibrium and Short-Run Dynamics." Discussion Paper Series, 2021.08. Bank of Israel Research Department. https://boiwebrepec.azurefd.net/RePEc/boi/wpaper/WP_2021.08.pdf.

8. Appendix

Supplementary material can be found *here*.

8.1 Robustness check

8.1.1 Changing the elasticity of substitution between house ownership and house rent

In the following simulations, we reduce the elasticity of substitution between house ownership and house rent from $\varepsilon = 10$ to $\varepsilon = 2$. That means that house ownership and house rent are much less substitutable for each other. We maintain the ownership-to-rent ratio, $\frac{h_0}{h_r}$, of both lenders and borrowers as observed in the data by appropriate adjustment of the ownership share in the preferences for housing, γ and γ'[12].

In Fig.A.1, we can see the impact of lower EIS on the response to monetary policy (MP) shock under two levels of the LTV cap. On the aggregate level (upper graphs), we see that the responses remain completely unchanged. For the lenders (unconstrained households), we see that the results still do not depend on the LTV cap, but they are much more modest for $\varepsilon = 2$. Interestingly, as expected, for the borrowers (constrained households), the main change is that in the medium term, there is no substitution effect. The reduction in rental housing is implausible and contradict the findings of research on this topic for Israel (such as Yakhin and Gamrasni (2021)), which supports our basic calibration of EIS, $\varepsilon = 10$. As the borrowers reduce housing ownership due to the debt deleveraging process, they do not increase demand for rental housing. Correspondently, the increase in rental prices is slightly lower.

In Fig. A.2, we can see the impact of lower EIS on the response to an LTV shock. In general, the qualitative responses do not change much, but there are significant quantitative changes. First, borrowers needing to deleverage modestly reduce household debt and home ownership. Then, they shift to rental housing, but with a lower EIS they rent much less. Consequently, the increase in investment is much weaker than in the benchmark case. With a lower EIS the substitution effect is much weaker: Borrowers increase rentals, but it does not compensate for the decline in ownership. Rental prices even fall after several periods. But why do home prices still increase in the short to medium term despite the weak substitution effect and the decline in rental

[12] We obtained $\gamma = 0.671$ and γ'=0.655 to match $\frac{h_0}{h_r} = 6$ and $\frac{h'_0}{h'_r} = 1.7$, respectively.

prices? The main reason is the significant fall in the interest rate due to decreased inflation, leading to a prolonged decline in the real interest rate, which is much stronger than in the benchmark case. The decline in inflation is primarily due to drops in rental prices and in the prices of consumption goods (excluding rentals). As in the benchmark case, the decline in inflation (excluding rentals) stems from a reduction in firms' marginal costs, originating from a positive labor supply effect of the borrowers, which is stronger under low EIS.

Figure A.1: Response to a 1 p.p. monetary policy shock under an LTV cap of 66% (blue line), and a tighter LTV cap of 56% (orange dash line), both for lower EIS ($\varepsilon = 2$).

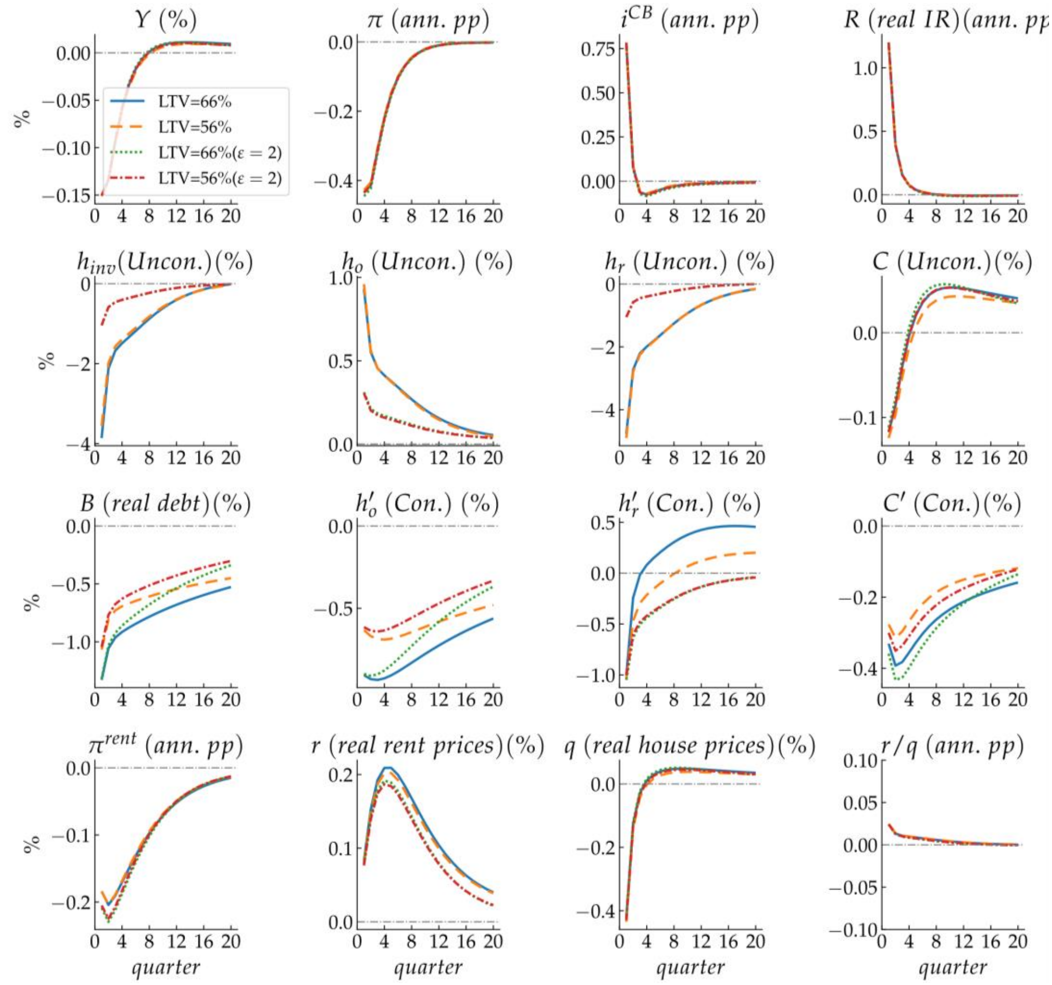
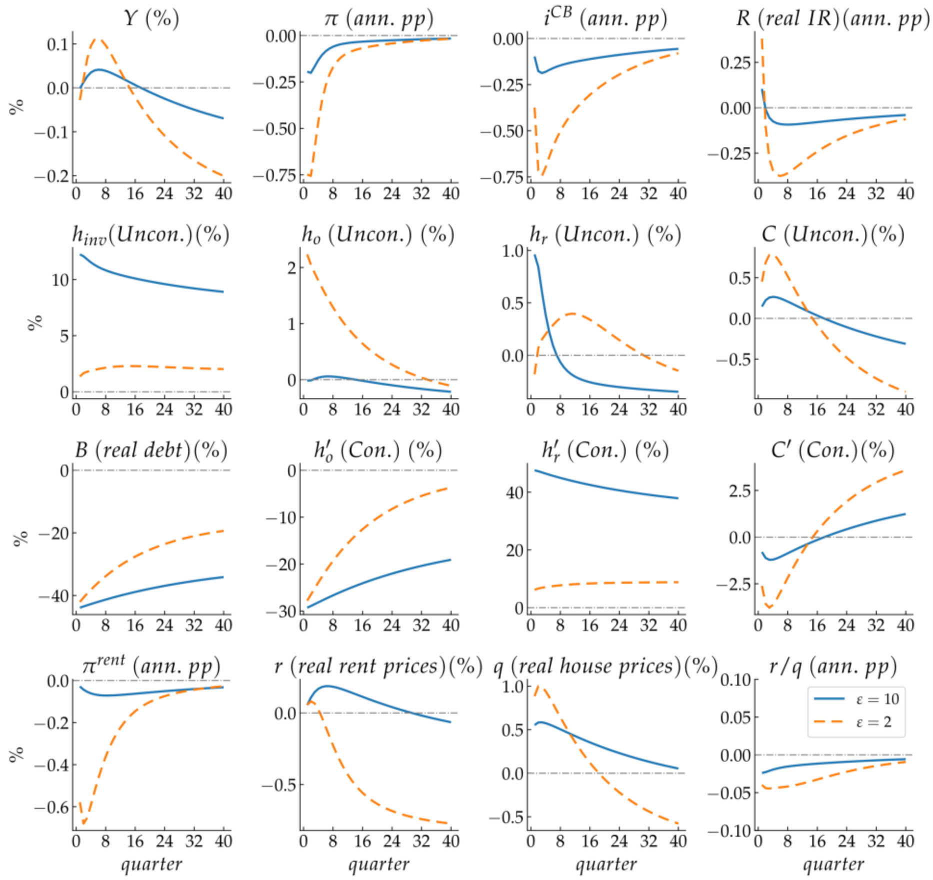


Figure A.2: LTV shock that reduces the LTV cap from 66% to 56%, under two EIS between home ownership and rent ($\varepsilon \in [10,2]$)



8.1.2 Changing the housing preference weight (j)

Here, we examine the effect of the housing preference weight j (see Section 4.1). Since there is no estimate for Israel, we test the case of $j = 0.12$ as in Iacoviello and Neri (2010) and Sun and Tsang (2017), while our baseline is $j = 1$.

Under the MP shock (Figure A.3), the response of most variables is similar to the baseline case. The most notable change is that borrowers increase rental demand and reduce ownership demand more prominently.

Under the LTV shock (Figure A.4), we observe only slightly different qualitative responses than under the benchmark, with generally faster and more moderate reactions.

Figure A.3: Response to a 1 p.p. monetary policy shock, for the baseline calibration j=1 (blue line) and for a lower j=0.12 (orange dash line).

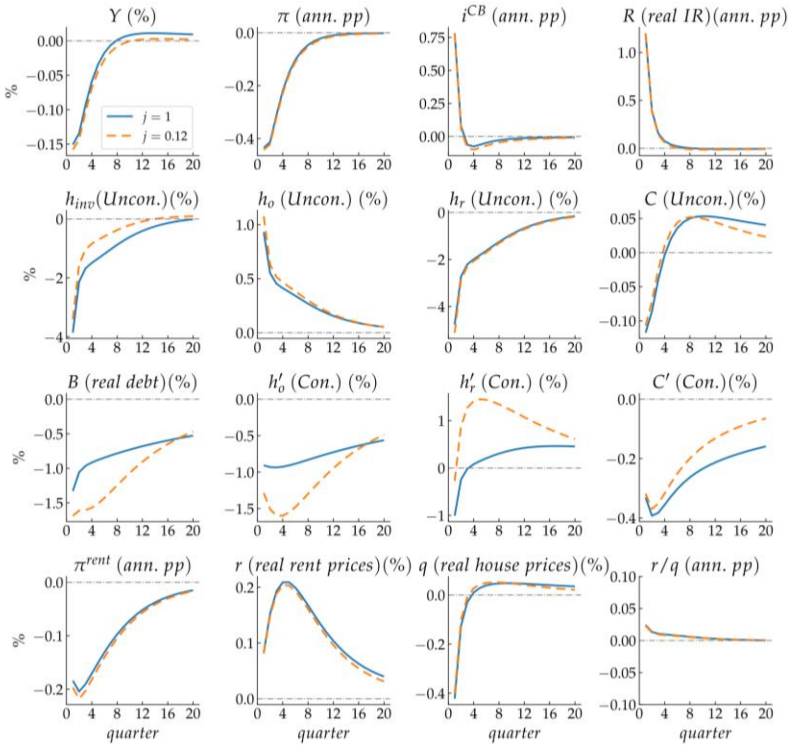
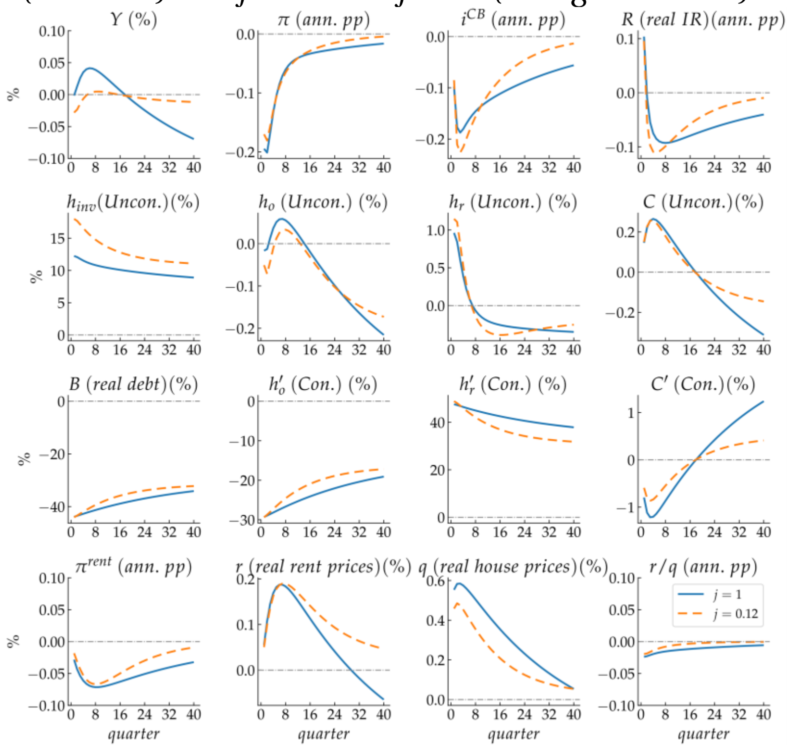


Figure A.4: The impact of macroprudential policy that reduces the LTV ratio cap from 66% to 56%, for the baseline calibration j=1 (blue line) and for a lower j=0.12 (orange dash line).



8.2 Additional Figures

Figure A.5: *Response to a 1 p.p. MP shock, under a baseline LTV restriction (of 66%, blue line) – additional variables*

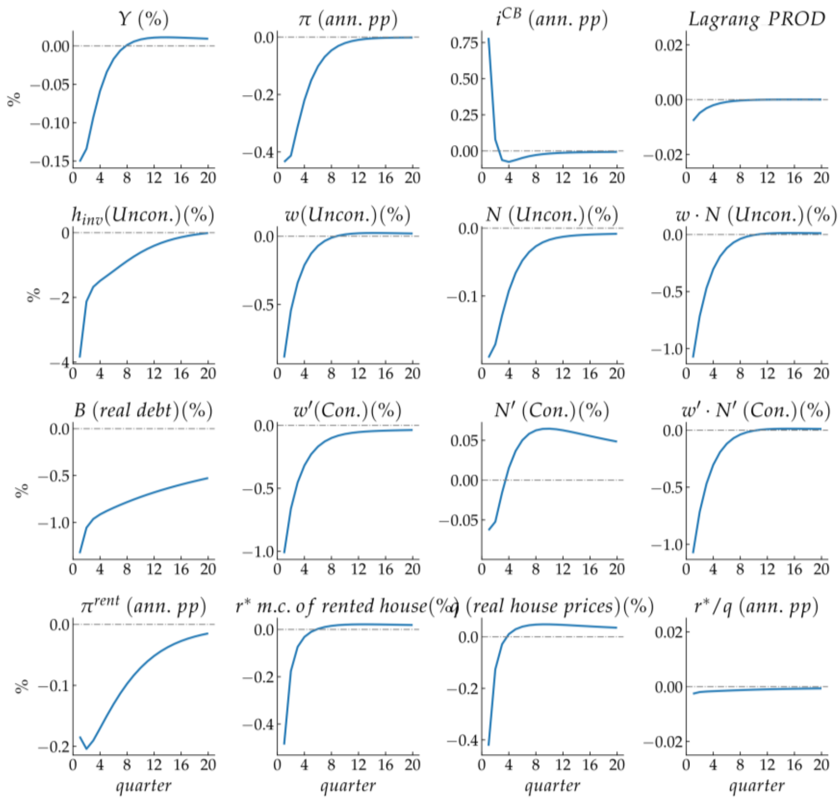


Figure A.6: *The impact of macroprudential policy that reduces the LTV ratio cap from 66% to 56% – additional variables*