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

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Abstract

We develop and calibrate a microfounded DSGE model featuring a housing market and heterogeneous households tailored to the Israeli economy. The model construction is based on key stylized facts about the Israeli economy and includes both ownership and rental markets. Our primary objective is to examine the effects of monetary and macroprudential policies on the housing market and the broader economy. In our model, macroprudential policy is represented by the Loan-to-Value (LTV) ratio, a common measure in the literature. Additionally, we investigate whether changes in the LTV ratio affect the central bank's ability to achieve its main objectives—price stability and the stabilization of real activity. Our findings could have significant implications for the implementation of monetary and macroprudential policies, not only in Israel but also in other economies.

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1. Introduction

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

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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 stricter macroprudential policy (a lower Loan-to-Value ratio) influence the effectiveness of monetary policy in achieving its primary goals?

3. How does the LTV policy influence housing market? In the short run and in the long run.

For this purpose, we build a structural model which has the advantage in analyzing policy questions. Structural models allow establishing 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, as we will elaborate.

The Israeli housing market has two interrelated sub-markets –ownership and renting. This distinction should be considered in policy analysis. Thus, our research conducts a comprehensive analysis based on a micro-founded Dynamic Stochastic General Equilibrium (DSGE) model, which includes both ownership housing market and rental market. Additionally, the model included two types of households – lenders and borrowers with collaterals constraint (tied to the value of houses, as in Iacoviello (2005)). Finally, the model is 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 more stringent macroprudential policy influences the effectiveness of monetary policy.

Note that 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. While macroprudential policy focuses on financial cycles and is implemented infrequently, typically once every couple of years. According to Mathias 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 mortgages.

Our results show that altering LTV ratio through macroprudential policy does not hinder monetary policy's effectiveness in achieving its main objectives, though it does lead to a slight distributional effect reflecting household heterogeneity. We find that a stricter LTV policy markedly lowers debt, but its influence on housing prices is minor. This contrasts with existing DSGE model literature, which suggests that a lower LTV ratio decreases housing prices. We argue that this discrepancy arises from a critical element that is absent in earlier models but incorporated in ours.

We contribute to this literature by developing and estimating a DSGE model with housing for Israel, which has a unique institutional setup for macroprudential policy. We analyze the effects of monetary and macroprudential policies on the housing market and the economy.

The structure of the paper is as following – Section 2 provides a brief literature review, Section 3 presents important stylized facts of the Israeli housing market, Section 4 describes the model and its calibration, Section 5 introduces the analysis of monetary and macroprudential policies, and Section 6 summarizes.

2. Literature Review

The literature that presents DSGE models with housing is vast. For instance, Iacoviello (2005) and Aoki et al. (2004) assume that houses are used for ownership only, providing housing services and serving as collateral to reduce borrowing costs. They show that the LTV restriction amplifies and propagates the effect of monetary policy shocks on housing investments, home prices, and consumption, which is known as the financial accelerator effect.

Sun and Tsang (2017) incorporate both ownership and rentals into their model, assuming that ownership and rent are imperfect substitutes. They show that rental market frictions can generate persistent deviations of housing prices from their fundamental value, and that monetary policy can affect the housing market through both the interest rate channel and the rental channel. They also find that the intertemporal preference shock accounts for more than half of the variation in home prices. In their model, entrepreneurs (firms) provide rental services, and face financial constraint. In contrast, in our model, which is suitable for the Israeli economy, the suppliers of rental services are financially unconstrained households (investors).

Some studies for Israel, mainly empirically oriented, investigated the housing market. Yakhin and Gamrasni (2021) and Nagar and Segal (2014) estimate a long-run equilibrium relationship between house prices, rents, interest rates, and other variables. They also explained short-run dynamics of rent and housing prices by using a Vector-error-correction model. Both found empirically that in the short run, rise in monetary interest rate lowers home prices but raises rents, as interpreted by them as ownership-rent substitution effect. Although these models are data driven and successfully characterize some of the Israeli economy properties, they are not microfounded and do not consider household's heterogeneity, financial friction, and general equilibrium effects. Thus, they are limited in analyzing policy (Lucas's critique). Our model fills this gap by incorporating these factors and providing a more comprehensive analysis of the housing market and its interactions with the broader economy.

Some studies examine macroprudential policy within a structural DSGE model and its interaction with monetary policy. In Israel, Benchimol et al. (2022) examine the impact of domestic macroprudential policy measures and domestic monetary policy on bank credit in Israel, using individual bank panel data. They find that macroprudential policy measures significantly reduce credit growth, particularly mortgages, although their impact on housing prices was not analyzed. Additionally, it was found that macroprudential policy measures also affect the transmission of monetary policy to banking credit. Benchimol et al. (2022) also find that macroprudential policy measures have heterogeneous effects across distinct types of banks, depending on their size, liquidity, capitalization, and exposure to foreign currency.

Bekiros et al. (2020) introduce various features in their models, such as loans, collateral constraints, nominal rigidity and debt defaults. They find that the effectiveness of monetary versus macroprudential policy depends on whether the economy is affected by non-fundamental or fundamental shocks. Similar to Bekiros et al. (2020), we aim to inspect the interaction between monetary and macroprudential polices, with the added layer of renting market.

Funke et al. (2018) develop a DSGE model with housing for New Zealand and analyze the effects of various housing-related macroprudential policies on the economy. They find that macroprudential policies can reduce house price volatility and improve welfare. Quint and Rabanal (2014) develop a DSGE model with housing for the euro area and analyze the optimal mix of monetary and macroprudential policies in an estimated two-country model with financial frictions. They find that macroprudential policies can complement monetary policy by reducing financial imbalances and stabilizing inflation. Cairó and Sim (2023) build a structural model and show that a central bank can improve both price stability and financial stability by adopting an aggressive inflation targeting regime. Additionally, when the credit cycle is driven by countercyclical household sector leverage, leaning with credit spreads can be more effective in improving both price stability and financial stability.

Cozzi et al. (2021) investigate how varying leverage ratios of banks, within the Gertler and Karadi model (2013), influence the sensitivity of inflation and output to monetary policy shocks. They found that the responses were similar across different leverage ratios.

Bosshardt et al. (2023) investigate the credit supply channel of monetary policy tightening and its distributional impacts in the U.S., using micro-level data from the Federal Housing Finance Agency's Credit Registry. They find that macroprudential policy measures have different effects on housing credit and business credit, and that they interact with monetary policy. They also find that monetary policy tightening reduces the supply of credit to households and firms and increases the probability of default.

3. Stylized facts of the Israeli housing market

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

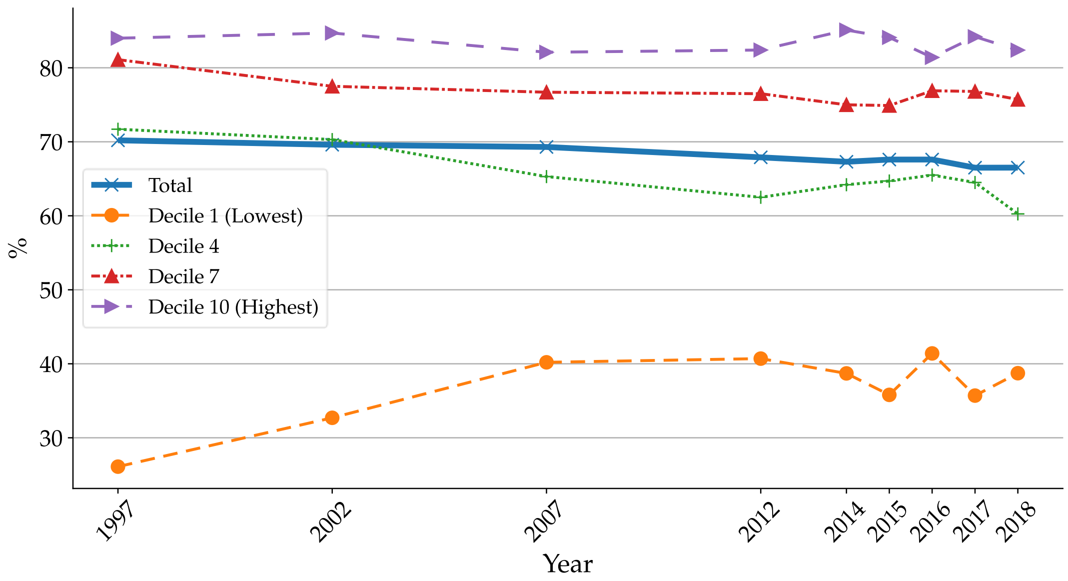
First, based on Fig. 1 we note that the total home ownership ratio in Israel is near 67%, and it is quite stable over time. However, there are significant disparities in home ownership rates across different income deciles. For the lowest (poorest) income decile, only 40% of households are homeowners. This is largely due to financial constraints, as evident by the small share of mortgages (14%) for the two lowest income deciles (Fig. 2).[2]

In contrast, more than 80% of households in the highest (richest) income decile are homeowners. Among them, only 33% have mortgages, indicating that most of them finance their homes from their own resources. It is worth noting that about 15% of rich households choose to rent houses, which can be interpreted as a revealed preference rather than a financial constraint. Moreover, the wealthy (high-income) households own (on average) one or more homes (Fig. 3). We thus conclude that they are the "investors" in the housing market, supplying the rental dwellings to the market. This is one of

[2] As income increase the share of households with mortgage is higher, which is robust phenomena worldwide (see Fig.A1 in the Appendix)

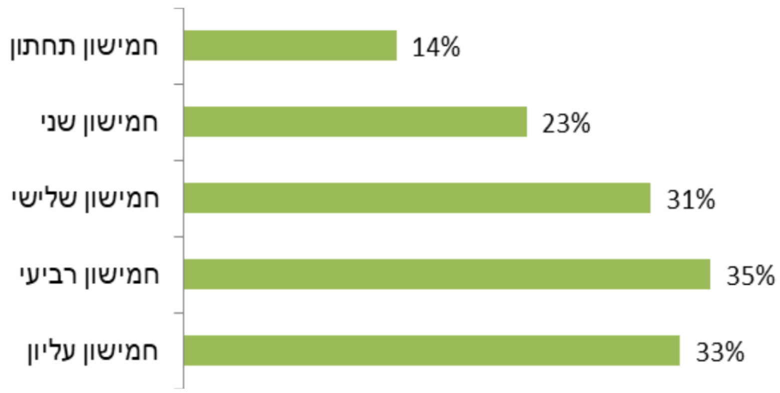
the Israeli housing market unique properties and we incorporate it into the model.

Figure 1: Share of owner-occupied households by selected income decile (1997-2018)



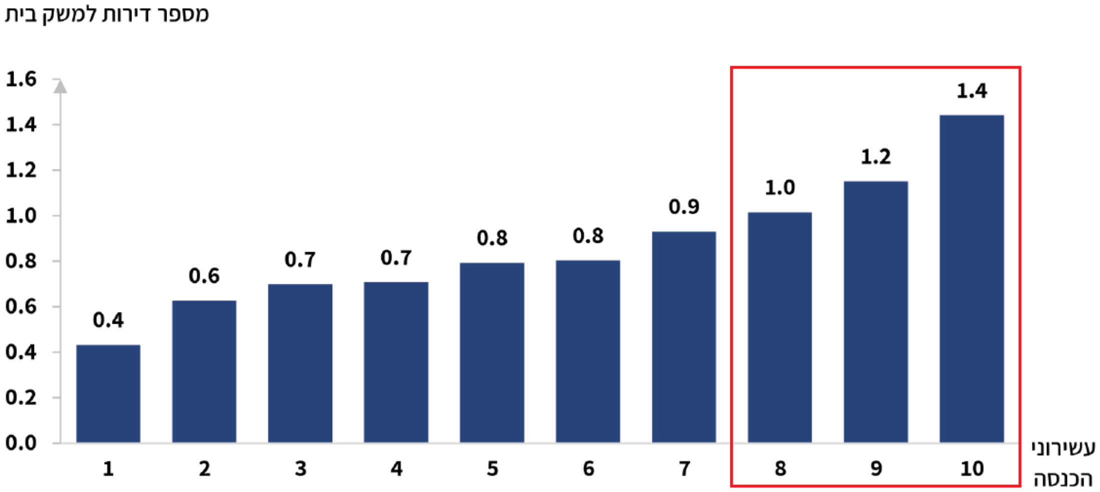
Source: Authors' Analyses. Data: CBS

Figure 2: Share of households with mortgages by income decile (2018)



Source: Nardit Stein-Kapach (2019)

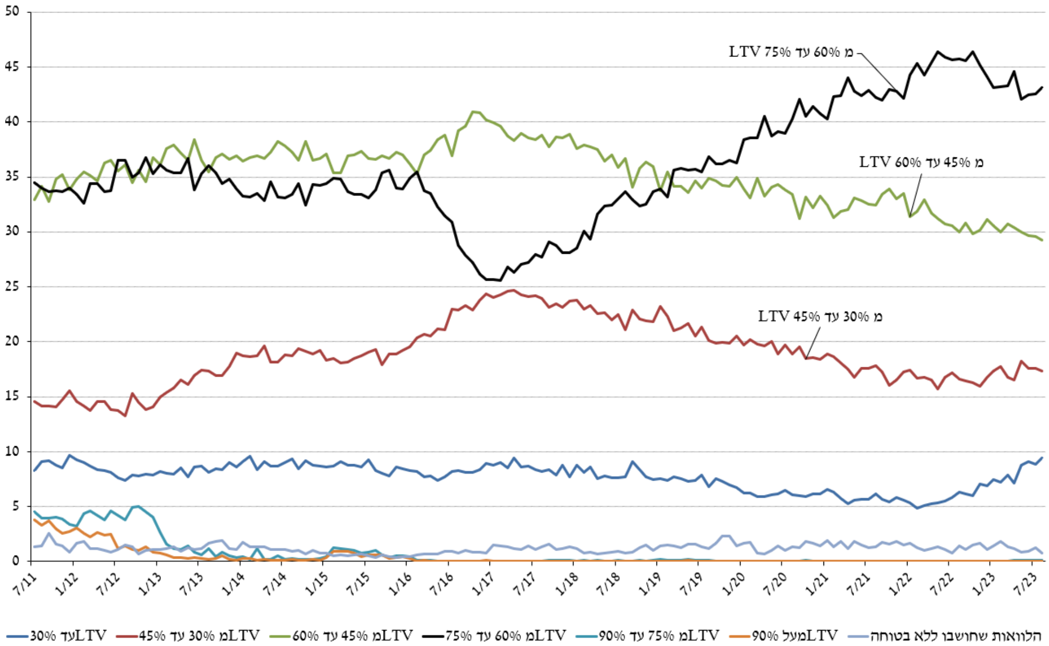
Figure 3: Number of houses for household by income decile (2018)



Source: Kosman Liran (2021)

Next, we will discuss about important measure of the mortgages market – the loan-to-value ratio (LTV). First, the average LTV ratio in Israel is low compared to other developed countries (see Fig. # at appendix and Laufer and Tzur-Ilan (2021)). Secondly, the LTV ratio has interesting dynamic over time, and is affected significantly by the macroprudential policy, that was activated from a round 2010 (see Fig. 4 and Benchimol et al. (2022)).

Figure 4: distribution of new mortgages (per month) by LTV ratio in Israel



Source: Bank of Israel

Lastly, the economic literature finds a higher level of nominal price rigidity in the rental prices relative to other prices (Genesove (2003), Shimizu et al. (2010), and Verbrugge et al. (2017)). Raz-Dror (2019) finds that there is a high degree of nominal rigidity in the rental prices in Israel. Based on sample from 2010-2015, he found that the rent contacts are signed at least for one year, on average, and it could be that changed in price within a year are mostly attributed to indexation to past inflation only. This indicates that the price rigidly in rent prices is higher compared to other components of the CPI, as Ribon and Sayag (2013) found that the average time of price change among different components of the CPI in Israel is less than one year – 9 to 11 months.

4. The Model

The model comprises two household categories, lenders and borrowers; 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.

We develop and calibrate a microfounded DSGE model tailored to the Israeli economy, reflecting its specific characteristics. Although Israel is a small open economy, we have modeled it as a closed economy because the housing market, our primary focus, is significantly insulated from international factors. The global engagement of Israel's economy has a limited impact on the housing sector. Additionally, Israeli households generally obtain mortgages from within the country's banking system, with foreign credit playing an insignificant role. 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 houses 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 homes 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 the proportion of Israeli workers being minimal[3]; (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

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

originates from two distinct household categories: 1. Borrowers, who are constrained by loan-to-value restriction, and 2. Lenders, who are unconstrained and act as investors by supplying rental properties. Both borrower and lender households generate demand for non-housing consumption goods and provide labor to firms.

Investors offer rental houses indirectly by leasing them to retailers, who then use these properties as intermediate goods. Retailers, functioning within a framework of monopolistic competition, are subject to price rigidity. The final rental product in the economy is composed of a variety of differentiated rental dwellings.

Firms produce consumption goods (excl. 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.

4.1 Households

Households' utility function include consumption C_t (excl. housing), housing H_t and labor N_t:

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

where Γ_C is a scalar (to ensure that in SS the marginal utility from consumption is independent on habit). ζ is a degree of habit in consumption, z_t and j_t is a preference shock to consumption and housing, respectively.

We assume the utility function of the following form:

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

We define housing bundle that consists of ownership, $h_{o,t}$, and rent, $h_{r,t}$:

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

where $\epsilon > 1$ is an intra-temporal elasticity of substitution between rent and ownership. γ, 0< γ <1 is a relative weight of ownership.

4.1.1 Borrowers (Constrained households)

Constrained households are subject to (maximum) loan-to-value (LTV) constraint à la Guerrieri and Iacoviello (2017), which is imposed by macroprudential policy (henceforth, MP). Therefore, the LTV is subject to shocks reflecting new regulations, and it is exogenous to the households (see detailed discussion in Section 4). The LTV constraint is:

$$\frac{B'_t}{V_t} \leq LTV_t, \qquad (1)$$

where B'_t is a volume of (indexed) debt in period t, $V_t = q_t h'_{o,t}$ is a value of houses purchased by constrained households for ownership ($h'_{o,t}$ is a number of housing units purchased for ownership), q_t is a (real) price of one unit of house.

The budget constraint of constrained households (expressed in real terms of price of consumption goods excluding housing, P_t^c):

$$C'_t + q_t h'_{o,t} + k q_t h'_{o,t} + r_t h'_{r,t} + R^L_{t-1} B'_{t-1} = B'_t + q_t h'_{o,t-1} - k q_t h'_{o,t-1} + w'_t N'_t, \qquad (2)$$

where on the L.H.S: C'_t is a consumption (excl. housing), $q_t h'_{o,t}$ is an expenditure on houses purchased for ownership, $r_t h'_{r,t}$ is an expenditure on rental services (r_t is a real price of rental services and $h'_{r,t}$ is an amount of rental services), $R^L_{t-1} B'_{t-1}$ is a payment on debt from the previous period (R^L_{t-1} is a gross real interest rate on mortgages).

On the R.H.S.:B'_t is an amount of new (real) debt, $q_t h'_{o,t-1}$ is a value of houses purchased for ownership in period t-1 and then sold in period t, and $w'_t N'_t$ is an income from labor. k is a transaction cost per 1 real dollar of purchased or sold houses. We assume that transaction costs for all households are refunded as a lump sum subsidy. We also assume that the constrained households do not receive any dividends, because they do not own any firm. We assume also that there are no taxes, because there is no government in the model.

The gross mortgage interest rate is defined as $R^L_t = R_t + \omega_t$, where R_t denotes a risk-free real interest rate, and ω_t is a (positive) spread. This is in contrast to the zero spread assumption made by Iacoviello (2005) and Sun and Tsang (2017). The positive spread is a realistic feature for practical modeling, particularly when it varies with household leverage. In the Israeli mortgage market, there are several types of mortgages, such as the 'Praim', which is non-indexed and tied to the Bank of Israel (BOI) 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.

To integrate the relationship between the spread and leverage into the model, we model the spread's dependence on leverage similarly to the approaches used by Benigno et al. (2020) and Ilek and Cohen (2023). In equation (3), the spread's deviation from its steady-state level is a function of the leverage deviation from its steady-state level, (with elasticity of α):

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

where u_t^{ω} is a supply shock to the spread, which stems from risk considerations of commercial banks (Benigno et al. (2020)). For a given leverage, higher perceived risk aversion of banks will result in a higher spread. If macroprudential policy do not change the maximum required LTV ($LTV_t = LTV$ for all t), then $\omega_t = \omega + u_t^{\omega}$.

Here we present the F.O.C of constrained households (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) $h_{o,t}' : j_t' \frac{\gamma' h_{o,t}'^{-\vartheta}}{\gamma' h_{o,t}'^{1-\vartheta} + (1-\gamma') h_{r,t}'^{1-\vartheta}} = \lambda_t'(1+k) q_t + \beta' \lambda_{t+1}' q_{t+1}(k-1) - \mu_t' LTV_t q_t$

where $\theta = \frac{1}{\epsilon}$; μ_t' is a lagrangian multiplier associated with the LTV constraint in eq. (1).

(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)

Unconstrained households' function in dual roles: as consumers and as investors. As consumers, they demand goods, rental services, and home ownership, supply labor, and value leisure. As investors, they buy properties as investments and rent them to retailers for one period; these retailers are the ultimate providers of rental housing in the market. Notably, investors do not gain direct utility from investment properties, viewing them instead as financial tool to increase their income.

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

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

where $h_{o,t}$ represents the quantity of houses purchased for ownership, while $h_{inv,t}$ represents the quantity of houses purchased for investment purposes (with all investors being identical). Investors lease out $h_{inv,t}$ to retailers as an intermediate good at nominal price P_t^m ($P_t^m = p_t^m P_t^c$), at the start of period t and reclaim the houses 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. Unconstrained households receive dividends from three sources: firms producing consumer goods, commercial banks, and retailers of houses.

The F.O.C. of the unconstrained households 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) $h_{o,t}$: $j_t \frac{\gamma h_{o,t}^{-\vartheta}}{\gamma h_{o,t}^{1-\vartheta} + (1-\gamma) h_{r,t}^{1-\vartheta}} = \lambda_t(1+k)q_t + \beta\lambda_{t+1}(kq_{t+1} - q_{t+1})$

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

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

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

If there are no transaction costs (k=0), the home price is determined by current and future payoffs received by the households from the retailers of houses,

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

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 a stochastic discount factor of the unconstrained households.

In the literature, this formula is typically used to relate the pricing of homes to rent prices in the economy, while in our model, it is determined by the price of the intermediate good of houses (p_t^m).

4.3 Retailers

The objective of this section is to generate nominal rigidity in rental prices, a phenomenon observable in the Israeli market as shown by Raz-Dror (2019). This rigidity is characterized by the significantly lower volatility of rental prices when compared to the fluctuations in house prices. A comparison between Raz-Dror (2019) and Ribon and Sayag (2013) suggests that rental prices exhibit greater nominal rigidity than consumer goods prices. This phenomenon is not exclusive to Israel; it is also observed globally, including in the US, as noted in studies by Sun and Tsang (2017) and Genesove (2003). To that end, we introduce a model of monopolistic competition in the rental market with price rigidity.

Retailers lease houses from investors for one period at price P_t^m, which are used as intermediate rental dwellings. 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 use intermediate rental dwellings from investors as the sole input (that is, $h_{inv,t}(j) = Y_{f,t}$, where $Y_{f,t}$ is a amount of houses of retailer f and $h_{inv,t}(j)$ is an intermediate rental dwellings of investor j). The final product of houses 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 house 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 by:

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

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 maximize:

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

where π is a steady-state inflation rate (excl. rental services), ϕ is a 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 $i > 0, sdf_{t,t+1} = \beta \frac{\lambda_{t+1}}{\lambda_t}$, a stochastic discount factor of the lenders (owners of retailer's firm).

First-order condition w.r.t. price $P_{f,t}^{rent}$ yields non-linear 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 ($r = \frac{\eta_r}{\eta_r - 1} p^m$). 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 Housing market clearing

The total number of houses 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 houses 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 ownership-to rent ratio?

Proposition 1:

With price flexibility and monopolistic competition in rental dwellings market, the ownership-to-rent ratio among lenders in any period t is determined by their preferences and the markup.

Proof:

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

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

It can be seen that the ratio $\frac{p_t^m}{r_t}$ 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 F.O.C. of the lenders (eq. (b) and (c) in Section 2.1.2.)

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

Plug in here $r_t = \mathcal{F}p_t^m$ 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 (and also in the SS), the ownership-to-rent ratio is:

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

Proposition 2:

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

Proof:

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

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

Proposition 3:

A lower loan-to-value (LTV) ratio results in a higher ownership-to-rent ratio for lenders.

Proof:

From eqs. (b)-(c) in Section 2.1.1., we derive the ownership–to-rent ratio of the lenders, which is valid for any value of $LTV_t,\ 0 \leq LTV_t \leq 1$).

$$\frac{h'_{o,t}}{h'_{r,t}} = \left[\frac{1-\gamma'}{\gamma'}\left(\frac{q_t(1+k)}{r_t} - sdf'_{t,t+1}\frac{q_{t+1}(1-k)}{r_t} - \frac{\mu'_t LTV_t q_t}{\lambda'_t r_t}\right)\right]^{-\varepsilon}$$

Taking a partial derivative w.r.t. LTV_t yields:

$$\frac{\partial\left(\frac{h'_{o,t}}{h'_{r,t}}\right)}{\partial LTV_t} = \varepsilon\frac{\mu'_t q_t}{\lambda'_t r_t}\left[\frac{1-\gamma'}{\gamma'}\left(\frac{q_t(1+k)}{r_t} - sdf'_{t,t+1}\frac{q_{t+1}(1-k)}{r_t} - \frac{\mu'_t LTV_t q_t}{\lambda'_t r_t}\right)\right]^{-\varepsilon-1} > 0$$

The derivative is positive since the terms both before and within the brackets are positive.

Proposition 4:

The ownership-to-rent ratio for borrowers is lower than that for lenders, given identical preferences, due to the loan-to-value (LTV) constraint.

Proof:

The ownership-to-rent ratio of the lenders:

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

The ownership-to-rent ratio of the borrowers:

$$\frac{h'_{o,t}}{h'_{r,t}} = \left[\frac{1-\gamma'}{\gamma'}\left(\frac{q_t(1+k)}{r_t} - sdf'_{t,t+1}\frac{q_{t+1}(1-k)}{r_t} - \frac{\mu'_t LTV_t q_t}{\lambda'_t r_t}\right)\right]^{-\varepsilon'}$$

It can be seen that under assumption, $\gamma' = \gamma, \varepsilon' = \varepsilon$ and $sdf'_{t,t+1} \cong sdf_{t,t+1}$,

$$\frac{h'_{o,t}}{h'_{r,t}} < \frac{h_{o,t}}{h_{r,t}}.$$

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.

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

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 an $AR(1)$ process.

The aggregate good Y_t is then sold in perfect competition at the price $P_t^c = \left(\int_0^1 P_t^c(z)^{1-\eta_t} dz\right)^{\frac{1}{1-\eta_t}}$ 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 a nominal profit of firm z is $X_t(z) = P_t^c(z)Y_t(z) - W_t N_t(z) - W_t' N_t'(z) - \frac{\chi}{2}\left(\frac{P_t^c(z)}{P_{t-1}^c(z)} - (\pi)^{1-\varpi}\left(\frac{P_{t-1}^c}{P_{t-2}^c}\right)^{\varpi}\right)^2 P_t^c Y_t$

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 factors of the lenders (owners of the firms). π is a steady-state inflation rate (excl. rent), ϖ is a degree of indexation to past inflation (excl. rent)[4] and χ defines the cost associated with changing the price and it is a source for price rigidity.

The first-order conditions w.r.t. price $P_t^c(z)$ yields 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 $sdf_{t,t+1} = \beta\lambda_{t+1}/\lambda_t$ is a stochastic discount factor of the lenders, and Γ_t is a marginal cost.

F.O.C of firm w.r.t. $N_t(z)$ 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:

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

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

4.7 Commercial Banks (intermediates)

Commercial banks serve as intermediaries, accepting deposits from lenders and providing loans to borrowers. The spread-leverage relationship (parameter α) is assumed to be chosen optimally by commercial banks to maximize their profits, subject to possible default risk of the borrowers. Here we present again eq. (3):

$$\omega_t\text{-}\omega\text{=}\alpha(LTV_t\text{-}LTV)\text{+}u_t^{\omega}$$

The maximum limit of LTV_t is determined by macroprudential policy.

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 [5].

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

4.8 Monetary policy

The monetary policy of the central bank 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, which is calculated as the weighted average of inflation of rent dwelling and inflation of CPI-excl. rent dwelling (with δ being the weight of rent dwelling in the CPI); Δy_t is a growth rate of GDP relative to growth rate in steady state; ϵ_t^{CB} is a monetary shock.

5. Calibration

We calibrate our model parameters to align with the Israeli economy's distinct features. The habit formation parameter for consumption ζ^c is set at 0.5 for all households, a value that falls between 0.62 from Argov et al. (2012)(Table 1) and 0.1 from Ilek and Rozenshroom (2018), (IL& R in Table 1). The disutility from labor parameter θ is set at 2.5, consistent with Ilek and Rozenshroom (2018). The elasticity of substitution between differentiated consumption goods ($\eta = 6$) is set to imply a steady state markup of 20%, consistent with Ilek and Rozenshroom (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. The LTV ratio is set at 66% for the steady state, as calculated by Cohen and Ilek (2024). We assume a high elasticity of

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

substitution between renting and owning (set at ϵ=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 also influenced by the 20% markup in the rental market, while the borrowers' ratio is affected by the steady-state LTV ratio of 66% (as detailed in Section 2). We set the borrowers' share in the economy (1-τ) at 31.2%, following the findings of Cohen and Ilek (2024). Lenders (patient households) have a discount factor β of 0.99, while borrowers (impatient households) have a discount factor β' of 0.975. These values are standard in the literature. Borrowers encounter a mortgage interest rate spread ω of 1.5% annually (0.375% quarterly), aligned with the average mortgage rate spread in Israel. 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 0.37 in Argov et al. (2012) and the zero in Ilek and Rozenshroom (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 Rozenshroom (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)[6], 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 2.5 obtained in Argov et al. (2012) and the 1.5 from Ilek and Rozenshroom (2018). The central bank's response to output growth θ_2 is set at 0.02, suggesting a more moderate response output changes. The interest rate inertia parameter ρ is set at 0.75, reflecting significant smoothing in interest rate. This inertia parameter aligns with Ilek and Rozenshroom (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-

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

state values, we observe that the model's payment-to-income (PTI) ratio aligns with empirical data, approximately standing at 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 savers	0.99	Literature
β'	Discount factor of borrowers	0.975	Literature
ω	Interest rate spread (in annual terms)	1.5%	Ilek and Cohen (2023)
LTV	Loan-to-value ratio	66%	Cohen and Ilek (2024)
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)
η	Elasticity of substitution between intermediate consumption goods	6	IL& R
η_r	Elasticity of substitution between intermediate rental houses	6	Authors calculations

θ	Curvature of utility w.r.t. 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 target of the BOI

6. Analysis

In this section, we will present analysis examining the impact of macroprudential policy on housing market and efficacy of monetary policy.

6.1 Impact of monetary policy on housing market

The responses to a monetary policy shock, as depicted in Fig. 5 (blue line represent the baseline case), are consistent with the conventional New-Keynesian model. Following a contractionary monetary policy shock of 1 pp (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 financially constrained and unconstrained households), result in a decrease in the demand for consumption (C, C') and housing rental services (h_r, h'_r).

Moreover, the demand of investors (unconstrained households) 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 housing for rentals leads to a higher real price of rent, r.

The escalation in interest rates also rise the mortgage rates, exhibiting a nearly one-to-one relationship. Consequently, mortgages become more expensive, push borrowers (financially constrained households) to reduce their debt burden and, consequently, to reduce their expenses and their housing ownership. Furthermore, the housing market experiences a significant reduction in house prices as valuations adjust to the higher interest rates. This makes the collateral constrain tighter and result in borrowers' debt deleveraging to meet their LTV constraint, further push down their expenses (income effect) and thus reduce ownership and rental demand.

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

Interestingly, unconstrained households take advantage of the lower house prices and increase their housing ownership, h_o. Furthermore, this is the only segment of housing which increase and clear the market.

As discussed, to meet the LTV constraint, the financially constrained households decrease their housing ownership, which could potentially result in an increased demand for renting (substitution effect between ownership and renting). However, this is not happened but delayed by 4-quarters. There are two main factors that discourage their demand for housing rental services: a.) A general reduction in demand as a result of high real interest rate and debt deleveraging process (income effect). b.) A higher rent real price (supported by low general inflation, as a relative price effect). It is essential to emphasize that, households may reduce both housing ownership and renting, for instance, by downsizing from a 4-room apartment to a 3-room apartment.

Compared to the relevant literature, our findings align qualitatively with much of the existing research, including studies such as Sun and Tsang (2017).

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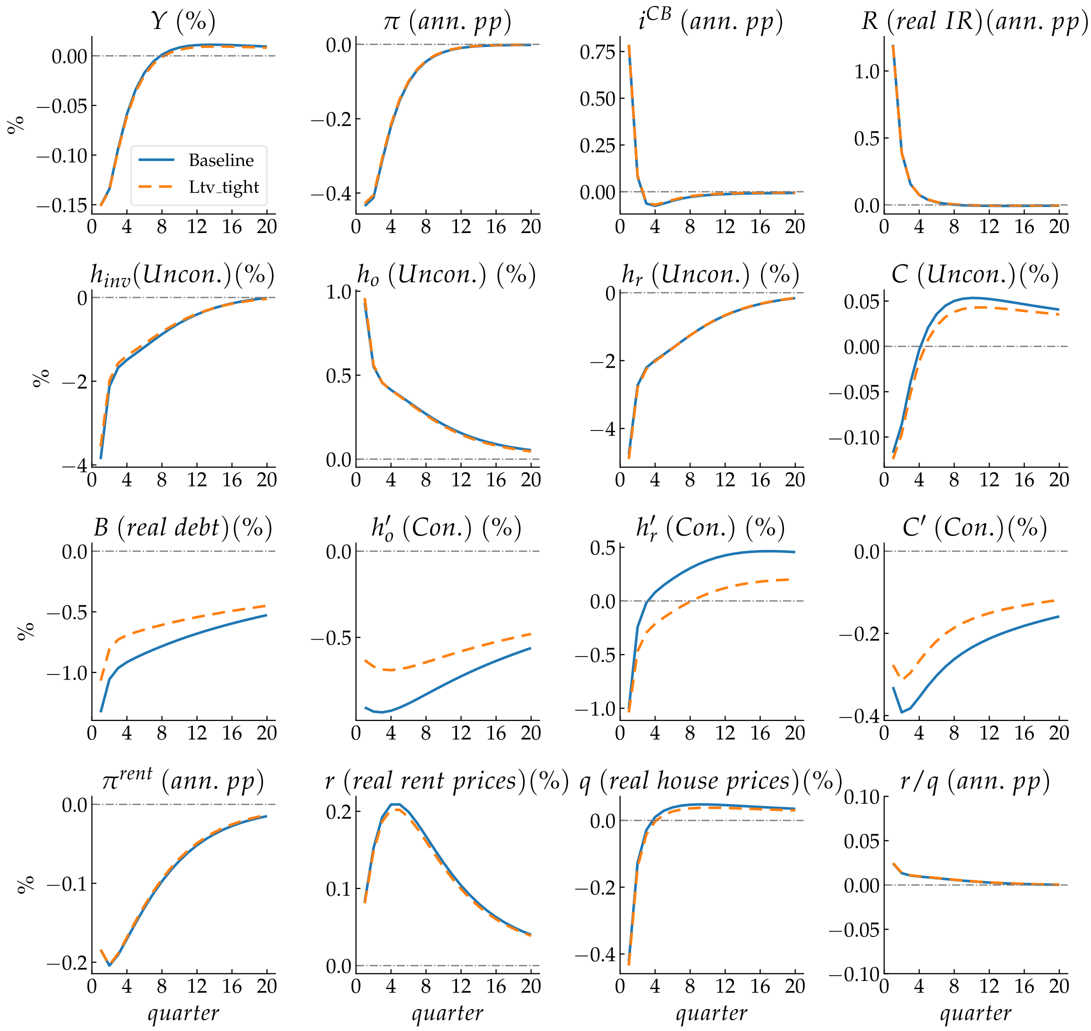
Nagar and Segal (2014) find that a permanent decrease of 1 p.p. in the monetary interest rate was found to abet a 6.5 percent upturn in home prices over a two-year period. In our model, a comparable measure gives approximately only 1.6 percent increase in real terms, and 5.4 in nominal terms. In Yakhin and Gamrasni (2021), a 1 pp increase in short rates decrease the real house prices by 2 present, where in our model this result in a decrease of only 0.8 present. We will emphasize that this comparison is only to get an order of magnitude, since in our current examination we evaluate only the direct impact of monetary policy shock.

Figure 5: Response to 1 pp monetary policy shock, under baseline LTV restriction (of 67%, blue line) and under tight LTV cap (of 55%, orange dash line).



Remark: Variables (in deviation from steady state): output, inflation, central bank rate, real interest rate, houses for investment (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, real house 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.

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

One of the interesting questions is whether the effectiveness of monetary policy to achieving price stability and stabilizing real activity is affected by the tightness of macroprudential policy (see Malovaná et al. (2023)). To investigate this question, we conduct an experiment where we introduce a monetary policy shock under two different regulations: a.) a baseline loan-to-value (LTV) ratio of 66% (as we analyzed above) and b.) a more stringent 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 dynamic of inflation and output is 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.* This results are consistent with Cozzi et al. (2021) (Fig. 12) although they considered leverage ratio of banks and not households.

Moreover, also the reaction of unconstrained households is almost unchanged under the two levels of LTV cap. And also, the home price and rent price doesn't change.

However, the reactions of constrained households (borrowers) are differed. This is because when LTV cap is lower/tight, the initial level of debt (steady state level) is lower (by 35% as we will discuss later). Thus, the increase in the interest rate, has smaller effect when one has smaller debt. With high LTV cap (66%), borrower has higher leverage, so interest rate burden may result in a significant deleveraging. Whereas, under the tight macroprudential policy, when LTV cap is low (56%), the interest rate payment is much comfortable. Thus, financially constrained households experience a less severe decline in consumption, and in house ownership, which is 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 (note that 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.

The results presented above exhibit substantial similarities to the analysis found in Section 4.4.4 of Funke et al. (2018), despite notable differences in model specifications and calibrations.

6.3 The Effect of Loan-to-Value Ratio on Housing 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 impacts housing prices? Research findings vary, suggesting that the impact of macroprudential policy on housing prices may depend on a country's specific housing market structure, making it difficult to draw definitive conclusions.

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[7]. More specifically, we simulate a scenario where macroprudential policy reduces the loan-to-value (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 savers-borrowers composition. Thus, we present here only the intensive borrowing margin.

Fig. 6 displays the impulse responses of the main variables to LTV permanent reduction of 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 housing prices is minimal.

Several studies used DSGE models have assessed the impact of changing LTV ratio on housing prices, and find that a permanent reduction in LTV ratios, immediately decrease housing prices[8]. However, as can be seen in Fig. 6, in

[7] similar to the approach in Alpanda and Zubairy (2017) footnote 34 and Funke et al. (2018).

[8] When scaling all results to a 10 percentage point permanent reduction in LTV ratios, the studies suggest an immediate decrease in housing prices as following: 19% according to Funke et al. (2018)(for New Zealand), 1.2% according to Bruneau et al. (2018) (for Canada), 0.5% according to Lee and Song (2015) (for Korea). The differences in the results are partially

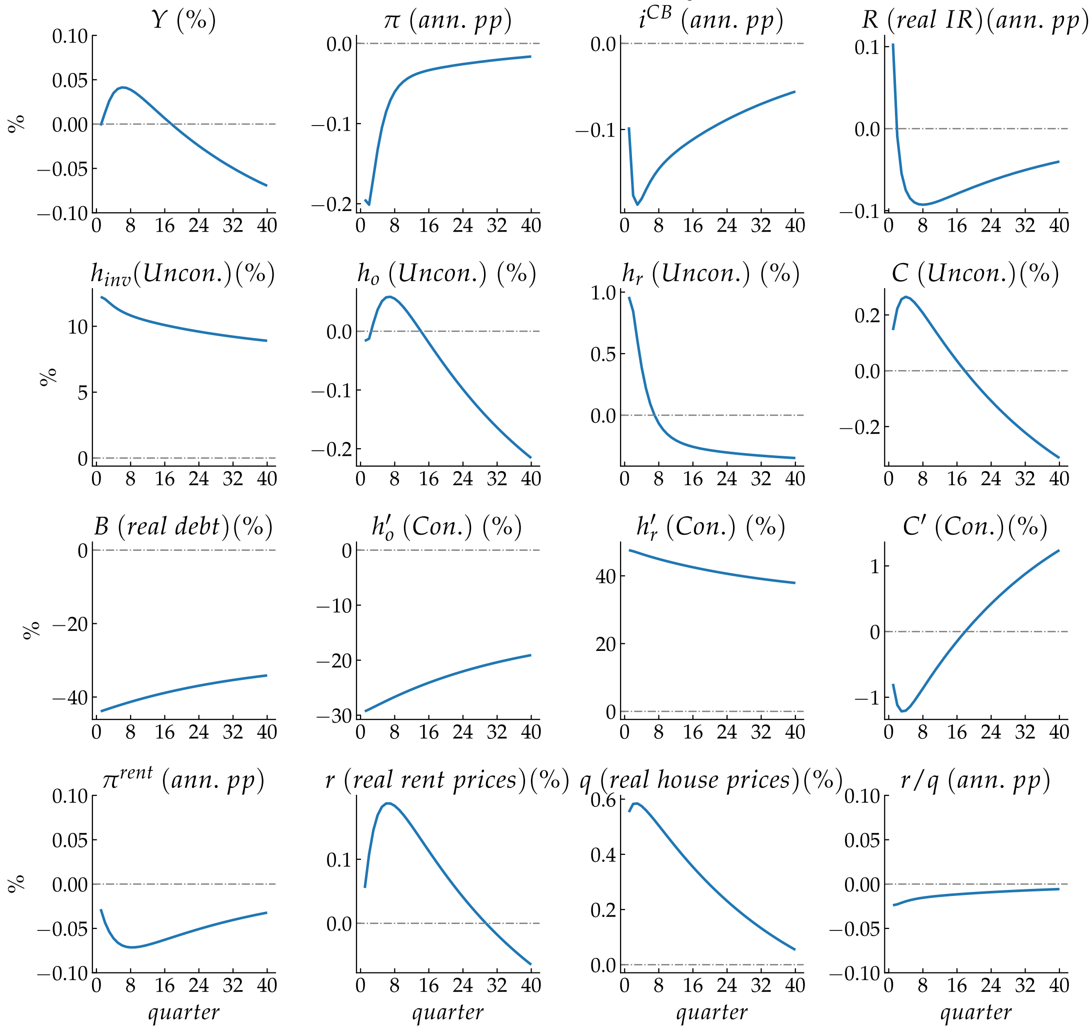
our model we find that a reduction of 10 percentage points in LTV regulation leads to a tiny raise of 0.6% in home prices. We hypothesize that the reason for this difference is due to the lack of a rental market in those models (which serves as a high substitution to ownership) combined with the unique mechanism of the rental housing supply in Israel (Section 2 describes the Israel's housing market).

The tight macroprudential policy – reduction in 10 p.p. in the LTV – significantly reduced a 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 greater than 10% is necessary to comply with a new LTV limit.

Since borrowers seek to reduce ownership, there is a downward pressure on home prices. In the models with ownership only described previously, home prices fall. However, when rental market is included into the model, given high substitutability between owning and renting, borrowers switch to renting, as evidenced by the increase in rent corresponding to the decrease in ownership. However, home prices do not fall, or may even rise slightly. This is because the increased rental demand from borrowers boosts investor demand for housing purchases (with about 10% increase in investment), as investment returns increase. Essentially, two opposing forces affect home prices: borrowers selling homes and moving to rentals, and investors buying properties to satisfy the increased rental demand, with these effects largely neutralizing each other. 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, eventually rise more than home prices, with the increase delayed by high price rigidity. Consequently, lenders lower their rental demand, resulting in a decreased ownership-to-rent ratio.

due to the assumption of separability between consumption and housing in the utility function (an assumption not made by Funke et al. (2018)).

Figure 6: The impact of macroprudential policy which reduces the loan-to-value (LTV) ratio 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.

Focusing on empirical studies, Cerutti et al. (2017) investigated the impact of macroprudential policies, such as loan-to-value (LTV) ratios, on housing prices and credit across 119 countries. Their findings indicated that LTV policies significantly curbed household credit growth. The impact on housing prices was slightly negative but not statistically significant in advanced economies, and slightly positive but insignificant in emerging markets.

The impact of macroprudential policy on Israel's housing prices varies between research's. Buitron and Denis (2014) reported that while macroprudential policies in Israel have somewhat decreased the volume of transactions in the housing market, there is no proof that they have helped to restrain house price inflation. The study revealed that direct macroprudential measures led to a 5% reduction in new housing loans within the initial six months of implementation, yet the impact on housing prices was minor and not statistically significant. This finding aligns with our model-based theoretical result concerning the weak reaction of housing prices.

Ribon (2023) found that housing prices in Israel declined as a result of macroprudential innovation, with the decrease becoming statistically significant only after one year. Prior to that, there was a slight and statistically insignificant increase in housing prices[9]. Laufer and Tzur-Ilan (2021) analyzed the impact of an October 2010 macroprudential measure using microdata. 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%. They obtained that this macroprudential policy measure led to a roughly 3% decrease in housing prices.

6.3.2 Long term effect

As observed earlier, the reduction in the 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 of 66%, and a scenario with tighter macroprudential policy featuring an LTV of 56%. Our interpretation of modifying the LTV limit relates more to a structural shift in the economy than to a dynamic policy action. In the steady state (SS), 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 X). 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 decline in the new mortgages in the new steady state (by 35%), consequently resulting in a higher rent ratio among borrowers (by 15.7%). 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 limit, a reduction in debt exceeding 10% is required, as detailed in Eq. (X).

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

[9]Ribon (2023) used a dummy variable to represent macroprudential (MP) measures. However, this variable covered all MP steps, not just those in the housing market. Additionally, the dummy variable was constructed under the assumption that the MP measures would be permanent.

(see Appendix X). Overall, the rent ratio in the economy increases from 16.8% to 18.6%, but this effect is solely via borrowers.

Table 2's outcomes presume that LTV ratio changes do not affect the share of constrained households or other model parameters. While in practice, LTV changes might alter the proportion of constrained households, our model does not account for an endogenous shift between two groups (savers to borrowers or vice versa). Such a transition would also imply a change in preferences for lenders and savers, given their differing initial discount factors (β). The final two columns of Table 2 present outcomes assuming 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 small deviation from the original scenario where the share of constrained households remains constant.

Table 2: Comparative Static –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 $\frac{h_r+h'_r}{\mathrm{h}}$	16.8%	18.6%	1.8%	19.1%	2.3%

6.4 Conclusions

The primary question for any central bank is the effectiveness of monetary and macroprudential policies. Our model of the Israeli economy shows that while a tighter macroprudential policy, represented by the LTV ratio, can significantly reduce debt levels and the ownership-to-rent ratio of constrained households, its impact on housing 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 decreases housing prices. We attribute this discrepancy to the absence of a rental market in those models, a key factor in 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 houses to meet the increased rental demand, thus counteracting the initial downward pressure on housing prices. These insights are crucial for policymakers, indicating that while macroprudential tools can help manage financial stability, their effects on housing prices must be carefully assessed alongside other monetary measures. Primarily, the main tool for reducing housing prices remains the monetary interest rate.

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

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

7. Reference

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8. Appendix

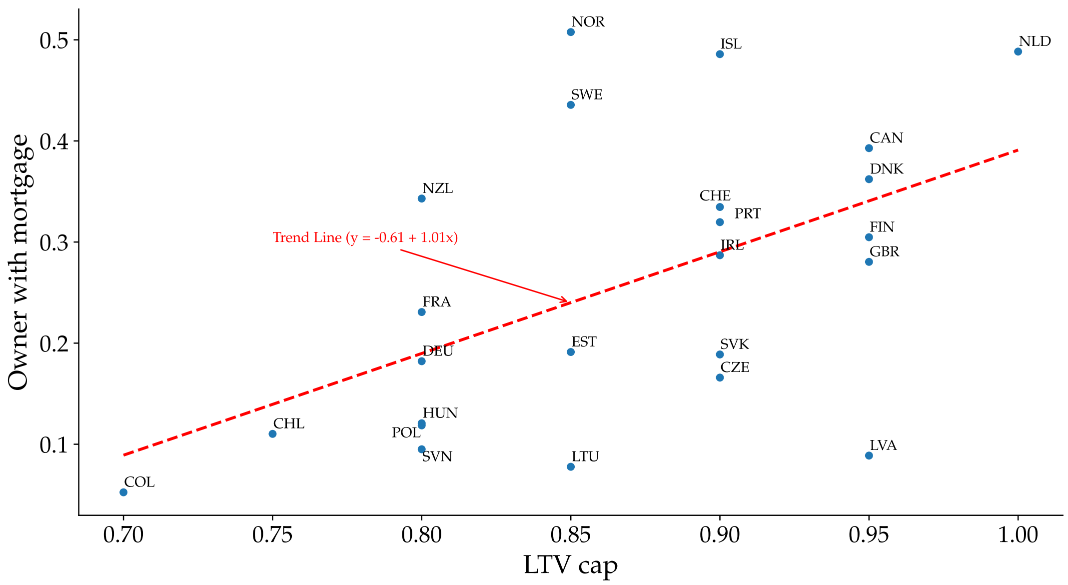
Supplementary material can be funded *here*.

8.1 Relationship between LTV cap, ownership with mortgage and leveraging – an international perspective

In this section, we demonstrate a key observation: as leverage restrictions are relaxed, a larger proportion of households may take out mortgages and become homeowners, resulting in higher overall leverage. It is important for our model to replicate this fact in order to accurately reflect the impact of leverage restrictions on homeownership and overall leverage.

Data from OECD countries (Hoenselaar et al. (2021)), depicted in Fig. A1, shows that countries with softer Loan-to-Value (LTV) restrictions tend to have a higher percentage of homeowners with mortgages (out of total population), on average. Additionally, as shown in Fig. A2, countries with a higher proportion of homeowners with mortgages tend to have higher mortgage leverage, which constitutes a sizable portion of household debt.

Figure A1: LTV restriction and households' part with mortgages



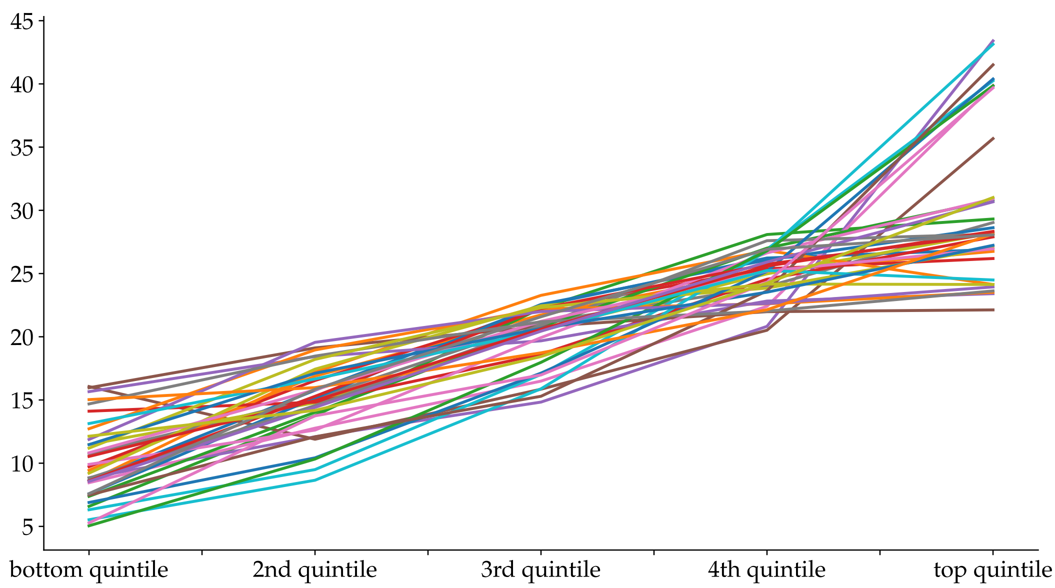
Source: Authors' Analyses. Data: OECD

Figure A2: households' part with mortgages vs. mortgages leverage (with respect to GDP)

Source: Authors' Analyses. Data: OECD

8.2 Additional graph

Figure A3: Distribution of mortgage share, by country (2020)



Source: Authors' Analyses. Data: OECD, countries: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, United States, Bulgaria, Croatia, Cyprus, Malta, Romania.