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Macroprudential Regulations of Mortgage Contracts

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Macroprudential Regulations of Mortgage Contracts*

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Abstract

We build an incomplete markets model to analyze the costs and benefits of borrower-based macroprudential policies. We calibrate it to match Sweden's economic environment in the early 2000's and analyze the effects of two regulations: a stricter down-payment requirement, from 10% to 15%, and a cap on debt-to-income (DTI) of 500%. We find that a stricter downpayment requirement has limited positive benefits in terms of reducing consumption sensitivity to temporary shocks to income or the mortgage risk premium while it reduces the homeownership rate of the middle-aged and has negative welfare effects for 78% of the households. A cap on DTIs at 500% has small effects—on house prices as well as households' welfare and resilience—because it is a binding constraint for only 8.5% of 25-year-olds but for no 35-year-old.

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1 Introduction

Since the financial crisis, countries have taken measures to safeguard financial stability, such as stricter regulations on banks' capital requirements (Basel III) and a bail-in process for systemically important banks. Since a large part of banks' risk exposure stems from residential mortgages, additional regulations that directly target the design of mortgage contracts have been introduced. Such regulations involve stricter down-payment requirements, a cap on debt-to-income or loan-to-income ratios, and amortization requirements. These regulations are often contentious – for many reasons. One reason is that there are clear winners and losers from them. Restricting access to the mortgage market will distort purchasing power in the market for owner-occupied homes. Naturally, it will benefit wealthier households that have a lesser need for borrowing, at the expense of wealth-poorer households with good labor income prospects. However, we argue that another important reason for the controversy surrounding these regulations is that there is limited evidence that the regulations ultimately improve financial stability. There are important empirical studies that evaluate reform effects with a focus on outcomes such as household indebtedness, house prices, and financial savings (e.g., Aastveit, Juelsrud and Getz Wold (2020), Bernstein and Koudijs (2023), Bäckman, Moran and van Santen (2024)). The Swedish regulatory agency, FI, has conducted a number of empirical studies based on samples of new mortgage borrowers (e.g., Finansinspektionen (2017*a*), Finansinspektionen (2017*b*), Andersson et al. (2018), Andersson and Aranki (2019).[1] Overall, this empirical literature finds strong responses, in that households reduce their debt, buy cheaper homes and increase their accumulation of net worth. Nevertheless, such studies have, by their design, only limited bearing on answering the question of whether regulations actually have improved financial stability. Consequently, given the current state of knowledge, it is difficult to trade off costs and benefits

[1] There is also a related literature that attempts to identify household statistics and metrics that would indicate an elevated risk of a macro-financial crisis. For instance, it has been debated whether debt overhang or debt-financed overspending is a better predictor of a crisis – see Dynan (2012), Andersen, Duus and Laerkholm Jensen (2016), Broadbent (2019) and Svensson (2021).

associated with the regulations.

Rather than evaluating implemented reforms, in this paper we use a model-based approach which offers new possibilities. First, it overcomes selection issues that can arise in data sets based on new mortgage origination if some households choose to not take on a mortgage (and instead rent their home). Second, it enables counterfactual analysis. More precisely, we are able to analyze household resilience in response to adverse shocks to labor income or mortgage interest expenses, which potentially could trigger a macro-financial crisis.[2] Third, a model offers a framework for trading off costs against benefits.

Specifically, we build a life-cycle consumption-savings model where markets are incomplete in that households face idiosyncratic uninsurable income risk (i.e., a model with heterogenous households). The model includes a decision whether to rent or buy a home, how much to borrow, and how much to consume in non-housing consumption and save in financial wealth. The owner-occupied housing market is in equilibrium, that is, the house price adjusts so that demand equals supply (which is fixed). We use the model to evaluate different borrower-based macroprudential regulations. We quantify welfare effects associated with changes to housing and consumption behavior. Moreover, we offer one perspective on the benefits of the regulations in that we measure household resilience to shocks, in terms of changes in marginal propensities to consume to temporary income shocks and temporary shocks to adjustable mortage interest rates. Our model is similar to Campbell, Clara and Cocco (2021), Guren, Krishnamurthy and McQuade (2021), and Kragh Balke, Karlman and Kinnerud (2024).

We calibrate the model to mimic the institutional and economic setting of Sweden in early 2000s, a period for which we have good household data on wealth. Then, we analyze two concrete regulatory changes, or reforms, one by one. The first reform is a stricter downpayment requirement where the minimum downpayment changes from 10 to 15 percent. It is akin to the introduction of Sweden's stricter downpayment requirement, which was introduced in 2010. The second reform is a cap on

[2]See Blanchard (2018) for a theoretical framework to diagnose the severity and causes of a macro-financial crisis.

debt-to-income ratios at the time of mortgage orgination. The intent of such a regulation could be to serve as a back stop in that it anchors aggregate debt to aggregate incomes (in normal times, the anchor may not be a constraint).

We have three main findings from analyzing the change of the minimum downpayment requirement from 10% to 15%. First, in the model 78% of households lose from such a reform. The winners are households that have a lot of wealth relative to their long-term earnings capacity (proxied by permanent labor income). The reason that they win is that they need access to the mortgage market the least and are able to buy large homes. Second, the demand for owner-occupied housing is reduced. House prices fall by 2% and the homeownership rate falls by 3.5 percentage points among 35-year-olds. Third, the benefits—in terms of household resilience—are limited. Aggregate mortgage debt decreases by 6.6%. However, we argue that improvements in measures of household indebtedness are best viewed as an intermediary macroprudential aim in countries with strong creditor rights (i.e., full recourse of mortgages). A more suitable metric is households' marginal propensity to consume in response to shocks. We find that homeowners' consumption response to temporary income shocks barely changes, from an average marginal propensity to consume of 0.156 to 0.151. The reason is that the liquid savings buffer remains largely unchanged. Furthermore, homeowners' consumption response to a mortgage expense shock—in the model arising from a shock to Swedish mortgages' risk premium—is unaffected. The marginal propensity of consumption to such a shock remains virtually unchanged at 0.137. The reason is that interest sensitivity is determined by two factors: the marginal propensity to consume out of temporary income shocks and the amount of debt with adjustable rates, and neither factor is affected to a large extent by the stricter downpayment requirement. This insight suggests that it might be necessary to regulate the duration of the household's mortgage portfolio directly if one wishes to reduce households' interest rate sensitivity.

We also analyze the introduction of a cap on mortgage debt-to-income (DTI) at 500%. We find that very few households are affected, and only temporarily. The share of 25-year-olds that wish to buy and take up mortgages corresponding to a DTI ratio of 500% or more is 8.5%. However, they are only temporarily constrained. At 35 years it is optimal for them to be below the cap. Since few households are affected, the purchasing power in the owner-occupied housing market is not distorted by much and hence house price changes and welfare effects are small. Likewise, the effects on household resilience are small.

We wish to point out that our model is stylized. For instance, the rental market in the model is overly accessible relative to the Swedish one. Moreover, the household problem is simple: households can only buy houses at two occasions, they cannot take out a second mortgage late in life and there is no market for uncollateralized debt. We also assume that all households face a positive spread between savings in financial wealth and the mortgage rate whereas in reality this depends on households' portfolio choice. The housing supply in the owner-occupied market is fixed, also in the long run, whereas in reality it would probably adjust to price changes. Further, we focus on stationary equilibria so we do not study the transitional dynamics after a change in regulation. Finally, the model is stated in real terms (i.e., inflation is absent), there is no response of the central bank to shocks, and the calculated welfare effects do not include any potential benefits in a crisis.

The rest of the paper is organized as follows. Section 2 describes our model and section 3 our calibration of it. Section 4 presents our results. Section 5 concludes.

2 Model

We set up a life-cycle model with two consumption goods to analyze the effects of macroprudential regulation. Households choose between renting and owning their house and can adjust their housing choice throughout the life cycle. All households can save in a bond and homeowners have access to a mortgage market. We use the model to analyze distortions on housing choices and consumption as well as effects on liquid savings and marginal propensities to consume out of transitory income and interest rate shocks.

2.1 Demographics

The model is a life-cycle model and one time period is one year. Let j denote the age of the household and t the calendar year. We also introduce notation for birth cohort $k = t - j$. Households enter the model and start economic life at $j = 25$. We follow households over the life-cycle (until $j = 100$), which consists of a working phase and a retirement phase with exogenous retirement at 65. When households enter the economy there is heterogeneity in terms of initial assets and idiosyncratic earnings risk.

2.2 Income process

During the working phase (up to age 64), the individual faces a labor income process with a life-cycle trend and persistent income shocks. Let y_{ij} denote the labor income of employed individual i at age j. Then for $j < 65$:

$$\begin{aligned} \ln(y_{ij}) &= g_j + z_{ij} + \nu_{ij}, && (1) \\ z_{ij} &= z_{ij-1} + \eta_{ij}, && (2) \\ y_{ij} &\geq \underline{y}. && (3) \end{aligned}$$

The first term, g_j, is a hump-shaped life-cycle trend. The second term, z_{ij}, is the permanent labor income component. The third term, ν_{ij} is an idiosyncratic transitory shock. The permanent component has an idiosyncratic shock, η_{ij}. The shocks have normal distributions and are distributed: $\nu_{ij} \sim N\left(-\sigma_\nu^2/2, \sigma_\nu^2\right)$ and $\eta_{ij} \sim N\left(-\sigma_\eta^2/2, \sigma_\eta^2\right)$. We allow for heterogeneity in income as early as age 25 by letting the initial persistent shock, z_{i25}, be distributed $\mathrm{N}\left(-\sigma_z^2/2, \sigma_z^2\right)$. Disposable income cannot be less than $\underline{y}$ which is a parsimonious way to account for welfare and transfers.

Upon retirement (at $j \geq 65$), households instead receive a safe pension income modeled as a deterministic replacement rate relative to permanent labor income at 64:

$$y_{ij} = \lambda^r y_{i64}^P = \lambda^r \exp(g_{64} + z_{i64}), \tag{4}$$

where y^P_{i64} can be thought of as permanent income at 64 and λ^r is the replacement rate from the pension system. Going forward we use the term permanent income to refer to $y^P_{ij} = \exp(g_j + z_{ij})$.

2.3 Preferences

Households have CRRA preferences over a consumption basket consisting of the non-durable consumption good, c_j, and housing services, h_j.[3] In every period, households choose how much to consume of non-durable consumption and housing services. Housing services may be either rented or owned. Owned housing can be used as collateral for borrowing. At age j, each individual gets utility from the utility function

$$u_j = \frac{(c_j^{1-\theta}(\kappa \cdot h_j)^{\theta})^{1-\gamma}}{1-\gamma}, \tag{5}$$

where γ is the coefficient of risk aversion and θ is the Cobb-Douglas expenditure share on housing. The parameter κ is between 0 and 1 and is a utility penalty if the household chooses to rent. Such a utility differential is standard in the literature (see, e.g., Castellanos, Hannon and Paz-Pardo (2024)). For notational convenience we define the consumption basket $C_j = c_j^{1-\theta} h_j^{\theta}$.

Individuals maximize life-time utility. From the perspective of 25 year-old this means that the objective function is:

$$U_{25} = E_{25}\left[\sum_{j=25}^{100} \beta^{j-25} u_j\right] \tag{6}$$

where β is the discount factor.

[3] To be more precise, households receive utility from housing services s. For simplicity, we assume a linear housing technology that transforms housing units to housing services such that $s = h$.

2.4 Financial markets: savings and the mortgage

In addition to housing, households can save in financial wealth, a_j with the gross (risk-free and time invariant) interest rate $R = 1 + r$.

Households that choose to buy their housing services may take up a mortgage. Households choose their loan-to-value (LTV) ratio at the time of purchase (λ_j), which we define as $\lambda_j = \frac{m_j}{P_t^h h}$, where P_t^h is the current house price per square meter. The following constraint on the loan-to-value ratio applies at mortgage origination in j:

$$\lambda_j \leq (1 - \delta), \tag{7}$$

where δ is the minimum requirement for downpayment. We specify an amortization function $q(.)$ that stipulates that a specific share of the current mortgage balance be amortized. Formally,

$$m_{j+1} = (1 - q(.))m_j.$$

The analogue for LTV is:

$$\lambda_{j+1} = (1 - q(.))\lambda_j \frac{P_t^h}{P_{t+1}^h}. \tag{8}$$

Notice that the law of motion implies a geometric rate of amortization rather than the linear rate implied by the macroprudential regulation.[4] The way that the law of motion is specified matters for the minimium amount to be amortized when house prices are non-stationary. We specify baselines for δ and $q(.)$ in the calibration and then explore policy experiments by making changes to δ and imposing a maximum value for debt-to-income too. The rate of return on the mortgage is

$$r^m = r + \kappa^m, \tag{9}$$

where κ^m is a premium relative to the rate of return on savings.

[4]The actual Swedish regulation could be written as $m_{j+1} - m_j = q(.)m^0$, where m^0 is the mortgage balance at the time origination.

2.5 Housing markets

There is a fixed supply of owner-occupied housing. Homeowners cannot rent out parts of their houses. The rental market has elastic supply of rental housing at a constant rent per square meter. We assume that the price per square meter and the rent per square meter, respectively, are independent of house size.

2.6 The household's problem

Households choose consumption (c_j) and financial wealth (a_j) in every period, subject to a no-borrowing constraint for $a_j (a_j \geq 0)$. Moreover, at age 25 and age 35 households can choose to purchase a house.

2.6.1 The choice of whether to own or rent

Age 25 At $j = 25$, households have the choice whether to buy a house or rent. Households that buy a house have access to a mortgage and choose their loan-to-value ratio λ_j.

Initial cash-in-hand is given by initial financial wealth, $\hat{a}$, and initial labor income, y_{25}:

$$x_{25} = \hat{a} + y_{25}, \tag{10}$$

where $\ln(\hat{a})$ is distributed $N(\mu_A, \sigma_A)$. Formally, at age 25 the household chooses the optimal tenure status:

$$\widehat{V}_{25} = \max \left\{ V_{25}^{B}, V_{25}^{R} \right\}. \tag{11}$$

where V_{25}^{B} is the value associated with buying and V_{25}^{R} is the value associated with renting.

Age 35 At $j = 35$ the household is given a second chance to buy a house, which means that it can either transit from rentership to ownership or sell its current house and upgrade or downgrade to a house of a different size in the owner market. Formally

$$\widetilde{V}_{35} = \max\left\{V_{35}^S, V_{35}^R, V_{35}^B\right\} = \max\left\{V_{35}^S, \widehat{V}_{35}\right\}, \tag{12}$$

where V_{35}^S is the value associated with staying (remaining a homeowner with $h_{35} = h_{34}$).

In all other time periods, a homeowner is choosing between staying or selling and becoming a renter and a renter must continue to rent:

$$\widetilde{V}_j = \max\left\{V_j^S, V_j^R\right\} \tag{13}$$

for $j = 25, 35$.

2.6.2 The household's problem

Let $\mathcal{S}_{25,t} = \{z_{25}, x_{25}, P_t^h\}$ denote the state at $j = 25$ and let $\mathcal{S}_{j,t} = \{z_j, x_j, \lambda_j, h, P_t^h\}$ denote the state variables for $j = 26, ..., 100$.

The renter's problem The problem of a household that chooses to rent in period j is given by:

$$V_j^R(\mathcal{S}_{j,t}) \quad = \quad \max_{c_j, h_j, a_j} \frac{(c_j^{1-\theta}(\kappa \cdot h)^{\theta})^{1-\gamma}}{1-\gamma} + \beta E_j\left[\widehat{V}_{j+1}\right], \tag{14}$$

subject to (1)–(4), (10), and the budget and borrowing constraints

$$c_j + a_j + \omega h_j = x_j, \tag{15}$$

$$a_j \geq 0, \tag{16}$$

the law of motion for cash in hand

$$x_{j+1} = a_j R + y_{j+1}, \quad j = 25, ..., J-1, \tag{17}$$

Notice that the renter does not choose house size, h_j, on a grid. It chooses total consumption expenditure, $c_j + \omega h_j$, and then splits this amount optimally in a static intratemporal problem. The parameter ω is the rent per square meter.

The buyer's problem The household that chooses to buy in period $j = 25$ or $j = 35$ maximizes:

$$V_j^B(\mathcal{S}_j) = \max_{c_j, a_j, h_j, \lambda_j} \frac{(c_j^{1-\theta} h_j^{\theta})^{1-\gamma}}{1-\gamma} + \beta E_j \left[\widetilde{V}_{j+1} \right], \tag{18}$$

where $\widetilde{V}_{j+1}$ is the value function of a household that enters period j as a homeowner, subject to (1)–(4), (7), (8), (10), (13) , and the budget constraints

$$c_j + a_j + ((1-\lambda_j) + r_t^m \lambda_j + \phi + \phi_b) P_j^h h = x_j \tag{19}$$

$$a_j \geq 0 \tag{20}$$

$$h_j \geq \underline{\mathrm{h}}, \tag{21}$$

where ϕ is a maintenance cost and ϕ_b is a purchasing cost, and the law of motion

$$x_{j+1} = a_j R + y_{j+1}. \tag{22}$$

Equation (21) puts a constraint on the home buyer. If choosing to buy, the household must buy a home which is at least $\underline{\mathrm{h}}$ square meters.

Homeowner's problem A household that enters a period as a homeowner chooses tenure status in addition to non-durable consumption (c_j) and financial wealth (a_j). Let V_j^S be the value associated with staying (remaining a homeowner with $h_j = h_{j-1}$):

$$V_j^S(\mathcal{S}_{j,t}) = \max_{c_j, a_j} \frac{(c_j^{1-\theta} h^{\theta})^{1-\gamma}}{1-\gamma} + \beta E_j \left[\widetilde{V}_{j+1} \right], \tag{23}$$

subject to (1)–(4), (8), (10), (12), (12), (13), and the budget constraints

$$c_j + a_j + ((r_t^m + q(.))\lambda_j + \phi) P_t^h h = x_j, \quad j = 2, ..., J, \tag{24}$$

$$a_j \geq 0, \tag{25}$$

and the laws of motion

$$x_{j+1} = a_j R + y_{j+1}, \quad j = 25, ..., J-1, . \tag{26}$$

Technical note on forced sales and optimal sales Conditional on entering period j as a homeowner the household may be forced to sell if cash-in-hand is not sufficient to service housing cost, i.e. $a_{j-1}R + y_j \leq ((r_t^m + q(.))\lambda_j + \phi)P_t^h h_j$. In this case, cash-in-hand equals

$$x_j = a_{j-1}R + y_j + (1-\phi_s)P_t^h h - \min\{1, \lambda_j\}P_t^h h \tag{27}$$

where ϕ_s is a sale cost. Notice that if $\lambda_j > 1$ then the bank makes a loss on the loan. The loss is equal to $\max\{0, P_t^h h(\lambda_j - 1)\}$. After a forced sale the household can choose to rent or (if feasible) buy a new house (adjusting h_j or λ_j).

Conditional on an optimal sale, the household's cash-in-hand is:

$$x_j^s = a_{j-1}R + y_j + (1-\phi_s)P_t^h h_j - \lambda_j P_t^h h_j. \tag{28}$$

2.7 Equilibrium definition

2.7.1 The market for owner-occupied housing

The price per square meter, P^h, clears the market for owner-occupied housing:

$$\begin{aligned} H = &\sum_{j=26}^{100} \int_i h_{ij}^O(z_{ij}, x_{ij}, \lambda_{ij}, h_{ij}, P^h)di + \int_i h_{i25}^B(z_{i25}, x_{i25}, P^h)di \\ &+ \int_i h_{i35}^B(z_{i35}, x_{i35}, P^h)di \end{aligned}$$

where $h_{ij}^O(.)$ solves the homeowner's problem and $h_{i25}^B(.)$ and $h_{i35}^B(.)$ the homebuyer's.

2.7.2 The market for rental housing

Rental housing is assumed to be under full rent control. The rent per square meter is fixed whereas supply is completely elastic. That the rent per square meter is fixed implies that ωP_t^h is set exogenously in the calibration.

3 Calibration

We calibrate the model partly according to standard parameter values in the literature but also to the economic setting of Sweden in the early 2000s. We briefly describe how we set parameters that relate to the Swedish setting and provide a summary of all parameter values in Table 1.

There is detailed wealth data on Swedish households for the period 2000–2007. To calibrate the model as well as possible, we use data from this time period. In particular, two parameters are determined by simulations of the model until the moments in the model are sufficiently close to moments in the data. The discount factor, β, is set to 0.960, which matches the average ratio of liquid financial wealth to income between 25 and 64 years (0.782). The utility penalty associated with renting is set so that 1 rented square meter is equal to 0.9375 owned square meters in utility terms. This matches the homeownership rate over the life-cycle (0.648). This process is equivalent to the one in Dahlquist, Setty and Vestman (2018) and Schlafmann, Setty and Vestman (2024) for determining liquid assets to income and the stock market participation rate. Figure 1 shows life-cycle averages for income, the homeownership rate and for financial wealth in the data and in model simulations.

Furthermore, we set the other parameter values for the labor income process to match the early 2000s. The values are taken from Schlafmann, Setty and Vestman (2024). We use the method of Rouwenhorst (1995), and more precisely the code of Fella, Gallipoli and Pan (2019), to discretize the state space for z_{ij} into seven bins for each age group. Another feature of the data is that those with highest incomes in their early 30s have SEK 100,000 more in net worth already at age 25. We match this feature of the data in the calibration by making the mean of the distribution for initial financial wealth ($\hat{a}$) conditional on the initial state of permanent income (z_{25}).

To obtain a calibration which is consistent across the labor and hous-

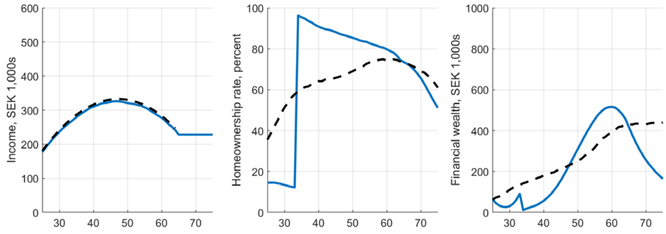
Table 1: Calibration—model parameters

	Notation	Value
Preferences and real rate		
Discount factor*	β	0.960
Relative risk aversion	γ	2
Preference for housing	θ	0.25
Disutility of renting*	κ	0.9375
Real rate	r	0.02
Housing and mortgage markets		
Purchase cost	ϕ_b	0.01
Sale cost	ϕ_s	0.02
Maintenance	ϕ	1.00
Rent per square meter	ω	SEK 575
Mortgage premium	κ^m	0.015
Down-payment requirement	δ	0.100
Amortization requirement**	$q(.)$	—
Price per square meter	P^h	SEK 11,500
Minimum house size in owner market (m^2)	$\underline{h}$	32
Labor income and financial wealth		
Labor-income profile***	g_t	—
Std, permanent idiosyncratic income shock	σ_η	0.0713
Std, transitory idiosyncratic income shock	σ_ν	0.101
Std, initial labor income	σ_z	0.366
Std, initial financial wealth	σ_A	1.392
Mean, initial financial wealth****	$e^{\mu_A+\sigma_A^2/2}$	168,292
Floor for income	$\underline{y}$	SEK 48,000
Replacement rate in retirement	λ^r	0.800

Note: The table presents the parameter values of the model. * The parameter value has been determined endogenously by simulation of the model. ** See equation (29). *** See the left-most panel in figure 1 for the profile. **** The two groups born with the highest permanent income have a conditional mean which is higher by SEK 100,000.

ing markets, we match the housing market characteristics of the early

Figure 1: Life-cycle averages for targeted variables



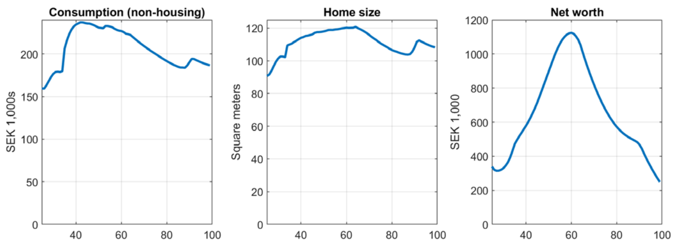
Notes: The figure shows averages for the targeted variables in the baseline calibration. The amortization function $q(.)$ is defined as in (29) and $\delta = 0.10$.

2000s. Using the official price indices for single-family houses (Statistics Sweden's FASTPI index) and co-op apartments (HOX from Valueguard) we approximate a country-average square meter price in 2004 of SEK 11,500. We use this value for P^h to back out H, which corresponds to an average of 111 square meters for each homeowning household. This is close to the average in our micro data – 108 square meters. We use $H = 111$ as target in our search for the equilibrium price under different macroprudential reforms. We also look for a suitable value for $\underline{h}$, the smallest house size in the owner-occupied market. We find that only 1 percent of homeowning households own less than 32 square meters and hence choose this value.

Finally, we set mortgage characteristics which is consistent with the early 2000s as well. This was before stricter borrower-based macroprudential regulations came in to place. We set the minimum down-payment requirement to $\delta = 0.10$ and define the amortization function $q(.)$ to be a function of the loan-to-value ratio with only moderate requirements for amortization.[5] More specifically:

[5]We thank Viktor Thell at FI for discussing typical features of Swedish mortgage contracts in the early 2000s.

Figure 2: Unconditional life-cycle averages



Notes: The figure shows the unconditional means in the baseline calibration. Net worth is defined as cash-in-hand plus home equity, $x_j + (1 - \lambda_j) \cdot P^h h_j$.

$$q(\lambda_t) = \begin{cases} 0.000 \text{ if } \lambda_t \in [0.00, 0.50] \\ 0.005 \text{ if } \lambda_t \in (0.50, 0.75] \\ 0.010 \text{ if } \lambda_t \in (0.75, 0.90]. \end{cases} \quad (29)$$

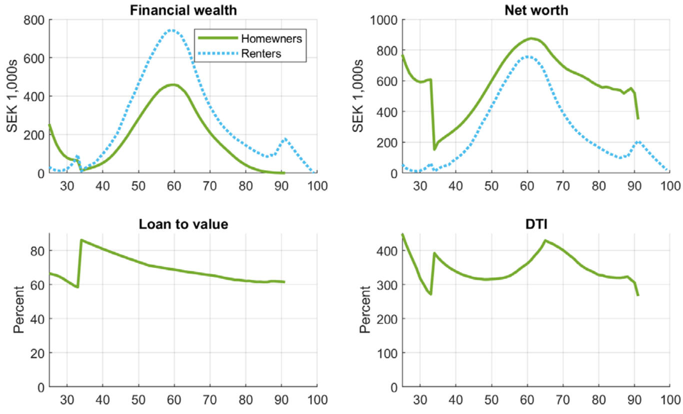
4 Results

In this section we present the economic mechanisms behind homeownership and borrowing, and then analyze the costs and benefits of borrower-based regulations. The costs are measured as distortions to homeownership, house size and consumption and the benefits are measured as improvements in household resilience.

4.1 The evolution of consumption and wealth

Figure 2 shows averages over the life-cycle for non-housing consumption, housing and net worth. On average, households only partly manage to smooth consumption over the life-cycle. This is due to borrowing constraints. Further, they accumulate substantial net worth until retirement which peaks at about 1.1 million SEK. Throughout, we define net worth

Figure 3: Evolution of balance sheets over the life-cycle



Notes: The figure shows the conditional means in the baseline calibration.

as cash-in-hand plus home equity: $x_j + (1 - \lambda_j) \cdot P^h h_j$.[6]

Figure 3 shows the evolution of households' balance sheets over the life-cycle. Homeowners accumulate less financial wealth but have more net worth, since they tie a substantial amount of their wealth in home equity. By age 90 all households rent. The bottom panels show the average loan-to-value ratio (LTV) and debt-to-income ratio (DTI) for homeowners. LTVs ratios peak at 35 when most households buy. Homeowners at 25 choose lower LTVs because they are richer and not all of them are constrained by the down-payment requirement. At 35 a vast majority switches from renting to owning which is why financial wealth of renters drops to virtually zero. After 35, LTVs gradually decline. DTIs also reflect the positive selection of households into homeownership at age 25. The U-shape during working life reflects that homeowners with positive income shocks may find it optimal to rent a bigger home whereas homeowners with negative income shocks achieve maximum consump-

[6]Net worth thus includes this period's income. While it is not the typical definition in empirical analyses, defining it this way helps to understand the model mechanisms.

tion smoothing by staying in their current home. LTVs and DTIs remain fairly high also late in life as amortization rates are fairly low.

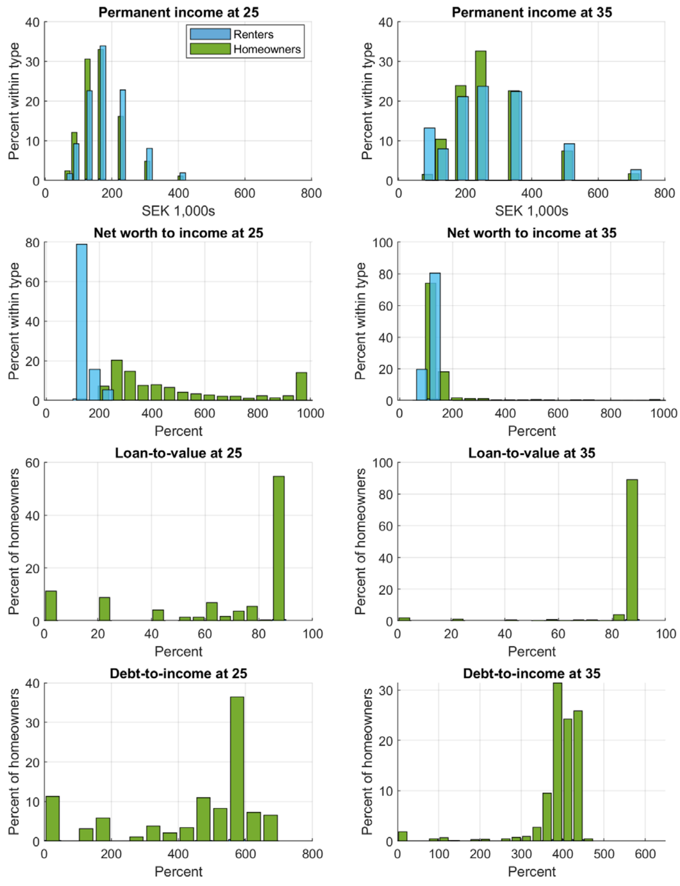
4.2 The economic mechanisms behind homeownership and borrowing

Figure 4 shows the conditional distributions for renters and homeowners at 25 and 35. They are helpful for understanding the decision to buy versus to rent. Since homeownership comes at a utility premium, households have a natural desire to own their home. Furthermore, the cost per square meter is in the baseline set to be equal between renting and owning. Consequently, the decision to buy is largely determined by whether it is possible to buy a home with suitable size (i.e., conditional on permanent income) while satisfying borrowing limits. Whether this is possible is in turn determined by the households' net worth in proportion to permanent income.

The panels to the left display distributions at age 25. The average net worth to income ratio for renters is 130 percent whereas it is 602 percent for homeowners (recall that net worth includes this period's income). Thus, homeowners are heavily positively selected in terms of this ratio at 25. At age 35, the average net worth to income ratio for renters is 104 percent and for homeowners 167 percent. At this point in the life-cycle, only negatively selected households, in terms of this ratio, remains renters.[7] Among the homeowners at 25, some are so rich that the downpayment requirement does not bind – they buy a house at a loan-to-value ratio below $1 - \delta$. In contrast, almost all homeowners at 35 have the maximum loan-to-value ratio. The debt-to-income ratio (DTI) is also different at the two stages of the life-cycle. Homeowners at 25 have an average DTI of 448 percent and a maximum of 699 percent. Homeowners at 35 have an average of 391 percent and a maximum of 474 percent. This reflects that some homeowners at 25 are very wealthy whereas others achieve maximum consumption smoothing by borrowing a lot. The more concen-

[7] There is almost no overlap in the distributions. The richest renter has a ratio of 114 percent and the poorest homeowner a ratio of 107 percent. The overlap is due to the transaction costs associated with buying and selling houses.

Figure 4: Conditional distributions at 25 and 35



Notes: The figure shows conditional distributions at age 25 and 35 in the baseline calibration.

trated distribution for DTIs at 35 reflects that the typical household has a more balanced ratio between net worth and permanent income. The optimal DTI is therefore less dispersed, at around 400 percent.

4.3 Two measures of households' resilience to shocks

One potential benefit of borrower-based macroprudential policies is that they reduce households' sensitivity to shocks so that their consumption becomes more stable. So, macroprudential policies that make households more resilient can reduce the risk that a shock to households leads to a loss in aggregate demand that triggers an economic crisis. To measure households' resilience we introduce two metrics which we label MPC^X and MPC^M. They measure how households' consumption (non-housing consumption, to be precise) responds to temporary shocks.

The metric MPC^X is the standard measure of marginal propensity to consume with respect to a temporary income shock. The household has a consumption function $c_{it}(t, z_{it}, x_{it}, \lambda_{it}, h_{it}, P_t^h)$, so mathematically, this measure is given by $\partial c_{it}/\partial x_{it}$. Typically, for a given household it has a value between just above 0 (r) and 1. In the heterogeneous agent (HA) macroeconomics literature this is a widely accepted measure of households' vulnerability to income shocks. It is also well-known that the main determinant of its magnitude at the level of the individual household is access to buffers, either in the form of liquid assets or in the form of credit lines. In a cross-country study, Kaplan, Violante and Weidner (2014) document that the share of households that have no buffer varies between 20 and 30 percent across countries.[8] Such households are called hand-to-mouth (HTM) households. In turn, one third of those households have positive net worth and they are called wealthy HTM households. Kaplan and Violante (2014) demonstrate that an economy's MPC^X increases in the share of wealthy HTM households.[9]

Since Swedish households have predominantly adjustable rates in their mortgage contracts (see, e.g., Flodén et al., 2021), an additional useful

[8] Andersson and Vestman (2021) report that 45 percent of Swedish households had less than SEK 100,000 in liquid financial wealth in 2012.

[9] See Kaplan and Violante (2018) for an overview of the literature.

metric for Sweden is the marginal propensity to consume with respect to a temporary shock to the mortgage premium, κ^m: $\partial c_{it}/\partial\kappa^m$. The source of such a shock could be stress in the market for covered bonds. At the outbreak of the pandemic, in March 2020, the risk premia on covered bonds emitted by Swedish banks rose by 30–35 basis points.

For a household with an adjustable rate mortgage, a temporary shock to the risk premium is equivalent to an expense shock. That is, it reduces cash-in-hand. The reduction, in SEK, is proportional to the household's mortgage balance. For a shock of $\Delta\kappa^m$ basis points, the change to household i's consumption is

$$\frac{\partial c_{it}}{\partial\kappa^m} \approx \frac{\partial c_{it}}{\partial x_{it}} \times m_{it}, \tag{30}$$

where the first factor simply is MPC^X and the second factor is the mortgage balance. The mortgage balance should in this context be thought of as the part of the household's mortgage which has an adjustable rate. Intuitively, the higher the household's mortgage balance, the more exposed the household is to the risk premium. That is, the larger is the expense shock. The reaction to the expense shock is in turn determined by MPC^X. We label (30) as MPC^M. Numerically, we approximate MPC^M as

$$MPC^M \approx \frac{c_{it}(t, z_{it}, x_{it} - \Delta\kappa^m \lambda_{it} P_t^h h_{it}, \lambda_{it}, h_{it}, P_t^h) - c_{it}(t, z_{it}, x_{it}, \lambda_{it}, h_{it}, P_t^h)}{-\Delta\kappa^m \lambda_{it} P_t^h h_{it}}. \tag{31}$$

In our analysis, we thus assume that households have a mortgage portfolio consisting entirely of adjustable rate mortgages. This is broadly consistent with the Swedish setting where the aggregate share of mortgages with just a 3-month interest fixation period has gradually increased to over 60 percent in the last twenty years (Holmberg et al., 2015).[10]

4.4 A reform of the down-payment requirement

In a first exercise we analyze the effects of changing the minimum down-payment requirement from 10 percent to 15 percent. We report the changes

[10] In July 2024, the value-weighted share of ARMs in the aggregate reached 69%.

of the allocation of the owner-occupied housing stock and effects on households' resilience to shocks. The analysis is based on a new stationary equilibrium, disregarding the transition.

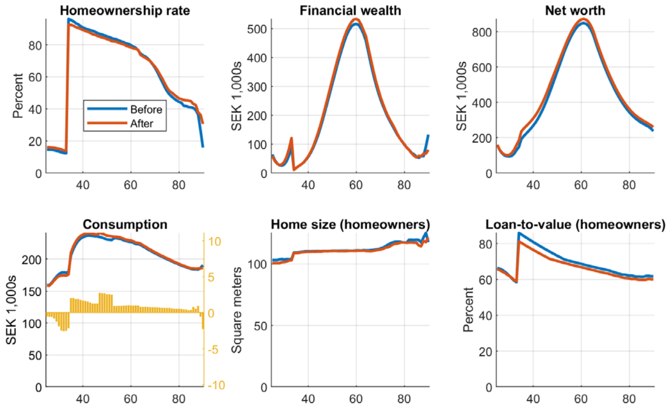
4.4.1 Main effects

Figure 5 shows how a stricter downpayment requirement changes household behavior. The top left panel displays the homeownership rate, which decreases among households of age 35-60. The change is most drastic at 35, with a decrease from 96.2% to 92.6%. Late in life, after 60 years, and also to a smaller extent early in life, between 25 and 34 years, the homeownership rate increases somewhat. The reason for the increase late in life is that households accumulate more financial wealth which they can run down after retirement. This enables old households to remain homeowners for longer, before it is optimal to sell in order to consume out of their home equity. While the increased downpayment requirement reduces the demand for owner-occupied housing for most age groups, the increased demand early and late in life counteracts this effect. Because of this, the house price falls only by 2.0%.

There are also consequences for consumption and savings. Because of the greater downpayment requirement, households accumulate more financial wealth before their home purchase (top middle panel). At 34, the average household has SEK 91,000 before and SEK 121,000 after. After their home purchase they continue to accumulate slightly more financial wealth because the accumulation of home equity until retirement is somewhat lower (since many households buy smaller homes; bottom middle panel). This is despite that loan-to-value ratios from 35 years and onwards are lower. Financial wealth peaks at an average of SEK 533,000 compared to SEK 516,000 before. Overall, the increased accumulation of financial wealth and net worth (top right panel) has effects on the life-cycle profile of non-housing consumption. There is an intertemporal shift towards consumption later in life (bottom left panel).

The top panel of Table 2 summarizes some important changes. Before the reform non-housing consumption increases by 47.7% between 25 and 47 years. After the reform the increase is 50.4%. Average square meters

Figure 5: Reform of down-payment – life-cycle profiles



Notes: The figure shows unconditional averages before and after a change in the down-payment requirement. The yellow bars marks differences in percent.

among homeowners decreases from 111.7 to 110.0 because the housing stock is shared among more older households.

4.4.2 Who is affected the most?

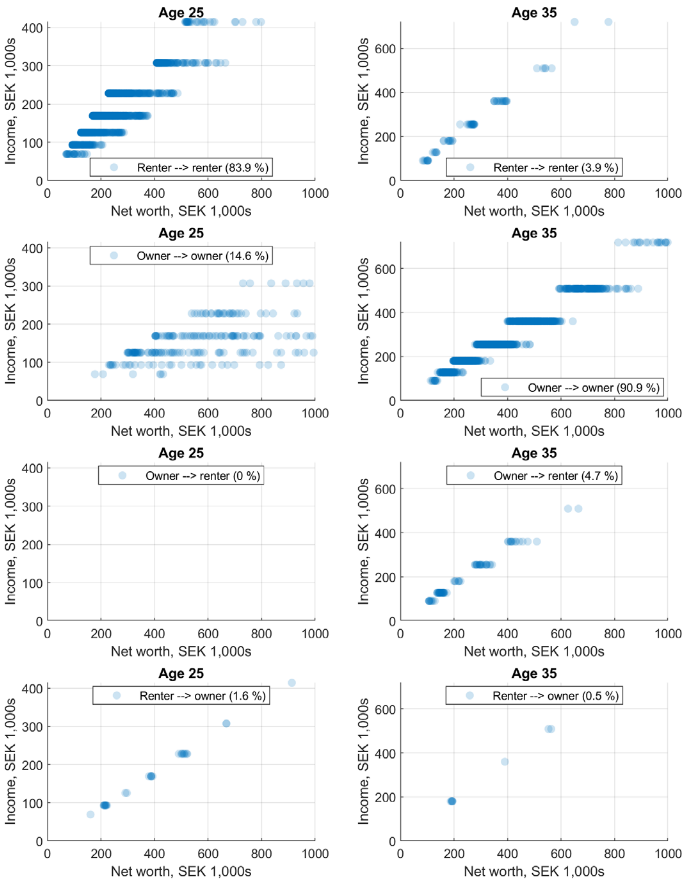
Which households are most affected by the reform? We investigate who changes housing arrangement the most by looking into extensive margin effects, that is, switches from rentership to ownership and vice versa. Figure 6 displays categories of households, depending on their extensive margin housing choice (i.e., rent/own) before and after the reform. The panels to the left refer to households that are 25 years. At 25, only households with the very highest net worth to permanent income buy. Most households have too little net worth relative to their permanent income and hence choose to rent. As the house price falls, a small group of wealthy households (1.6%) choose to switch from rentership to homeownership.

Table 2: **Effects of borrower-based measures**

	Baseline	Stricter down-payment	Cap on debt-to income
Distortions			
House price	11,500	11,270	11,486
Homeownership rate 25–65 years	0.697	0.688	0.695
Homeownership rate 25–100 years	0.547	0.552	0.547
Consumption increase 25–>47 years	47.7%	50.4%	47.3%
Square meters, homeowners	111.7	110.0	111.7
Household resilience*			
MPC^X, all households	0.175	0.162	0.173
MPC^X, homeowners	0.155	0.151	0.152
MPC^X, —- ″ —- (δ)**	0.156	0.151	—
MPC^X, —- ″ —- 36-40 years (δ)**	0.426	0.422	—
MPC^X, —- ″ —- (Ψ)**	0.154	—	0.152
MPC^M, —- ″ —-	0.138	0.137	0.136
MPC^M, —- ″ —- (δ)**	0.138	0.136	—
MPC^M, —- ″ —- (Ψ)**	0.136	—	0.136

The table presents averages under different macroprudential regimes, with changes relative to the baseline in percent in parenthesis. The second column refers to a down-payment requirement of 15% ($\delta = 0.15$). The third column refers to a maximum debt-to-income ratio of 500% at origination of the mortgage ($\Psi = 5.00$). MPC^X obtained by unexpectedly increase cash-in-hand by SEK 1,000. MPC^M is obtained by unexpectedly increasing the mortgage premium (κ^m) by 10 basis points. Increase in consumption from age 25 to 47 years (when labor income peaks). * All MPC measures are computed on households aged 25-65 years unless otherwise is stated. ** Refers to households that are homeowers both before and reform. The symbols δ and Ψ refers to which reform that defines the sample of homeowners.

Figure 6: Reform of down-payment – housing decisions before and after



Notes: The figure shows scatter plots of net worth and permanent income for households categorized according to their extensive margin housing decisions before and after the reform. The households at 35 and the sample shares are based on the subset that do now own in the beginning of the time period. Households' state variables are before the reform.

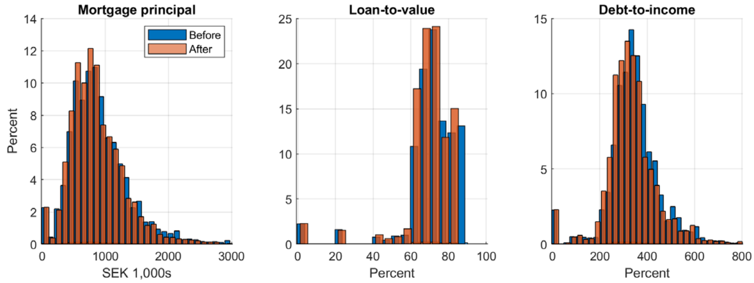
At age 35, 3.7% of households that would have bought before the reform now choose to rent instead. This corresponds to a decrease in the homeownership rate by 3.5 percentage points in that age category. This group of households stands out in two ways relative to households that buy also after the reform. They have lower net worth to permanent income and they have lower permanent income in absolute terms, too. Their net worth to permanent income is on average 1.20 compared to 1.37 for those that buy in either regime. In terms of financial wealth, the averages for the two groups are SEK 41,800 and SEK 101,500, respectively. Notice that these numbers refer to the regime with the smaller downpayment requirement (i.e., 'before'). The difference is starker in the regime with the greater downpayment requirement because both groups of households react to the new regulation. The households that buy in both regimes now need to accumulate more financial wealth for the down-payment. In contrast, the households that switch to renting foresee that early on and accumulate less financial wealth between age 25 and 35. After the reform the net worth to permanent income ratios are 1.08 and 1.52, respectively, and financial wealth is SEK 16,000 and SEK 143,000 for the two groups.

Among both 25- and 35-year-olds there is a small group of households that switch from renting to owning (1.6% and 0.5%, respectively). They have very high net worth relative to permanent income but were unable to find a suitable home size prior to the reform. After the reform, they take advantage of the price decrease.

4.4.3 Effects on household indebtedness

An intermediary aim for borrower-based macroprudential policies has been to reduce household indebtedness. Figure 7 reports the effects on three measures: mortgage principals, loan-to-value ratios, and debt-to-income. There are noticeable reductions in all three measures. Average mortgage debt among homeowners decreases from SEK 912,000 to SEK 852,000. That is, aggregate mortgage debt decreases by 6.6%. The average LTV decreases from 71.2 percent to 68.3 percent. The average DTI decreases from 350 percent to 329 percent. However, household indebt-

Figure 7: Reform of down-payment – effect on debt measures



Notes: The figure shows cross-sectional distributions for debt (mortgage principals, LTVs, and DTIs) among homeowners.

edness is at best only an intermediary aim for improving household resilience. Next, we turn to our preferred measures that are based on consumption.

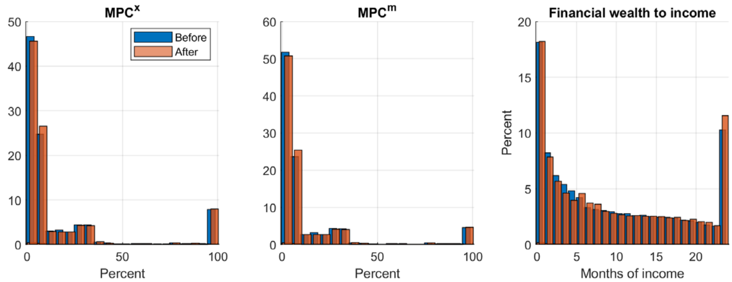
4.4.4 Effects on household resilience

Figure 8 reports the cross-sectional distributions of the MPC measures and savings buffers for homeowners of age 25-65 years, before and after the reform. Savings buffers are in terms of financial wealth relative to permanent income and multiplied by 12 to obtain months worth of buffer (i.e., $12 \cdot (a_{ij}/y_{ij}^p)$).[11] The marginal propensity to consume out of temporary income shocks, MPC^X, is barely affected – the average for homeowners shifts from 0.155 to 0.151 and the median value is unaffected: 0.052. The reason for the small change is that among households with the highest MPC^X, which are the 35- to 40-year-olds, the liquid savings buffer is lower or the same. Likewise, households interest rate sensitivity, MPC^M, is unaffected at an average of 0.137 and median of 0.049.

Overall, these changes of the MPC measures are too small to be economically meaningful. The main reason for the miniscule effects is that

[11] We restrict the sample to working age households to avoid effects of a short time horizon.

Figure 8: Reform of down-payment – savings buffers and MPCs



Notes: The left panel shows the cross-sectional distribution of MPC^X and the middle one MPC^M. The right panel shows the cross-sectional distribution of financial wealth divided by permanent income (multiplied by 12). Sample restricted to homeowners age 25-65 years in all panels.

savings buffers do not change much. The average savings buffers increases slightly, from 10.2 months of income in financial savings to 10.6 months (median buffers: 6.9 months to 7.4 months).

The second panel of Table 2 reports additional MPC statistics to separate the effect of the reform from the effect of selection in and out of the market for owned housing. Among all the households—that is, including renters—there is a reduction in MPC^X from 0.175 to 0.162. This is coming predominantly from young renters, aged 25 to 34, that save for their downpayment. Focusing on the sample that are homeowners both before and after does not affect the MPC calculations by much. We thus conclude that the effects are due to changes in behavior among homeowners rather than due to selection effects.

4.4.5 Welfare calculations

Another way to identify winners and losers is to compute the certainty equivalent consumption associated with either macroprudential policy regime and then compute the percentage increase in consumption required before the reform to make household i indifferent between that regime and the regime after the reform. This measure is called consump-

Table 3: **Welfare effects by net worth to permanent income**

	Q1	Q2	Q3	Q4
Net worth to permanent income	1.0326	1.1548	1.4400	4.3304
Consumption equivalent	−0.0253	−0.0255	−0.0199	0.2209

The table presents averages by quartiles of net worth to permanent income. Net worth is defined as cash-in-hand plus home equity. The consumption equivivalent is computed according to equation (32).

tion equivalent. For the preferences stipulated by (5), it can be computed as

$$\mathrm{ce}_i = 100 \cdot \left(\left(\frac{\widehat{V}_{i25}^{\text{After}}}{\widehat{V}_{i25}^{\text{Before}}} \right)^{\frac{1}{1-\gamma}} - 1 \right), \tag{32}$$

where the values are obtained from equation (11). That is, a positive value for ce_i is the same as winning from the reform.

Table 3 reports this metric for households sorted into quartiles with respect to net worth to permanent income at 25. The bottom three quartiles are all losers from the reform, even though the losses are modest at about 0.02% of consumption. The gains in the richest quartile are greater, at about 0.22% of consumption. A closer inspection of the full distribution tells that 78% of households lose from a stricter downpayment requirement.

4.5 A cap on the debt-to-income ratio

To complement downpayment requirements, countries have also introduced a maximum level for debt-to-income. Such a cap can either encompass only mortgages or mortgages plus other debts (such as auto loans and uncollaterized consumer debt). To implement such a cap in our model, we modify the constraint (7) in the home buyer's problem to

$$\lambda_j \leq \min\left\{(1-\delta), \frac{\Psi y_{ij}^P}{P^h h_{ij}}\right\}, \tag{33}$$

where Ψ is the cap on the DTI at the time of purchase. We set $\Psi = 5$ (i.e., a cap of 500%). Since our model only has mortgage debt it corresponds to a higher cap in a setting which offers additional forms of debt contracts.

4.5.1 Main effects

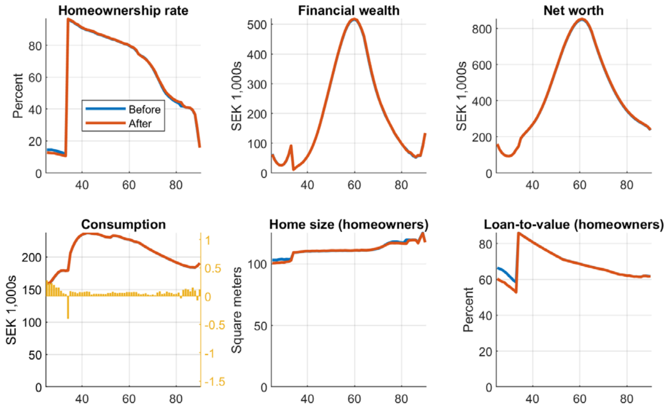
Overall, the effects of a cap on DTI at 500% has smaller effects than changing the downpayment requirement. The reason is that this constraint does not bind at all among home buyers at age 35 and only for some home buyers at 25 (see Figure 4, bottom panels). To be precise, before the introduction of the cap, 14.5% of all 25-year-old households buy and 58.4% of them choose a DTI which is greater than 500% (i.e., 8.5% of all 25-year-olds). However, this group of households remain constrained for at most 10 years because at 35 no household wishes to have a DTI greater than 500%. Hence the aggregate effects are small. The first panel of Table 2 reports the main effects. House prices fall by only 0.12%, and the homeownership rate remains unchanged. On average, consumption increases by no more than in the baseline between age 25 and 47 and the average number of square meters among homeowners remains virtually the same.

Figure 9 shows small effects also on life-cycle profiles. The homeownership rate is not much distorted and the average savings and consumption profiles are visually unaffected. Consequently, the welfare consequences are tiny – in each quartile of net worth to permanent income the effect is smaller than $+/-$ 0.02%.

4.5.2 Effects on household indebtedness

Figure 10 shows small effects on the debt measures. Mortgage principals among homeowners is merely reduced from SEK 912,000 to SEK 910,000. LTVs are reduced from 71.2 percent to 71.1 percent and DTIs from 350 to 348 percent. These changes are very small compared to the changes

Figure 9: Introducing a cap on DTIs – life-cycle profiles



Notes: The figure shows unconditional averages before and after introducing a cap on DTIs at the time of home purchases. The yellow bars marks differences in percent.

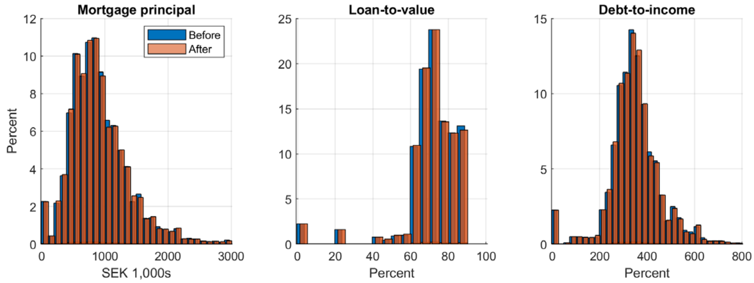
associated with the reform of the downpayment requirement. Again, our conclusion is that a DTI cap at 500 percent (a mortgage to income cap, to be precise) is essentially not binding.

4.5.3 Household resilience

For completeness, we also report effects on MPC^X, MPC^M and savings buffers for homeowners in Figure 11. The average MPC^X changes from 0.155 to 0.152 and the average MPC^M from 0.138 to 0.136. Savings buffers are unaffected, at an average of 10.2 months worth of income.

The second panel of Table 2 reports effects on household resilience. Households decrease their sensitivity to income shocks somewhat. Among the group of households that own in both economic settings, there is a minor reduction in MPC^X from 0.154 to 0.152. There is little added resilience with respect to mortgage interest shocks. The MPC^M for homeowners decreases from 0.138 to 0.136, only. This is natural given that the

Figure 10: Introducing a cap on DTIs – effect on debt measures



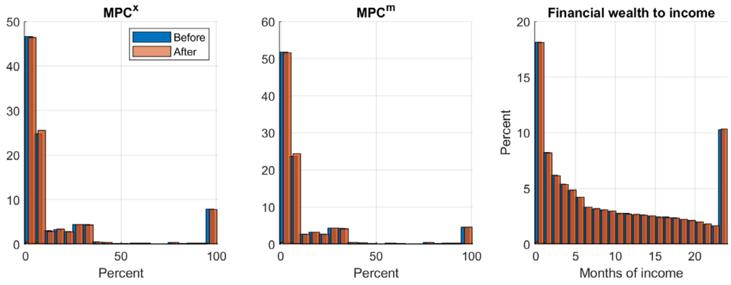
Notes: The figure shows cross-sectional distributions for debt (mortgage principals), LTVs, and DTIs.

DTI cap binds for few households. For the group of households that own in either setting there is no reduction at all.

5 Concluding remarks

This paper builds a life-cycle model to study so-called borrower-based macroprudential regulations that target households' mortgages. We use the model to study distortions in the owner-occupied market and in non-housing consumption and their associated welfare consequences. We also study the effects on household resilience in terms of marginal propensity to consume in response to a temporary income shock or a temporary shock to the mortgage interest rate. We study two changes in regulations. First, we find that after imposing a stricter downpayment requirement (from 10% to 15%) more than three quarters of the households lose while the improvements in household resilience are limited. Second, we find that a debt-to-income cap at 500% has small effects because it is only binding for a small share of 25-year-olds. The analysis is based on a model that has many important building blocks but nevertheless is simplified.

Figure 11: Introducing a cap on DTIs – savings buffers and MPCs



Notes: The left panel shows the cross-sectional distribution of MPC^X and the middle one MPC^M. The right panel shows the cross-sectional distribution of financial wealth divided by permanent income (multiplied by 12). Sample restricted to homeowners age 25-65 years in all panels.

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