Taxing Homeowners in China: Who are the Winners and Losers?*

Yunho Cho† Jinseong Park‡ Sisi Zhang§

March 21, 2022

Abstract

This paper examines the welfare implications of property tax in China using a general equilibrium overlapping generations model with heterogeneous agents. Through a series of counterfactual policy experiments, we find that implementing the universal property tax would reduce house prices and increase rents. When tax reform is targeted at investment properties, the negative effect on house prices becomes quantitatively insignificant, but it generates a large reduction in housing investment. The steady state welfare analysis suggests that households would prefer to be born in an economy with property tax when additional tax revenue is redistributed as a lump-sum transfer. However, newborn households prefer the status quo when the revenue is not redistributed. The median welfare effect, albeit redistribution, is negative along the transitions, with less than 45% of households favoring a reform. Renters, poorer, and younger households are better off, whereas homeowners and older households who own many housing assets are worse off.

Keywords: Property taxes; OLG model; Heterogeneous agents; Chinese housing market; Welfare
JEL code: E21, H24, R13, R2

*We thank He Chao, Qian Li, and seminar and conference participants at China Economic Fluctuations and Growth meetings (Guangzhou), China Meeting of the Econometric Society (online), Jinan-SMU-ABFER Conference on Urban and Regional Economics (online), and Jinan University for useful comments and suggestions. We also thank Jiajia Gu for her help with obtaining the China Household Finance Survey in the initial stage of this project. Cho appreciates financial support from the National Natural Science Foundation of China grant no. 7195041623.

†Institute for Economic and Social Research, Jinan University; yunho.cho@outlook.com
‡Department of Economics, Dong-A University; parkjs@dau.ac.kr
§Institute for Economic and Social Research, Jinan University; sisi.zhang@gmail.com

1 Introduction

This paper examines the welfare implications of property tax - ad valorem tax imposed on real estate - in China. Implementing property tax in China often generates active policy discussions. Supporters of property tax argue that the policy could mitigate housing demand and thereby house price growth, making housing more affordable. At the same time, collecting more taxes from the housing market would help the government raise revenue. On the other hand, opponents point out that introducing property tax would lead existing homeowners that account for over 90% of the population to bear excessive tax burden, depressing consumption, and social welfare. The main focus of this paper is to provide quantitative evaluations of property tax in the Chinese housing market, including its effects on house prices, rents, housing investment, and distributional welfare consequences.

We first document reduced-form evidence of the impact of a targeted property tax on house prices using high-frequency data on new house transactions. In particular, our difference-in-differences framework compares the average house prices in Shanghai before and after the policy change to those of other upper-tier cities that have not imposed property tax for the same period. Our result indicates that the adoption of targeted property tax in Shanghai did not curb the house price growth in the first three years, which is consistent with Du and Zhang (2015). Interestingly, we find that the house prices increased by a larger amount four years after implementing the targeted property tax.

In light of this evidence, this paper attempts to provide positive and normative implications of property tax reforms in China. We develop an overlapping generations model with heterogeneous agents to examine the impact of property taxes on house prices as well as the welfare outcomes under multiple policy scenarios. The model economy is populated by overlapping generations of finitely-lived households who derive utility from non-durables and housing services. Households face age-dependent death shocks throughout the life-cycle and earn labor income subject to uninsurable idiosyncratic income shocks. Households can choose to be a renter or a homeowner. Homeowners can lease out houses in the rental market, in which case they become a landlord. A decision to purchase a house provides access to collateralized borrowing, which requires minimum downpayments. The downpayment requirements are set separately for owner-occupied and investment houses. The government collects taxes from labor income, capital income, and rental income, where the total tax payment is determined by progressivity consistent with the Chinese income tax system. The equilibrium price and rent are determined by the market-clearing conditions for the housing and rental markets. A housing construction sector adjusts the supply of new housing in response to price changes.

The model is calibrated to the Chinese economy by matching moments computed from the China Household Finance Survey (CHFS) necessary to generate realistic policy implications. The model can generate plausible life-cycle profiles and distribution of important endogenous variables such as the homeownership rate and match other important moments, including landlord rate, loan-to-value ratio, and rent-to-income ratio in the data. Once a stationary equilibrium is solved, we conduct the following four counterfactual policy experiments: (1) universal property tax imposed on every homeowner without redistribution; (2) universal property tax imposed on every homeowner with redistribution; (3) targeted property tax imposed on investment properties without redistribution; and (4) targeted property tax imposed on investment properties with redistribution. We experiment each of these cases with the annual tax rates of 0.2%, 0.5%, and 1.0% of the housing value.

The main findings are as follows: First, introducing property taxes reduces house prices and increases rents. A negative effect on the demand for owner-occupied houses driven by an increase in the cost of homeownership leads to a fall in house prices and a rise in rents. However, we find that the effect on house prices is quantitatively insignificant when the tax reform is targeted, which is in line with our empirical findings. Under the universal tax reform, house prices fall from 1.1% to 4.6%, whereas under the targeted reform, they only decrease by 1.0% even with the annual tax rate of 1%. In the latter case, the tax reform induces a higher cost associated with an investment in the housing market, directly impacting the demand for investment properties. When the tax reform is targeted, many landlords switch their investment housing assets to owner-occupied houses. The decrease in the total demand for housing assets becomes therefore limited, resulting in a smaller decline in house prices.

Our second key finding is in terms of steady state welfare. Using the notion of ex-ante consumption equivalent variation, we find that households would prefer to be born in an economy where universal property taxes are implemented with redistribution. Redistribution of additional tax revenue appears to be a key mechanism for welfare gain. When the revenue is not redistributed, newborn households would experience a welfare loss even if the lowest tax rate level (0.2% per annum) is applied. In the model economy, over 90% of households would eventually become homeowners where such a transition requires them to bear the burden of property tax. There is also a general equilibrium effect. Higher rents and lower house prices negatively and positively impact ex-ante welfare, respectively. On the one hand, higher rents imply that newborn households would have to pay more for the same amount of housing services, and ceteris paribus, this reduces the present value of their lifetime resources. On the other hand, lower house prices enable households to become homeowners at a lower cost by reducing the downpayment requirement for those who rely on borrowings for home purchases. Nonetheless, the policy reform would negatively affect welfare if additional tax revenue is not redistributed to households.

The third result relates to the analysis of transition dynamics, which captures the effects on the economy immediately after the unexpected permanent implementation of property tax. In particular, we focus on the welfare effects for counterfactual economies where we introduce the universal property tax rate of 0.5% with and without redistribution. The immediate welfare effect is negative when a property tax is imposed without redistribution. Measured by ex-post consumption equivalent variation, the policy reform leads to a median welfare loss of 2.7%, and almost every surviving household in the economy prefers the status quo. When the policy reform involves redistribution, the size of welfare losses becomes close to the welfare neutral state, and 45% of surviving households become better off. This result confirms the importance of redistribution when the government considers implementing property taxes.

The welfare consequences are largely distributional and vary significantly across households. We find that most homeowners are worse off in both experiments, with and without redistribution. In addition to the increased tax burden, a large part of the reduction in house prices occurs during the first period of the reform, which outweighs any benefits associated with the lump-sum transfers. In contrast, many renters become better off when they receive lump-sum transfers. Renters are typically in low-income brackets, and therefore they tend to benefit proportionately more from the lump-sum transfer. The tax reform tends to benefit younger and poor households who do not have much housing wealth in their portfolio.

Both steady state and instantaneous welfare results highlight an essential role of redistribution when introducing a property tax. For an economy with a high homeownership rate like China, taxing real estate ownership would be a way to easily raise government revenue. However, it may trigger strong opposition from the public if the government chooses to spend its revenue as wasteful resources. Some - usually the poor - would prefer to live in a world where the government imposes a tax on real estate and redistributes additional revenue to the public.

This paper is related to three strands of literature. First, several studies examined how property tax impacts the Chinese housing market. However, most studies in this area have mainly been empirical in nature, see for example Bai, Li and Ouyang (2014) and Du and Zhang (2015), and findings are limited to evidence from the two pilot cities, Shanghai and Chongqing, with the focus on the impacts upon house prices. Cao and Hu (2016) employs a static partial equilibrium model to assess the potential impacts of property tax reform in China. The most closely related paper would be Zhu and Dale-Johnson (2020), which also examines the implications of property tax in China using a quantitative life-cycle model, similar to the model used in this paper. We differ from Zhu and Dale-Johnson (2020) by providing the welfare analysis in both steady state and during transitions. The main focus of our paper is to understand the source of welfare changes and heterogeneous impacts across different households in the economy.

Second, the paper is closely related to the literature that explores the welfare implications of various taxation in housing markets using quantitative macroeconomic models in a stationary environment, e.g., Chambers, Garriga and Schlagenhauf (2009), Floetotto, Kirker and Stroebel (2016), Sommer and Sullivan (2018), and Cho, Li and Uren (2022). While the model presented in this paper shares many similar features, it focuses on the implications of introducing property tax in a general equilibrium framework.

Going beyond the macroeconomic literature and Chinese applications, many studies show that property taxes reduce house prices due to the increase in the cost of homeownership, e.g., Simon (1943); Netzer et al. (1966); Poterba (1992), and Yinger et al. (2016). Several studies find that the rise in public expenditure from collecting additional tax revenue has positive spillover effects to the economy, e.g. Oates (1969); Hamilton (1976); Rosen and Fullerton (1977); Fischel (1992); and Lang and Jian (2004). One recent empirical paper by Elinder and Persson (2017) finds, using evidence from a policy reform of removing property tax in Sweden, no evidence of scrapping property tax raised house prices. The present paper contributes to this large literature by focusing on structural analysis, quantitatively investigating the potential impacts of property tax on the housing market aggregates.

The remainder of the paper is organized as follows: Section 2 describes the background and empirical evidence. Sections 3 and 4 presents the model and describes calibration. Section 5 discusses the results in terms of steady state and transition dynamics. Section 6 concludes.

2 Background, Data, and Evidence

2.1 House prices and property tax in China

The Chinese housing market became privatized in 1998, allowing the public to trade houses in the commercial market. As a result, the Chinese housing market has expanded rapidly and experienced a surge in house prices. A study by Fang, Gu, Xiong and Zhou (2016) estimates that, across 2003 and 2013, the average real growth rate of house prices in the first tier cities - Beijing, Shanghai, Guangzhou, and Shenzhen - reached 13.3%. The annual real growth rates for the second and third tier cites were also high; 10.5% and 7.9%, respectively. To slowdown the house price growth, policymakers have often considered taxing homeowners in the form of the recurrent property tax. In fact, the government started the trial property taxes in Shanghai and Chongqing in 2011. In Shanghai, the taxes are imposed on households that purchase investment houses at the rate of 0.6%. In Chongqing, property taxes are imposed on households that purchase investment house and high-end residential properties (houses bigger than 140 square meters). The annual tax rate is 0.5% of the house value for houses with prices lower than RMB 15,000 per square meter and for investment properties. If the value of houses exceeds RMB 15,000 per square meter, home buyers are required to pay 1% of the house value. As such, these trial property taxes are targeted to a certain fraction of homeowners in Shanghai and Chongqing.

2.2 Data

For this analysis, we rely on project-level data on monthly new housing transactions provided by the Chinese Real Estate Index System (CREIS).[1] The CREIS data records project names, city of project, the volume of transactions and their values, total transaction area and total construction area in square meters, and more. Originally, the data

[1] A project consists of single or multiple buildings which contain at least one residential unit (Lu et al., 2021).

Table 1: Summary statistics

	Control	Shanghai
Number of transactions (per month)	30.53	19.52
	(72.18)	(40.67)
Total sales (in 10,000 CNY)	4306.5	5588.7
	(10292.6)	(10335.2)
Total area transacted	3201.3	2315.2
	(6853.0)	(4199.7)
Area per unit	136.8	156.5
	(244.3)	(85.05)
house price (CNY/m^2)	14550.4	25699.1
	(11706.1)	(17202.7)
Observations	125617	42962

Note: This table reports the means and the standard deviations (given in the parentheses) for key variables in the Chinese Real Estate Index System data for Shanghai and other cities before and after the property tax imposition.

contains 572,844 observations from 2004 to 2015. However, transaction records for only four cities are available before 2009.[2] To make the best use of our data and to construct a reasonable counterfactual, we restrict our estimation sample to the following six cities: Shanghai, Beijing, Guangzhou, Hangzhou, Ningbo, and Wuhan.[3]

Table 1 documents the summary statistics for key variables in the CREIS data. The average monthly transactions are larger for cities in the control group than Shanghai. However, the amount of total sales is greater for Shanghai because properties in Shanghai is more expensive. The average house price per meter square for Shanghai is approximately 177% of the house price per meter square in the control cities.

2.3 Reduced-form evidence

We begin by presenting reduced-form evidence from the following event study specification:

$$y_{ijt} = \Sigma_{t=-2}^{-1} \alpha_t^{pre} Time_t \times Treat_j + \Sigma_{t=1}^{9} \alpha_t^{post} Time_t \times Treat_j + \delta_j + \theta_t + \beta \times t_j + \gamma_j \times t_j^2 + \varepsilon_{ijt} \tag{1}$$

[2]These cities are Shanghai, Tianjin, Hanzhou, and Wuhan. Observations from those cities account for 70.28%, 20.8%, 3.78%, 5.14% of the full pre-2009 sample, respectively.

[3]Data for Chongqing is only available during the post-treatment period. Instead of making a strong assumption regarding the trend in Chongqing's housing price before 2011, we perform a case study of Shanghai.

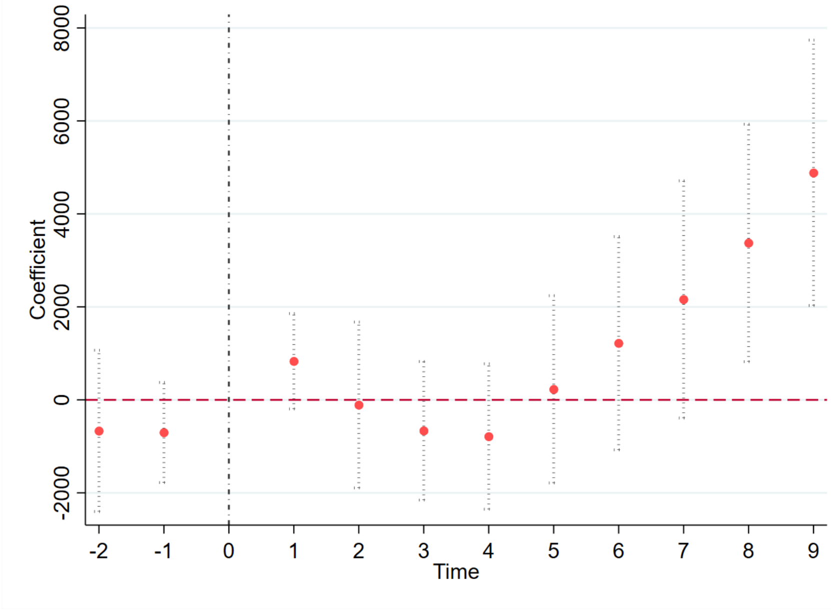


Figure 1: The effects of property tax imposition in Shanghai
Note: Each dot represents the estimate for α_t for a particular time period t, and the dotted lines represents its 95 percent confidence intervals. Standard errors are clustered at the county level.

where $Treat_j$ is the treatment status, which equals 1 if the city j imposed property taxes, and 0 otherwise, $Time$ is a dummy for a normalized calendar half-year t, and y_{ijt} is the outcome of interest for project i in city j at time t.[4] Our specification also controls for city fixed effects, δ_j, and time fixed effects, θ_t, and the city-specific linear and quadratic time trends, t and t^2. Standard errors are clustered at the county level to account for any correlation within a county and heteroskedasticity.

Our key identifying assumption is that house prices in Shanghai would have trended similarly to house prices in other cities on average, in the absence of the adoption of the property tax regime. Although the validity of the parallel trend assumption cannot be tested explicitly, obtaining insignificant estimates for both α_{-2}^{pre} and α_{-1}^{post} would give us some assurance that the assumption is likely to be valid.

Figure 1 summarizes our estimation result. Each dot represents the coefficient estimate for a particular calendar half-year, and the dotted lines are its 95 percent confidence intervals. Prior to the property tax implementation, house prices in Shang-

[4]We normalize the calendar half-year to the first half of 2011, which is the event year. We also estimate an event-study specification using monthly time periods and quarterly time periods. Although the results using an alternative time definition are noisier due to smaller observations in a given time-city cell, they are qualitatively similar to the main results given in Figure 1 The results from alternative specifications are available upon request.

Table 2: Results from difference-in-differences estimation

	(1)	(2)	(3)	(4)
Post × Treat	1057.3	-364.8	27.25	140.6
	(1142.6)	(977.1)	(831.0)	(928.2)
City fixed effects	Yes	Yes	Yes	No
County fixed effects	No	No	No	Yes
Time fixed effects	Yes	Yes	Yes	Yes
City-specific linear time trends	No	Yes	Yes	Yes
City-specific quadratic time trends	No	No	Yes	Yes
N	168611	168611	168611	168610
R^2	0.230	0.239	0.240	0.466

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

hai were not statistically different from those of control cities, conditional on two-way fixed effects and the city-specific time trends. The pattern supports the validity of the parallel trend assumption. Surprisingly, house prices in Shanghai in the first three years after the property tax imposition were not significantly different from those of control cities. Moreover, from the first half of the fourth year, Shanghai's house prices started to soar rather than plummet.

We also estimate a standard difference-in-differences model given as the following:

$$y_{ijt} = \alpha Post_t \times Treat_j + \delta_j + \theta_t + \beta \times t_j + \gamma_j \times t_j^2 + \varepsilon_{ijt} \quad (2)$$

where $Post_t$ takes 1 for transactions occurred after the first half of 2011, and 0 otherwise. Table 2 presents the estimation results. Overall, the results are consistent with the graphical evidence presented in Fig 1: none of the estimates are statistically significant. Although the signs of the coefficients are positive except column (2), interpreting the economic magnitude of the effects is limited due to the large standard errors.

Our result is consistent with Du and Zhang (2015) who conduct a counterfactual analysis using the house price index data provided by National Bureau of Statistics in China. The authors find that the imposition of the property tax had no impact on house prices in Shanghai. On the other hand, Zheng and Zhang (2013) estimate that the tax policy lowered Shanghai's house price by 2,127 CNY per square meter (or 13.4%) using a synthetic control method. However, their finding does not necessarily contradict our finding given many differences in the details of the two empirical studies, including research design and the period of estimation.[5]

[5] Zheng and Zhang (2013) using the CREIS data from May 2009 to November 2012.

3 Model

To investigate the effects of property tax in the Chinese housing market, we consider an overlapping generations model with incomplete markets, similar to the model in Cho et al. (2022). Households derive utility from consuming a numeraire non-durable consumption good and housing services. Over the life-cycle, households receive idiosyncratic income shocks which can be partially insured through either purchasing risk-free assets or housing assets. The model allows households with endogenous choices of renting and home ownership decision, as well as being landlords. Purchasing houses is subject to transaction costs. The government collects income tax from households which mimics the Chinese income tax system. The supply of housing is determined by a competitive construction sector that generates changes in the stock of housing in response to changes in house prices. The equilibrium house price and rental rate are determined endogenously through the clearing conditions in the respective markets.

3.1 Households

Demographics. Time is discrete. The age of households is denoted as j and households live until the maximum age of J. Households face an age-dependent survival rate given by κ_i. The population size remains constant as deceased households are replaced by new-born households every period.

Preferences. Households derive utility from a consumption good c, housing services s and leaving a bequest b. The expected life-time utility of a household is given by

$$\mathbb{E}_0 \left\{ \sum_{j=1}^{J} \beta^{j-1} \left[\kappa_j u_j(c_j, s_j) + (1-\kappa_j) v(b) \right] \right\} \tag{3}$$

where β is a discount factor which lies between 0 and 1. The flow utility is assumed to follow a CRRA utility function of the following form:

$$u_j(c, s) = \frac{(c^{\alpha} \lambda s^{1-\alpha})^{1-\sigma}}{1-\sigma} \tag{4}$$

where α measures the preference for non-durable consumption and σ is the risk-aversion coefficient. λ is a utility premium for homeowners with $\lambda > 1$ if a household receives utility from living in owner-occupied houses.

The function $v(b)$ in Equation (3) captures the utility received from leaving a bequest. The bequest function is given by

$$v(b) = \gamma \frac{b^{1-\sigma}}{1-\sigma}$$

where b is the size of the bequest, which equals the total assets of the deceased households, and γ measures the degree of bequest intensity.

Income. Households receive exogenous age-dependent periodic income given by

$$\log y_{i,j} = \eta_j + z_{i,j} \tag{5}$$

where η_j is a deterministic age-dependent income component and $z_{i,j}$ is an idiosyncratic persistent income shock. We assume that $z_{i,j}$ follows an AR(1) process:

$$z_{i,j} = \rho z_{i,j-1} + u_{i,j} \tag{6}$$

with $u_{i,j} \sim N(0, \sigma_u^2)$.

Housing arrangement. Households choose whether to rent or own their homes. If a household chooses to become a homeowner, i.e. $h > 0$, it consumes s with $s \leq h$. Any remaining housing assets can be rented out in which case it becomes a landlord. If a household chooses to become a renter, i.e. $h = 0$, it obtains housing services by renting s. The price of buying and renting a unit of housing are denoted as p and q, respectively, and determined endogenously via the market demand and supply of housing.

Depreciation, maintenance and transaction costs Homeowners incur maintenance expenses δ to offset depreciation of their housing stocks. Houses are costly to buy and sell. Consistent with the practice in the Chinese housing market, we assume that households face transaction costs of ϕ^s percent when selling a house but zero transaction cost when buying a house, i.e. real estate agent fees are paid by the seller. We use $TC(h_{-1})$ to describe transaction costs associated with owner-occupied and investment housing. They are expressed as:

$$TC(h_{-1}) = \begin{cases} 0 & \text{if } h_{-1} = h \\ \phi^s p h_{-1} & \text{if } h_{-1} \neq h \end{cases}$$

These transaction costs are a dead-weight loss for the economy.

Borrowing and saving. Households have access to a risk-free asset, a, that pays interest r which is exogenous. Every period, a household can save by purchasing this risk-free asset. Homeownership confers access to collateralized borrowing at a constant markup over the risk-free interest rate such that $r^m = r + m$. Borrowers need to meet a downpayment requirement. In a steady state where the house price does not change across time, the constraint on borrowing is given by:

$$a \geq -(1-\theta)ph \tag{7}$$

where

$$(1-\theta)ph = \begin{cases} (1-\theta_1)ph & \text{if} \quad h = s \\ (1-\theta_1)ps + (1-\theta_2)p(h-s) & \text{if} \quad h > s \end{cases}$$

and $\theta_1 > 0, \theta_2 > 0$ are downpayment requirements for primary and secondary home respectively.

Taxation. Households pay income tax on their total income, which is defined as

$$Y = y_j(z) + ra_{-1}\mathbb{1}_{\{a_{-1}>0\}} + NRI \tag{8}$$

where the first term, $y_j(z)$, is the household's labor income which depends on its age j and realisation of idiosyncratic income, z. The second term, $ra_{-1}\mathbb{1}_{\{a_{-1}>0\}}$ is the interest income from financial assets where $\mathbb{1}$ is an indicator function. The last term, NRI, stands for net rental income which is earned when the household is a landlord. The NRI is given as

$$NRI = \left[(q - p\delta)(h-s) + (r + r_m)a\left(\frac{h-s}{h}\right)\mathbb{1}_{\{a<0\}} - \xi\right] \tag{9}$$

The net rental income also consists of three components. The first term, $(q - p\delta)(h - s)$ represents the rental income earned after paying maintenance expenses. The second term, $(r + r_m)a\left(\frac{h-s}{h}\right)\mathbb{1}_{\{a<0\}}$, is any mortgage expenses incurred from the housing asset, and the last term, ξ, is the fixed cost which a household needs to pay if it becomes a landlord.

Household dynamic programming problem. At the beginning of each period, households first make their housing decision. That is, households chooses whether to rent, stay in a current owner-occupied house or move to a new owner-occupied house. Households then choose consumption c, housing services s, saving or borrowing a, and housing assets h. The state vectors are: age j, current realization of idiosyncratic income z, housing assets h_{-1}, and savings a_{-1}. In addition to these state variables, the housing purchase and rent decisions depend on the equilibrium house price and rent (p, q). For notational convenience, we denote $x \equiv (j, z, a_{-1}, h_{-1})$ and the value function as

$$V(x) = \max\{V^{\text{rent}}(x), V^{\text{stay}}(x), V^{\text{move}}(x)\} \tag{10}$$

The problem of renters is as follows:

$$V^{\text{rent}}(x) = \max_{c,s,a} u(c,s) + \beta \left[\kappa_j \mathbb{E}_{z'|z} V(x') + (1-\kappa_j) v(b)\right] \tag{11}$$

subject to

$$\begin{aligned} & c + a + qs + TC(h_{-1}) + \delta p h_{-1} + T(Y) \\ & \qquad = y_j(z) + p h_{-1} + (1 + r + m\mathbb{1}_{\{a_{-1}<0\}}) a_{-1} \\ & b = a \geq 0 \end{aligned}$$

where $x' \equiv (j+1, z', a, 0)$. The term $T(Y)$ represents the income tax paid to the government which is described below. The taxable income Y for renters is given by $Y = y_j(z) + r a_{-1} \mathbb{1}_{\{a_{-1}>0\}}$.

A homeowner who chooses to remain in its current home solves the following problem:

$$V^{\text{stay}}(x) = \max_{c,a,s} u(c,s) + \beta \left[\kappa_j \mathbb{E}_{z'|z} V(x') + (1-\kappa_j) v(b)\right] \tag{12}$$

subject to

$$\begin{aligned} & c + a + \delta p h_{-1} + T(Y) + \xi \mathbb{1}_{\{h_{-1}>s\}} \\ & \qquad = y_j(z) + q(h_{-1} - s) + (1 + r + m\mathbb{1}_{\{a_{-1}<0\}}) a_{-1} \\ & b = a + p h_{-1} \\ & a \geq -\left[(1-\theta_1) p s + (1-\theta_2) p (h - s)\right] \end{aligned}$$

Lastly, a homeowner who chooses to move house solves the following problem:

$$V^{\text{move}}(x) = \max_{c,a,h,s} u(c,s) + \beta \left[\kappa_j \mathbb{E}_{z'|z} V(x') + (1-\kappa_j) v(b)\right] \tag{13}$$

subject to

$$
\begin{aligned}
& c + a + ph + TC(h_{-1}) + \delta p h_{-1} + T(Y) + \xi \mathbb{1}_{\{h_{-1} > s\}} \\
& \qquad \qquad \qquad \qquad = y_j(z) + p h_{-1} + q(h_{-1} - s) + (1 + r + m\mathbb{1}_{\{a_{-1}<0\}}) a_{-1} \\
& b = a + p h_{-1} \\
& a \geq -\left[(1-\theta_1) ps + (1-\theta_2) p(h-s)\right]
\end{aligned}
$$

Note that the taxable income for homeowners include the net rental income such that $Y = y_j(z) + r a_{-1} \mathbb{1}_{\{a_{-1}>0\}} + NRI$.

3.2 Government and income taxation

The government collects income taxes and assets from deceased households. Below, we present a parsimonious structure of the Chinese tax system where households taxable income (labor income + rental income + capital income) is taxed at different marginal rates. The total amount of taxation imposed on household income is determined by:

$$
T(Y) = \begin{cases} 0 & \text{if } Y \leq \bar{Y}_1 \\ \tau_1 (Y - \bar{Y}_1) & \text{if } \bar{Y}_1 < Y \leq \bar{Y}_2 \\ T_1 + \tau_2 (Y - \bar{Y}_2) & \text{if } \bar{Y}_2 < Y \leq \bar{Y}_3 \\ \vdots & \\ T_{K-2} + \tau_{K-1}(Y - \bar{Y}_K) & \text{if } \bar{Y}_{K-1} < Y \leq \bar{Y}_K \end{cases}
$$

where $\bar{Y}_k$s are income thresholds, τ_k is the marginal tax rates, T_k is the tax payment threshold. It is assumed that $T_k = T_{k-1} + \tau_k(\bar{Y}_{k+1} - \bar{Y}_k)$.

Apart from tax revenue, the government finances its spending by selling the wealth of deceased households. Each period, the government sells housing stocks owned by those who die unexpectedly and pays off any outstanding debt. A household who dies unexpectedly therefore leaves accidental bequests. In the baseline economy, we assume that the government consumes its revenue on public goods that does not influence the household decision. In one of the counterfactual experiments, We allow the government to redistribute additional tax revenue raised from property tax to households in a lump-sum fashion.

3.3 Construction Sector

There is a competitive construction firm that governs the aggregate housing supply of the economy. This firm buys existing dwellings from households who choose to sell their housing assets, develops new dwellings using a production technology, and sells existing and new dwellings at price p to households who choose to purchase housing assets. Because there is no capital gain on average, the competitive construction firm does not earn profits from buing and selling existing dwellings. The production technology of this construction firm is given by $H^{\text{new}} = \psi_1 L^{\psi_2}$ where L is the amount of land permits purchased from the government. We assume that the supply of land is perfectly elastic and the firm purchases the land at a constant price which is normalized to 1, and sells the newly produced housing stock in the market at price p. The parameter ψ_2 is a scale parameter that is less than 1. The construction firm therefore solves the following static problem:

$$\max_{L} \left\{ p\psi_1 L^{\psi_2} - L \right\} \tag{14}$$

which results in the following new housing stock,

$$H^{\text{new}} \equiv \psi_1 (L^*)^{\psi_2} = \psi_1 \left(\frac{1}{\psi_1 \psi_2 p} \right)^{\frac{\psi_2}{\psi_2 - 1}}.$$

Note that the aggregate housing supply elasticity is given by $\varepsilon = \psi_2/(1-\psi_2)$. The transition equation for the aggregate housing stock is given by

$$H = H_{-1}(1-\delta) + H^{\text{new}}. \tag{15}$$

3.4 Stationary equilibrium

The definition of model's stationary equilibrium is follows: The household state variables are given as $x \equiv (j, z, a_{-1}, h_{-1})$ which correspond to household's age, income, housing asset, and financial assets, respectively. Let $j \in \mathcal{J} \equiv \{1, ..., J\}$, $z \in \mathcal{Z} \equiv \{z_1, ..., z_7\}$, $a \in \mathcal{A} = \mathbb{R}$, $h \in \mathcal{H} = \{0, h_1, ..., h_7\}$. The household state space is then given by $\mathcal{X} \equiv \mathcal{J} \times \mathcal{Z} \times \mathcal{A} \times \mathcal{H}$. A stationary equilibrium consists of value functions $V^{\text{rent}}(x)$, $V^{\text{stay}}(x)$, $V^{\text{move}}(x)$, household decision rules $\{c(x), a(x), h(x), s(x)\}$, housing price p and rent q, an aggregate housing stock $\bar{H}$, and a stationary distribution on $\mathcal{X}$, μ, such that

1. Taking p and q as given, households optimize by solving (8)-(11) with value functions $\{V^{\text{rent}}(x), V^{\text{stay}}(x), V^{\text{move}}(x)\}$ and decision rules $\{c(x), a(x), h(x), s(x)\}$.

2. The aggregate housing stock satisfies (13) with $H = H_{-1} = \bar{H}$.

Table 3: Externally Chosen Parameter Values

	Parameter	Model value	Source
J	Length of life	19	–
r	Risk-free interest rate	0.093	Chen et al. (2020)
m	Mortgage premium	0.152	Chen et al. (2020)
σ	Coefficient of risk aversion	2	Standard value
γ_1	Downpayment rate for primary home	0.3	Standard practice in China
γ_2	Downpayment rate for investment home	0.5	Standard practice in China
ϕ^s	Trans. cost for seller	0.03	Chen et al. (2020)
δ	maintenance/depreciation cost	0.061	OECD
η_a	deterministic part of income	See text	CHFS 2015
ρ	Persistence of income shock	0.645	İmrohoroğlu and Zhao (2018)
σ_u	Std. dev. of income shock	0.253	İmrohoroğlu and Zhao (2018)
κ_a	Survival probability (age-dependent)	See text	World Bank
$T(Y)$	Taxation thresholds and proportions	See text	State Tax Admin.
ε	Housing supply elasticity	3	Wang et al. (2012)

3. The housing and rental markets clear:

$$\int_{\mathcal{X}} h(x)d\mu = \bar{H} \tag{16}$$

$$\int_{\mathcal{X}} (s(x) - h(x))d\mu = 0 \tag{17}$$

4. The distribution μ is stationary and consistent with household behavior.

4 Calibration

The calibration of the model is implemented in two stages. In the first stage, We choose the values of certain parameters without solving the model. In the second stage, We calibrate the remaining parameters by matching the model moments in the baseline steady state to their data counterparts computed from the China Household Finance Survey (CHFS) 2015 as closely as possible. We summarize parameters that are externally determined in Table 3. The parameters calibrated internally are summarized in Table 4 while the respective data and model moments are reported in Table 5.

4.1 Externally calibrated parameters

Demographic and preferences. The model period is set to 3 years. Households enter the economy at age 25 and exit at 79, which makes $J = 18$. The survival probabilities, κ_j, is taken from the World Health Organization's Global Health Observatory data repository. The coefficient of risk aversion parameter, σ is set at 2 which is a standard value in the macroeconomics literature.

Income. For age-dependent deterministic componenent of income, we use the measure of household gross income from the CHFS 2015 which is extracted using the forth-order polynomials in age. The idiosyncratic income process parameters, ρ and σ_u^2 are set at the annual values of 0.86 and 0.06 as suggested by İmrohoroğlu and Zhao (2018). These values are then converted into the three-year values. The income process is then discretized in to seven states states using the Rouwenhorst (1995) method. Note that the median income in the data over a three-year period is RMB 371,930 and we use this value to normalize variables in monetary units.

Housing. We discretize the state space for housing asset, h, into $K = 7$ discrete sizes, i.e. $h = \{0, h(1), h(2), ...h(7)\}$. Following the literature (see e.g. Floetotto et al. (2016) and Cho et al. (2022)), we introduce a minimum housing size for owner-occupied houses, $h_{min} = h(1)$, which is calibrated to match the homeownership rate for households under age 30. The largest housing size is chosen such that it is 5.3 times larger than the minimum size housing.

The transaction cost for selling a unit of housing, ϕ^s, is set to 3% consistent to the selling cost chosen in Chen et al. (2020). The downpayment requirements for owner-occupied and investment housing are set at 0.3 and 0.5, respectively. These values are consistent with the standard practice in China. The fixed cost of being a lanlord, ξ, is calibrated internally which is explained in the next section. The depreciation rate of housing asset is set to 2%. This follows from the depreciation rate estimated by the OECD.

Interest rates. The return on risk-free asset, r, is taken from Chen et al. (2020) which corresponds to the average benchmark deposit rate in 2010–2013. The mortgage premium, m, is also from Chen et al. (2020) where the authors estimate the mortgage rate from the CHFS. As such, the three-year values we assign for r and m are 9.3% and 15.2%, respectively.

Taxation. The income tax function exactly follows the progressivity of the Chinese personal income tax schedule. The parameters calibrated are income thresholds for each tax bracket $\bar{Y}_k$, the marginal tax rate τ_k, and the tax payment threshold for each

Table 4: Internally calibrated parameters

	Parameter	Value
λ	Utiliy premium for homeowners	1.20
h_{min}	Minimum housing size for owning	0.76
ϑ	Bequest intensity	5
ζ	Fixed cost of being a landlord	0.024
β	Discount factor (annual)	0.95
α	Share of non-durable consumption	0.63
ψ_1	Scale parameter for housing production	6.11

bracket, T_k. These are obtained from the State Tax Administration China.

Housing supply elasticity. Wang et al. (2012) estimate that the price elasticity of housing supply in China at the national level varies from 2.8 to 5.6. Relying upon their estimates, we set the housing supply elasticity in the model as 3 and this yields the scale parameter in the housing production function ψ_1 equals to 0.75.

4.2 Internally calibrated parameters

The remaining parameters are calibrated internally by jointly matching important moments from the data. The values for these parameters and the related moments are reported in Tables 4 and 5, respectively.

The utility premium for homeowners, λ, has a strong influence on the average homeownership rate for the economy. We therefore choose the value of λ to match the average homeownership rate. The CHFS 2015 survey suggests that the homeownership rate is 92%. With $\lambda = 1.20$, the average homeownership rate in the baseline model is 92%. The minimum housing size for owner-occupied housing h_{min} controls the homeownership rate for households in their younger ages. As such, we set h_{min} to match the homeownership rate under age 36. When we set $h_{min} = 0.76$, the model produces the homeownership rate for households under age 36 of 78% close to the rate observed from the CHFS survey which is 76%. Likewise, the bequest intensity is chosen to match the homeownership rate for households over age 70. In the baseline model, when the bequest intensity is set equal to 5, we obtain the homeownership rate over age 70 as 94% which is also close to its data counterpart. In the CHFS 2015 survey, the homeownership rate for such an age group is found to be 91%.

The fixed cost of being a landlord, ξ, is set to target the average landlord rate. Ac-

Table 5: Target moments

	Data	Model
Homeownership rate	0.92	0.92
Homeownership rate under 36	0.76	0.78
Homeownership rate over 70	0.91	0.94
Fraction of landlords	0.16	0.15
Rent to income ratio	0.38	0.42
Loan to value ratio	0.34	0.35
House value to income ratio	7.42	7.19

Notes: Data moments are computed from the CHFS 2015.

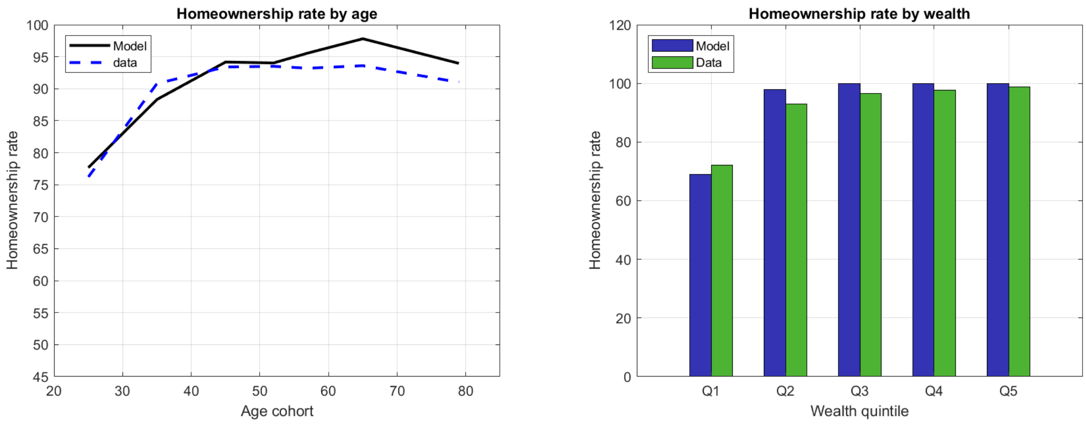


Figure 2: Homeownership rate: over the life-cycle (left); across wealth quintile (right)

cording to the CHFS 2015, the landlord rate is 16% and when we set $\xi = 0.024$, the landlord rate in the baseline model becomes 15%. The share of non-durable consumption, α, has a strong effect on the allcoation of resoures between non-durable consumption and housing services in the model, so we choose the rent-to-income ratio as the target moment. When $\alpha = 0.63$, we obtain the rent-to-income ratio in the model as 0.42 while its data value in the CHFS 2015 is 0.38. The discount factor, β, is calibrated to match the median loan-to-value ratio, which is 0.34 in the CHFS 2015. We set the annual value of $\beta = 0.95$ and obtain the median loan-to-value ratio in the model equal to 0.35. Finally, the scale parameter in housing production function, ψ_1, largely determines the total size of housing stock and it is calibrated to match the median housing wealth to income ratio.

Table 6: Untargeted moments

	Data (CHFS 2015)	Model
Median housing wealth-to-income ratio	5.51	5.70
Median loan-to-income ratio	2.42	2.60
Price-to-rent ratio (median-to-median)	43.4	46.8

4.3 Model fit

Homeownership rate over the life-cycle and across wealth. The left panel in Figure 2 displays the life-cycle profile of the homeownership rate. The homeownership rates in the model and data are depicted with the black solid and blue dashed line, respectively. As shown in the figure, the homeownership profile in the model matches well the life-cycle profile observed in the data although it slightly overestimates the rates for older cohorts. The homeownership rate starts around 78% and then increases to over 90% at the age of 50. The model also generates plausible homeowner rates across wealth quintile as shown in the right panel of Figure 2. The increasing patterns with wealth are broadly consistent with that observed in the CHFS.

Moments not targeted in calibration. In Table 6, we report several other key moments that were not targeted in calibration, including median housing wealth-to-income ratio, median loan-to-income ratio, as well as the price-to-rent ratio. Encouragingly, the model produces moments similar to that computed from the CHFS. The median housing wealth-to-income ratio generated by the mode is 5.70, compared to 5.51 in the CHFS. The median loan-to-income ratio is also matched closely to the data where the model value is 2.60 while the information computed is 2.42. Finally, the price-to-rent ratio, an equilibrium object in our model, is similar to that observed from the CHFS. The price-to-rent ratio in the model and the data are 46.8 and 43.4, respectively.

Overall, it appears that the calibrated model discussed in Sections 3 and 4 provides a reasonable laboratory to conduct the normative implications of introducing property taxes in the Chinese housing market.

5 Results

This section presents the main results. With the calibrated baseline model, we conduct the following counterfactual policy experiments:

1. Universal property tax imposed on every homeowner without redistribution;
2. Universal property tax imposed on every homeowner with redistribution;
3. Targeted property tax imposed on landlords without redistribution; and
4. Targeted property tax imposed on landlords with redistribution.

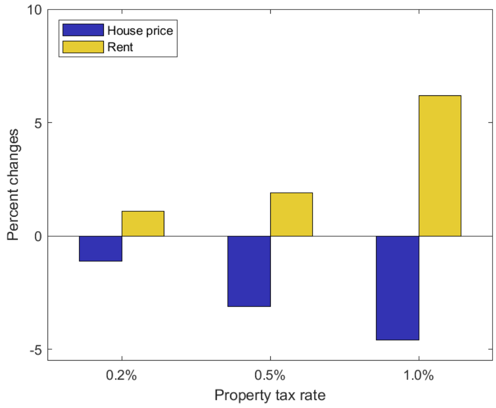
For each experiment, we simulate counterfactual steady sates with the annual property tax rates of 0.2%, 0.5%, and 1.0%.[6] In Section 5.2, we extend the analysis to transition dynamics.

5.1 Steady state outcomes

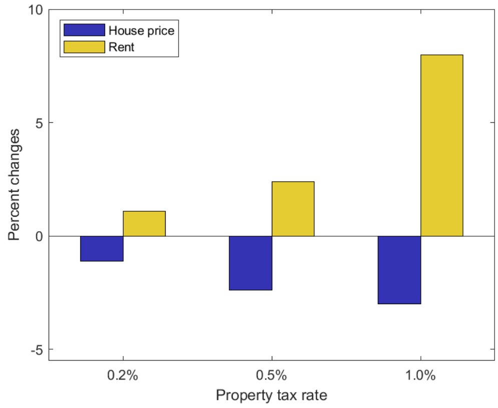
Effects on house price and rent. Figure 3 presents the percentage changes in house price and rent depicted in bar graphs. The figures in the top panel show the changes under the universal property tax. When property tax is imposed on every homeowner without redistribution (top left panel), we find that the house price decreases by the range between 1.1% and 4.6%. In contrast, the rent increases by 1.1%, 1.9% or 6.2% for the property tax rates of 0.2%, 0.5%, and 1.0%, respectively. When the government redistributes additional revenue raised from property tax, the changes to house prices and rents are similar, as depicted in Panel (b) in Figure 3. Note that the changes in the house price and rent are monotonic in the property tax rate.

Figures in the bottom panel show the house price and rent changes for the cases of targeted property tax. A key difference from universal property tax is that the targeted property tax results in much smaller declines in house prices but larger increases in rents. When property taxes are imposed only upon investment housing, the house prices only decrease by around 1% in both experiments. The declines are similar across the different rates of property taxes. We view that the small and quantitatively insignificant drop in house prices aligns with our empirical finding presented in Section 2. On

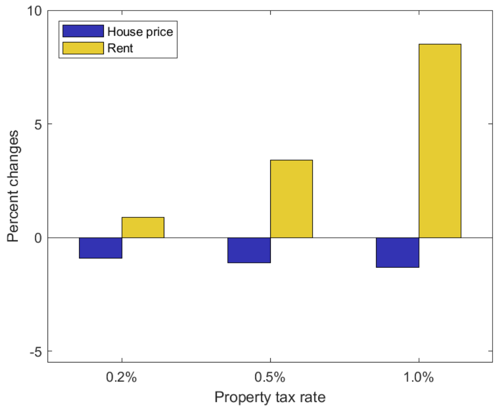
[6]Note that these counterfactual policy experiments are similar to what was conducted in Zhu and Dale-Johnson (2020).



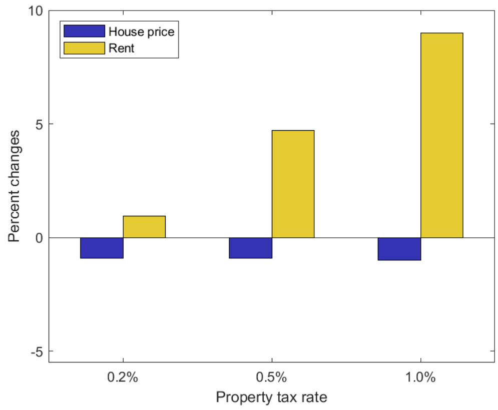
(a) Universal property tax: no redistribution



(b) Universal property tax: with redistribution



(c) Targeted property tax: no redistribution



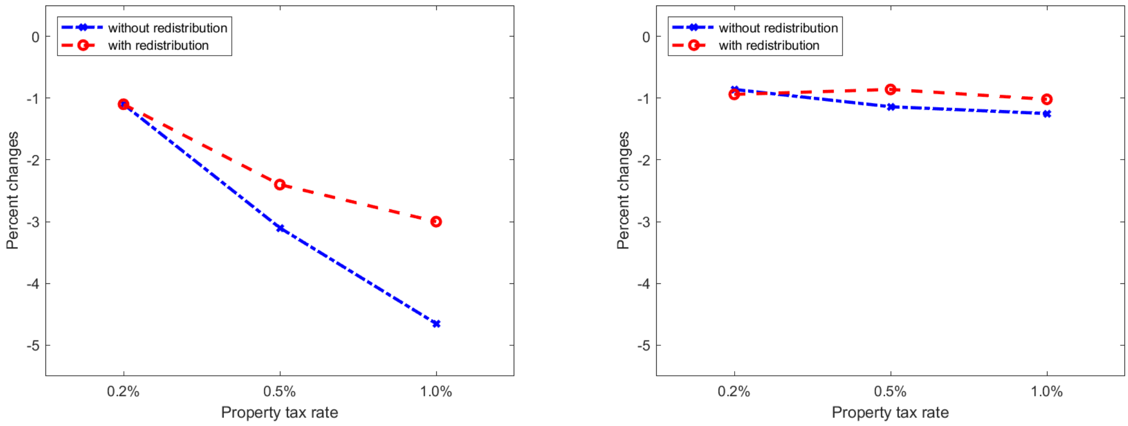
(d) Targeted property tax: with redistribution

Figure 3: Percentage changes in house prices and rents

the other hand, the rent increases quite dramatically, up to 9% when property tax of 1% is applied to houses rented out.

Why do house prices decrease and rents increase when property taxes are imposed? Imposing taxes on housing assets increase the cost of homeownership, reducing housing demand along the intensive margin. The percentage declines in the amount of housing assets purchased for owner-occupied purposes (intensive margin of homeownership) are displayed in Figure 4. Panel (a) shows that, in the case of universal property tax, the changes in the demand for housing assets decrease relatively significantly when additional revenue is not distributed to households. The blue line on the left panel shows that the total housing demand falls from 1.1% (with the tax rate of 0.2%) to 4.6% (with the tax rate of 1%). When additional tax revenue is redistributed, the decline in housing demand is shallower, suggesting that lump-sum transfers partly help households maintain their housing demand. This is also reflected in Panels (a) and (b) of Figure 3 such that the fall in house prices is smaller when tax revenue is redistributed. Panel (b) in Figure 4 suggests that, when property taxes are targeted, the decline in housing demand moves around 1.0% across all three tax rates considered and the levels of the decline are similar between the two redistributive policies. Under the targeted reforms, households invest less in the housing assets for renting, but instead, many of them switch their existing housing assets for owner-occupied purposes. As a result, the fall in total housing demand is smaller, which translates to a smaller decline in house prices.

Demand for investment housing. Universal and targeted property taxes generate different implications for investment activities in the housing markets. We find that the demand for investment housing is relatively unaffected in the universal property tax case. Although introducing property tax increases the ongoing cost associated with housing investment, the rise in the equilibrium rent, driven by the increase in rental demand, maintains the level of investment housing in the counterfactual steady states. In contrast, targeted property taxation significantly reduces housing investment demand. Our simulation suggests that the demand for investment houses decreases over 40% (20%) when the 1% (0.5%) tax rate is implemented. Taxing investment houses reduces housing investment activities as it increases the cost of owning investment properties. This reduces the supply of rental housing and therefore moves the rent upward. Unlike universal taxation, the rise in rent leads some renters to become homeowners, further



(a) Universal property tax (b) Targeted property tax

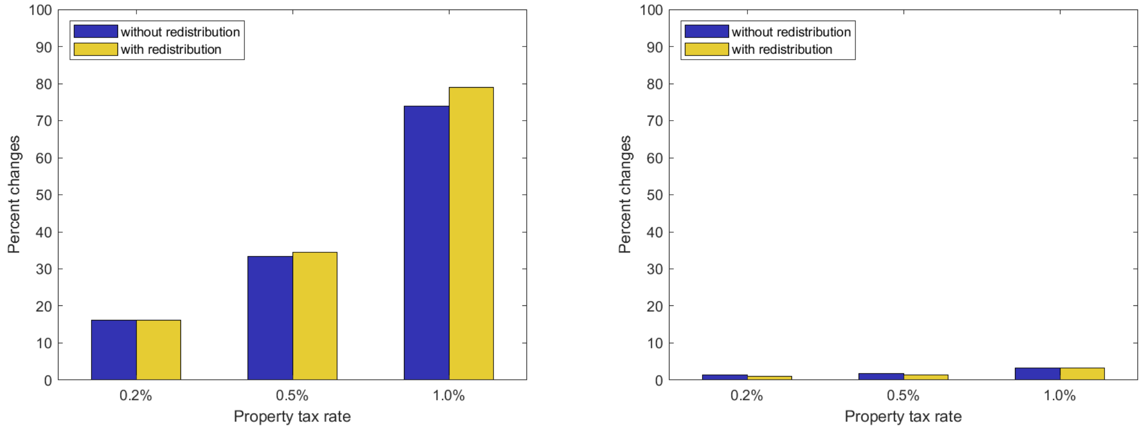
Figure 4: Percentage change in housing demand

reducing the equilibrium quantity of rental houses traded in the rental market.

Average tax rates. Introducing property tax leads to a rise in the tax burden borne by households. However, universal and targeted approaches yield significantly different levels of the average tax rate. Panel (a) in Figure 5 shows that imposing property taxes on every homeowner increases the median value of the average tax rate ranging from 16% to 79%. This suggests that the government can collect a considerable amount of additional revenue through property tax. Over 90% of households own a home in China, and such a high homeownership rate is sustained even if owning a house is taxed. In contrast, the rise in the average tax rate is minimal when the tax reform is targeted. As shown in Panel (b), the median value of the average tax rate increases at most by 3.2%. In this case, the impacts upon households' tax burden and government revenue are more negligible because the policy reform involves taxation on investment properties where such properties only account for 10% of the total housing stock in the economy. As we will see in the next section, lump-sum transfers financed from property taxes play an important role in understanding the welfare implications.

5.2 Steady state welfare analysis

Following the literature, we use the notion of ex-ante consumption equivalent variation, *cev*, defined as the percentage change in non-durable consumption that equates the discounted expected sum of lifetime utility under the baseline economy to that under a counterfactual economy for newly born households. Formally, *cev* is calculated



(a) Universal property tax

(b) Targeted property tax

Figure 5: Percentage change in average tax rate

from the following equation:

$$cev = \left[\frac{V^{cf}(x')}{V^{bl}(x')} \right]^{\frac{1}{\alpha(1-\sigma)}} - 1 \tag{18}$$

where $V^{bl}(x')$ and $V^{cf}(x')$ are the expected life-time utility for newborn households with state vector $x \equiv (1, z, 0, 0)$ in the baseline and counterfactual economies, respectively.

Table 7 reports *cev* in all four experiments. Interestingly, the steady state welfare results depend crucially on whether a policy reform involves the redistribution of additional government revenue financed from taxing homeownership, in particular when the tax is imposed upon all homeowners. As reported in the top panel of Table 7, in the universal property tax case, newborn households are worse off when additional revenue is not redistributed. The size of welfare loss in the case of universal taxes varies from -0.9% to -4.8%. Note that the size of welfare loss decreases in the rate of property tax. Although households start their life-cycle as renters, most of them become homeowners in the later stages in which they need to pay property tax under the reformed economy. Furthermore, those households who would remain as renters suffer from the higher rental rate. However, households would prefer to be born into an economy in which the property tax revenue is redistributed to households where welfare gain varies from 1.3% to 4.7%. While the rise in rent would hurt newborn households in the earlier stages of their life-cycle, they benefit more from lump-sum transfers. Moreover, lower house prices make it easier for households to become homeowners as it lowers the amount of downpayment required to take mortgages.

Table 7: Steady state welfare (ex-ante *cev* in %)

	0.2%	**0.5%**	**1.0%**	**0.2%**	**0.5%**	**1.0%**
	Universal Property Taxes					
	w/o redistribution			with redistribution		
Ex-ante *cev*	−0.89%	−1.81%	−4.78%	1.27%	3.01%	4.71%
	Targeted Property Taxes					
	w/o redistribution			with redistribution		
Ex-ante *cev*	0.33%	0.04%	−0.71%	0.49%	0.95%	−0.29%

The bottom panel in Table 7 shows that newborn households are generally better off when the tax is only imposed on investment properties, except for the case when the property tax is imposed at 1.0% where a sharp fall in housing investment increases the rent. The welfare gain arises from lower house prices which outweighs any possible losses incurred from the rise in rents. In particular, lower house prices would benefit the first-time homebuyers who are typically credit-constrained. Again, when the tax revenue is redistributed, we find that the improvements in welfare are more significant.

5.3 Transition dynamics

In this section, we extend the analysis to transition dynamics of the economy after the unexpected permanent introduction of property tax. An analysis of transition dynamics informs us immediate impacts of a tax reform on the equilibrium house prices and rents, as well as allows us to identify winners and losers in a reformed economy. Here, we examine the normative implications of potential policy changes by focusing on universal property tax with and without redistribution scenarios.

Dynamics of house prices and rents. Figure 6 plots the dynamics of house prices (left panel) and rents (right panel) when the property tax rate of 0.5% is introduced, and the tax revenue is redistributed. The transitions to the new steady state have taken place for at least 40 years since the reform is implemented. Upon implementation, house prices immediately decrease by 1.4% (57% of the total decline) and further drop by another 1.8% over the first 15 years of transitions. After that, house prices gradually converge to the new steady state level. On the other hand, rents increased by 3.1% in the first period since the reform took place. They then increase by another 0.4% in the following year and converge to the new steady state level.

The immediate changes in house prices and rents in response to the tax reform

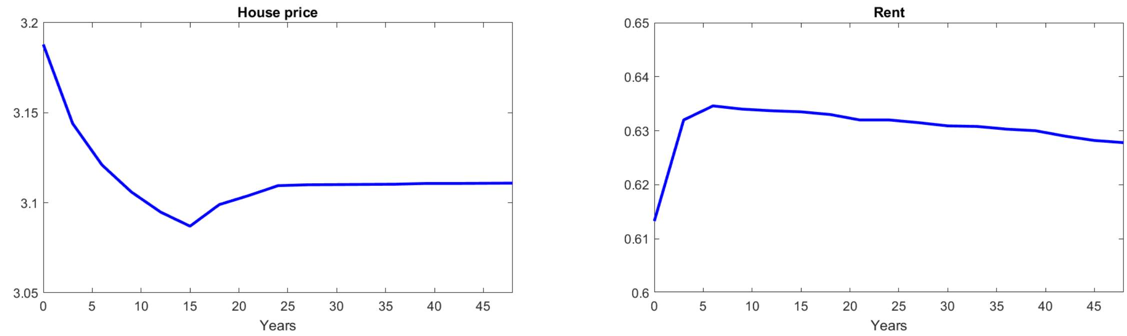
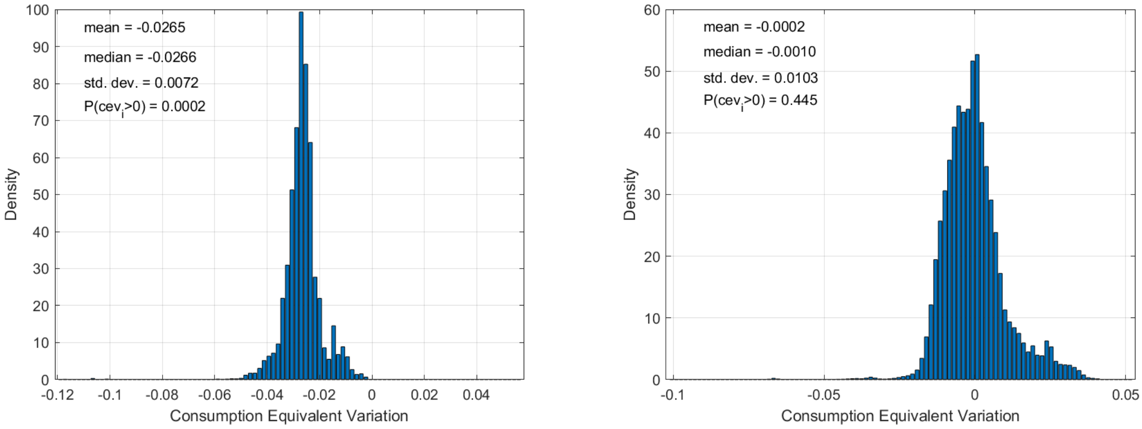


Figure 6: Transition paths:house prices and rents

appear large. When property taxes are suddenly introduced, households at the margin of becoming homeowners optimally choose to continue renting. Similarly, households who barely afford homeownership may decide to become renters as the cost of homeownership increases. As a result, the demand for rental housing increases, which pushes up the rent. This mechanism is also reflected in the homeownership rate, which decreases substantially by 7 percentage points following the implementation of property tax.

Aggregate welfare along transitions. We examine the welfare gains and losses for households who are heterogeneous in terms of the model's state vector - risk-free asset (a), housing asset (h), age (j), and income (z) in the period when a property tax is implemented. Therefore, we can capture ex-post consumption equivalent variation, cev_i, for every household that survived at the time of the reform.

Figure 7 plots the distribution of cev_i across households who are survived in the period when property taxes are imposed upon all homeowners. First, focusing on the case without redistribution in which its distribution of cev_i is depicted on the left panel, the introduction of property tax leads to a welfare loss of 2.7%, and almost every household experiences loss in their welfare. As pointed out in the steady state welfare analysis, there is an overall welfare loss because over 90% of households become subject to property taxes. In addition, homeowners would also lose from the fall in house prices at the time of the reform. On the right panel, we plot the distribution of cev_i when the additional government revenue is redistributed. Unsurprisingly, redistribution shifts the whole distribution to the right, increasing a median cev_i to the welfare neutral state. Moreover, the percentage of surviving households who experience a welfare gain increases to 45%. This also confirms the steady state results where we showed



(a) Without redistribution

(b) With redistribution

Figure 7: Distributions of cev_i

that the lump-sum transfers are crucial for welfare gains from the policy reform.

Heterogeneous welfare effects. As we have seen in Figure 7, the welfare effects vary significantly across households. We thus quantify welfare effects along the dimensions of households' homeownership status, age, and wealth to identify who are the winners and losers of the change in the tax system. In Table 8, we compare welfare results for households with different housing tenure statuses. While most homeowners are worse off regardless of redistribution, almost every renter experiences a sizable welfare gain of 2% in the redistribution case. Renters typically earn a lower income, which benefits proportionately more from lump-sum transfers. Homeowners, in contrast, lose even if they receive lump-sum transfers mainly because of the additional tax burden and the fall in the value of housing assets. As expected, welfare loss increases with the number of housing assets held.

Next, we examine the welfare results across the age groups stratified into young (under age 36), middle-aged (age between 37-54), and old (over age 55). The results reported in Table 9 deliver two observations. First, the variation in welfare loss across the age groups does not appear heterogeneous when the additional tax revenue is not redistributed. As we have seen in all households case, the median welfare loss is around 2.5% although households in the young group exhibit a slightly lower loss level. However, the effects vary significantly when households receive lump-sum transfers across the age. While we find that over 80% of households under age 36 report a welfare gain, households in the middle age group are shown to be indifferent between the two

Table 8: Welfare along transitions by housing tenure status

Age group	**without redistribution** mean	median	$P(cev_i) > 0$	**with redistribution** mean	median	$P(cev_i) > 0$
Renters	-0.013	-0.014	0.183	0.023	0.024	1
Owner-occupiers	-0.028	-0.027	0	-0.002	-0.002	0.398
Landlords	-0.033	-0.032	0	-0.008	-0.008	0.155

Table 9: Welfare along transitions by age group

Age group	**without redistribution** mean	median	$P(cev_i) > 0$	**with redistribution** mean	median	$P(cev_i) > 0$
Young (≤ 36)	-0.022	-0.023	0.000	0.007	0.005	0.813
Middle ($37-54$)	-0.027	-0.027	0.000	0.001	0.000	0.544
Old (≥ 55)	-0.028	-0.028	0.000	-0.005	-0.006	0.184

policy regimes, and older households tend to lose. The mechanism behind this heterogeneous welfare result across age groups is closely tied up with the homeownership status of households. Younger households tend to be renters or first-time homeowners who live in relatively smaller houses. Therefore for these households, the benefit from lump-sum transfers outweighs an increase in costs associated with property tax and the decline (rise) of house prices (rents). The opposite is true for the case of older households. Because they typically hold more housing assets, their tax burden is larger and hence prefer the system where homeownership is not taxed.

Finally, we show in Table 10 that households who tend to be poorer benefit the most (or lose the least in the without redistribution case) and wealthier households lose. This again highlights the role of redistribution. Poorer households tend to benefit more from lump-sum transfers such that the policy reform would lead to significant redistributive consequences reallocating resources from the rich to the poor.

Table 10: Welfare along transitions by wealth group

Age group	**without redistribution** mean	median	$P(cev_i) > 0$	**with redistribution** mean	median	$P(cev_i) > 0$
Bottom [0,25)	-0.021	-0.022	0.000	0.012	0.009	0.941
Middle [25,75]	-0.028	-0.027	0.000	-0.002	-0.001	0.394
Top (75,100]	-0.029	-0.028	0.000	-0.009	-0.009	0

Table 11: Revenue neutral experiment: 0.5% universal tax

	Baseline	**Univ. 0.5%**	**Rev. neutral**
Price	3.188	3.088	3.104
Rent	0.613	0.664	0.664
Homeownership rate	0.919	0.897	0.891
Housing investment	1.000	0.944	0.950
Govt. tax revenue	1.000	1.510	1.000
Ex-ante *cev*	–	-1.81%	1.84%

5.4 Revenue neutral experiment

This section explores the steady state effects of property taxes in a revenue neutral manner. We achieve revenue neutrality of the policy reform by reducing the marginal income tax rates τ_k. The last column in Table 11 reports the steady state outcome when a universal property tax rate of 0.5% is implemented. The simulation suggests that the universal property tax of 0.5% per annum would increase the government revenue relative to income tax by over 50%. Therefore, the marginal tax rates had to be reduced significantly to preserve revenue neutrality.

The rise in household after-tax income leads to a slightly smaller reduction in house prices relative to the non-revenue neutral experiment reported in the second column of Table 11. While the effects on rents, homeownership rate, and the level of housing investment are similar to the non-revenue neutral case, the implications on welfare are significantly different. The revenue-neutral experiment leads to a welfare gain of 1.84% for newborn households. This suggests that the benefit of the increase in disposable income outweighs the cost associated with property tax once newborn households become homeowners. More precisely, the rise in disposable income plays a similar role as a lump-sum transfer by compensating newborn households from the higher rents and the increased burden of property taxes.

6 Conclusion

This paper provides quantitative evaluations of introducing property taxes in China using an equilibrium OLG model with heterogeneous agents. Introducing universal property taxes decreases house prices and increases rents. When tax reform is targeted to investment properties, the decline in house prices becomes quantitatively insignificant, but it triggers a large drop in housing investment. We highlight that the negligible effect on house prices is consistent with our empirical analysis, which focuses on the targeted property tax reform in Shanghai.

Our welfare analysis suggests that households prefer to be born in an economy with a property tax when additional tax revenue is redistributed as a lump-sum transfer. The welfare gains arise from lower house prices and redistribution of extra income. When we examine transition dynamics, we find that less than the majority of households favor the reform. In general, renters, poorer and younger households, become better off while homeowners and older households who own many housing assets tend to be worse off.

Our model focuses on a stationary equilibrium where house prices are constant at a steady state. Given the long boom in the Chinese housing market, it may be natural to consider the environments with endogenous house price growth by introducing the aggregate house price belief and credit shocks as in Kaplan, Mitman and Violante (2020). We also abstract from local public goods, which is often discussed in property taxation in urban literature. We view that relaxing the assumption of redistribution in a lump-sum fashion and featuring the local public goods is another important future research agenda in evaluating property tax reforms in the Chinese housing market.

References

Bai, ChongEn, Qi Li, and Min Ouyang, "Property taxes and home prices: A tale of two cities," *Journal of Econometrics*, 2014, *180* (1), 1–15.

Cao, Jing and Wenhao Hu, "A microsimulation of property tax policy in China," *Journal of Housing Economics*, 2016, *33*, 128–142.

Chambers, Matthew, Carlos Garriga, and Don E. Schlagenhauf, "Housing policy and the progressivity of income taxation," *Journal of Monetary Economics*, November 2009, *56* (8), 1116–1134.

Chen, Kaiji, Qing Wang, Tong Xu, and Tao Zha, "Aggregate and Distributional Impacts of LTV Policy: Evidence from China's Micro Data," Working Paper 28092, National Bureau of Economic Research November 2020.

Cho, Yunho, Shuyun Li, and Lawrence Uren, "Investment Housing Tax Concessions and Welfare: Evidence from Australia," Technical Report 2022.

Du, Zaichao and Lin Zhang, "Home-purchase restriction, property tax and housing price in China: A counterfactual analysis," *Journal of Econometrics*, 2015, *188* (2), 558–568.

Elinder, Mikael and Lovisa Persson, "House price responses to a national property tax reform," *Journal of Economic Behavior & Organization*, 2017, *144*, 18–39.

Fang, Hanming, Quanlin Gu, Wei Xiong, and Li-An Zhou, "Demystifying the Chinese housing boom," *NBER macroeconomics annual*, 2016, *30* (1), 105–166.

Fischel, William A, "Property taxation and the Tiebout model: evidence for the benefit view from zoning and voting," *Journal of Economic Literature*, 1992, *30*, 171–177.

Floetotto, Max, Michael Kirker, and Johannes Stroebel, "Government intervention in the housing market: Who wins, who loses?," *Journal of Monetary Economics*, 2016, *80*, 106–123.

Hamilton, Bruce W, "The effects of property taxes and local public spending on property values: A theoretical comment," *Journal of Political Economy*, 1976, *84* (3), 647–650.

İmrohoroğlu, Ayşe and Kai Zhao, "Intergenerational transfers and Chinaâs social security reform," *The Journal of the Economics of Ageing*, 2018, *11*, 62–70.

Kaplan, Greg, Kurt Mitman, and Gianluca Violante, "The Housing Boom and Bust: Model Meets Evidence," *Journal of Political Economy*, 2020, *128* (9), 3285–3345.

Lang, Kevin and Tianlun Jian, "Property taxes and property values: Evidence from Proposition 212," *Journal of Urban Economics*, 2004, *55* (3), 439–457.

Lu, Zhentong, Sisi Zhang, and Jian Hong, "Examining the impact of home purchase restrictions on China's housing market," *China Economic Review*, 2021, *67*, 101620.

Netzer, Dick et al., "Economics of the property tax.," *Economics of the property tax.*, 1966.

Oates, Wallace E, "The effects of property taxes and local public spending on property values: An empirical study of tax capitalization and the Tiebout hypothesis," *Journal of political economy*, 1969, *77* (6), 957–971.

Poterba, James M, "Taxation and Housing: Old Questions, New Answers," *The American Economic Review*, 1992, *82* (2), 237–242.

Rosen, Harvey S and David J Fullerton, "A note on local tax rates, public benefit levels, and property values," *Journal of Political Economy*, 1977, *85* (2), 433–440.

Rouwenhorst, Geert, *Asset pricing implications of equilibrium business cycle models*, Princeton University Press, Chapter 10., 1995.

Simon, Herbert A, "The incidence of a tax on urban real property," *The Quarterly Journal of Economics*, 1943, *57* (3), 398–420.

Sommer, Kamila and Paul Sullivan, "Implications of US tax policy for house prices, rents, and homeownership," *American Economic Review*, 2018, *108* (2), 241–74.

Wang, Songtao, Su Han Chan, and Bohua Xu, "The estimation and determinants of the price elasticity of housing supply: Evidence from China," *Journal of Real Estate Research*, 2012, *34* (3), 311–344.

Yinger, John, Howard S Bloom, and Axel Boersch-Supan, *Property taxes and house values: The theory and estimation of intrajurisdictional property tax capitalization*, Elsevier, 2016.

Zheng, Huanhuan and Qingyong Zhang, "Property Tax in China: Is It Effective in Curbing Housing Price?," *Economics Bulletin*, 2013, *33* (4), 2465–2474.

Zhu, Guozhong and David Dale-Johnson, "Transition to the property tax in China: A dynamic general equilibrium analysis," *Journal of Urban Economics*, 2020, *115*, 103214.

Appendix for Online Publication

A Computational details

In this section of Appendix we provide details on computing the stationary equilibrium and transitional dynamics.

State and control variables. The state of a household in every period is determined by five state vectors including savings s_{-1}, housing asset h_{-1} obtained in previous period, the realisations of income shock z, and age j in current period. The control variables include savings s, housing asset h, housing services $\tilde{h}$, and non-durable consumption c. We discretize the housing asset into seven discrete sizes, $h \in \{0, h_{\min}, ..., h(7)\}$. The housing grids are set such that they are finer at smaller house sizes. Note that there is a minimum size of housing asset which is calibrated internally as explained in the main text. While the housing services grid for homeowners is the same as the housing asset grid, we allow renters to choose housing services smaller than the minimum housing size. More precisely, housing services grid for renters are given by $h^{\text{rent}} \in \{h^{\text{rent}}(1), h^{\text{rent}}(2), h^{\text{rent}}(3), h(1), ..., h(10)\}$, with $h^{\text{rent}}(1) = h(1)/3$, $h^{\text{rent}}(2) = h(1)/2$ and $h^{\text{rent}}(3) = 3h(1)/4$. The risk-free asset is discretized into 40 grids. Households are allowed to choose the maximum possible borrowing for each housing size, $a = -(1-\theta_1)ps + (1-\theta_2)p(h-s)$. Between a pair of these maximum borrowing points, we allow for four equally spaced grids so that it gives more flexibility in choosing the size of mortgages. For positive values of s, we employ a power grid where the maximum value of the risk-free asset is capped at RMB 500,000.

Computation of stationary equilibrium. The stationary equilibrium is computed using a constant house price p and a constant rent q. We start first by guessing these two equilibrium objects. Given p and q, we compute the optimal policy and value functions for the final period $A = 19$. Once the optimal policy and value functions for the final period is obtained, we solve the household problem for all other periods using backward induction. Once we obtain policy functions, we simulate the economy with 10,000 households until a stationary distribution of households over the state space is achieved. Each household starts their life cycle with zero savings and housing assets. In the beginning of each period, households draw income shocks and make rent/stay/move decisions, choose non-durable consumption, housing services, housing stock, and saving/borrowing. At the end of each period, households receive an age-dependent death shock governed by the survival probabilities conditional on age.

Households exit the economy with certainty after 19 periods. If a household survives, it continues to make choices and we simulate the optimal behavior of these households forward using the computed policy functions. If a household dies, it is replaced by a newly born household who starts its life cycle from the following period. The stationary distribution is obtained when the age distribution, average savings, average income and average housing asset across 10,000 households are all stabilized. We iterate the whole process until the market clearing p and q that clear housing and rental markets are found.

Computation of transition dynamics. Define a vector $w_t = [p_t, q_t]$. Recall that μ_t captures the ergodic distribution in the stationary equilibrium at time t. The baseline economy is when $t = 0$ and the steady state in the counterfactual economy corresponds to $t = T$. Solving for the transition dynamics requires us to find the transition paths of the equilibrium house price and rent for each t. We employ an algorithm from Cho et al. (2022) which is summarised as below:

Algorithm:

1. Choose the length of the transition phase, T. Choosing a large number increases the computational burden. We choose $T = 18$, i.e., the transition to the new steady state finishes within 54 years.

2. Guess a sequence of housing prices and rents $\{p_t, q_t\}$ for $t = 1, ..., T-1$. Note that $\{p_T, q_T\}$ are set to the housing price and rent in the steady state of the counterfactual economy.

3. Given the guessed sequence of $\{p_t, q_t\}$, solve backward for the value function V_t (taking as given V_{t+1}), starting from $T-1$. Note that V_T is the steady state value function for the counterfactual economy, which is known.

4. Given the value functions $V_t, t = 1, 2, \ldots, T$, find the market clearing housing prices and rents for each period $t = 1, 2, \ldots, T-1$. The computation for finding

the market clearing prices in period t follows the procedure described earlier for computing the equilibrium prices in a stationary equilibrium but the simulation only involves simulating households one period forward from the distribution in $t-1$ (μ_0 is the stationary distribution in the baseline economy). This gives a sequence of market clearing prices $\{\hat{p}_t, \hat{q}_t\}$ and corresponding distribution $\hat{\mu}_t$ for each period $t = 1, ..., T-1$.

5. Compare $\{\hat{p}_t, \hat{q}_t\}$ and $\{p_t, q_t\}$. If they differ, go back to Step 2 to update the guessed price sequence and repeat Step 3 and 4, until convergence in prices is achieved.

6. Calculate the distribution in period T, $\hat{\mu}_T$, and compare it with the stationary distribution in the counterfactual economy. Increase T if the two distributions differ.