# Housing Privatization as Intergenerational Redistribution

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# Motivation

- Many emerging economies, such as Korea, Taiwan, and other East Asian Miracle economies, had experienced rapid growth of wage incomes, followed by an eventual slowdown;
- China's economic growth miracle seems to be slowing down significantly as well.

# China’s GDP Per Capita: 1993-2022

# Question of the Paper

- The fast economic growth in China over the recent decades has disproportionally benefited those working-age cohorts more than those old-age cohorts;
- **General Question:** How should the re-distributive policy be designed such that those old-age cohorts can also enjoy the benefits?
- **Main Idea:** subsidized housing purchase during housing market privatization plays the role of inter-generational redistribution.
- **Main Channel:** Initial generations may sell their houses later on to reap the *capital gains* to finance larger houses and consumption.

# Asset Price vs. PAYGO as Intergenerational Transfer

- Housing prices, in general asset prices, incorporate future growth expectations;
- Initial generations, i.e. generations at the 1994 public housing reform, received the IPO of "Chinese housing", which was then "floated" in 1998 when residential mortgages were introduced into the commercial housing market in China
- Housing prices grew at about 10% per year from 1998 to 2018, followed by housing market corrections

# Asset Price vs. PAYGO as Intergenerational Transfer

- To transfer wealth from future generations to the initial generations in the 1990s via PAYGO, very generous replacement rates are needed, but it will be financially unsustainable when the growth rates slow down eventually.
- Problem exacerbated by the increasing dependency ratio due to population aging.
- In contrast, asset prices as intergenerational redistribution *automatically* stop when growth slows down.
- Alternative: indexing pension payment to prevailing wages **and** old-age dependency ratio.

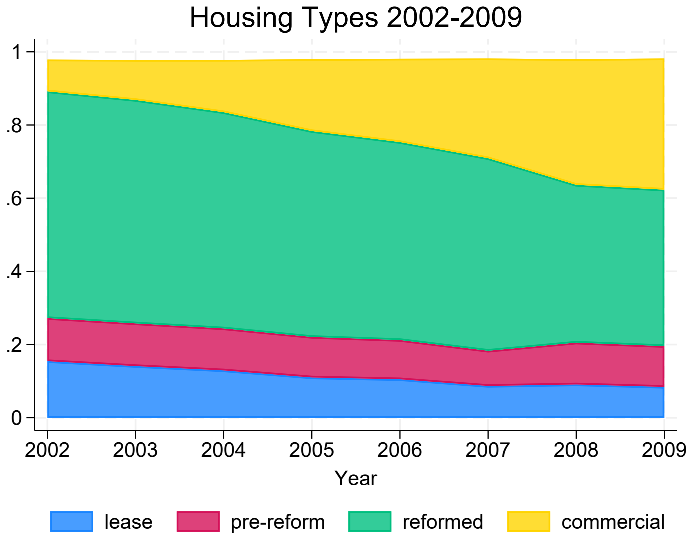
# What We Do

- Develop a quantitative general equilibrium framework to explore the distributional impacts and welfare implications from the housing privatization reform.
  - We incorporate the two major housing market privatization reforms during 1994-2000;
  - Model is calibrated into the Chinese economy during 1994-2014;
- Counterfactual analysis:
  - Evaluate welfare gain/loss for both those born before and after the reform;
  - Evaluate the role of housing privatization reform;
  - Compare housing reform to an alternative pension reform;
  - Evaluate the budgetary consequences of an unexpected slowdown under the housing reform vs. under an alternative pension reform.

# Literature

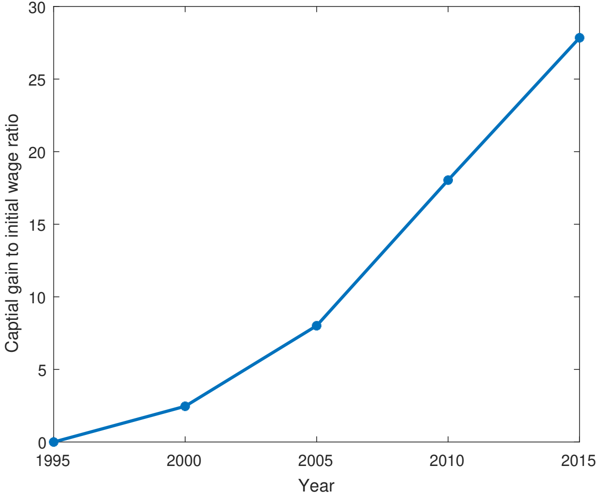
- Role of asset prices in intergenerational redistribution: Glover, Healthcote, Krueger and Rios-Rull (2020, JPE)
- China's housing reforms and housing booms: Wang (AER, 2011), Logan, Fang and Zhang (Housing Studies, 2010), Fang, Gu, Xiong and Zhou (NBER Marco Annual, 2016), Chen and Wen (AEJ: Macro, 2017)
- Social security reforms in China: Song, Storelessten, Wang and Zilibotti (AEJ: Macro, 2015)

# Housing Types in the Chinese Housing Market

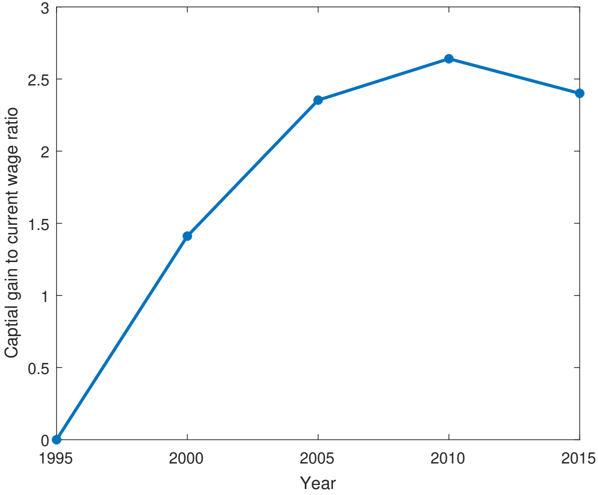


# Capital Gains Relative to Initial Wages

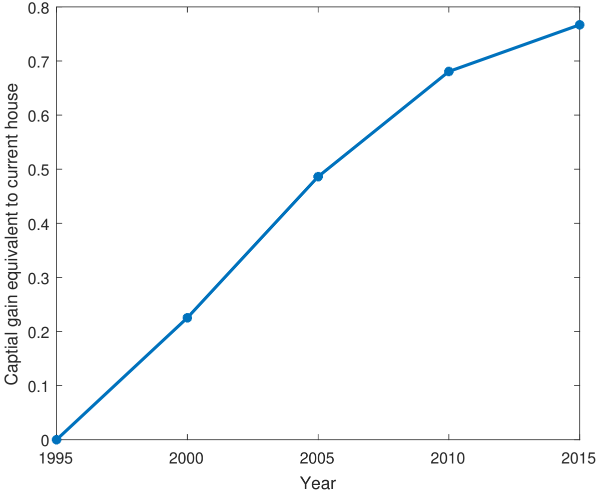
Suppose a household bought a house of 30 square meters in 1995.



# Capital Gains Relative to Current Wages



# Capital Gains Relative to Current House Prices



# Demographics

- Each period a continuum of household is born; population grows at a exogenous rate $n_t$.
- Households live a maximum $J$ periods. They are active as workers until age $J_w$.
- All households face a probability $S_j = \prod_{k=1}^{j} \psi_k$ of surviving up to age $j$, and $\psi_k$ is the conditional survival probability from age $k-1$ to age $k$.
- The fraction of households of age $j \in \{2, ..., J\}$ at the calendar time $t$ evolves according to
$$\mu_{t,j} = \frac{\psi_j}{1+n_t} \mu_{t-1,j-1},$$

# Preferences

For a household born at period $\tilde{t}$, his/her lifetime utility is

$$U_{\tilde{t}} = \sum_{j=1}^{J} \beta^{j-1} S_j \left\{ \log(c_{\tilde{t}+j-1,j}) + \phi \log(s_{\tilde{t}+j-1,j} - \underline{s}) + \iota \log(\mathbf{b}_{\tilde{t}+j-1,j} + \underline{\mathbf{b}}) \right\}$$

where

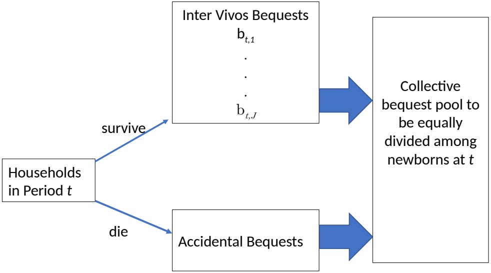
- $\underline{s} > 0$ is subsistence housing services.
- $\iota \log(\mathbf{b}_{\tilde{t}+j-1,j} + \underline{\mathbf{b}})$ denotes the *warm-glow* utility from leaving the *inter vivos* bequest to children.
- $\underline{\mathbf{b}} > 0$.

- For simplicity, parents do not obtain utility from accidental bequests.

# Inter Vivos and Accidental Bequests

Total collectible bequests in period $t$ include both inter vivos bequest and accidental bequests. They are transferred to the newborn equally by the government.

$$\sum_{j=1}^{J} \mathbf{b}_{t+1-j,j} S_j N_{t,j} + (1 - S_j) N_{t,j} NW_{t,j},$$



# Income Process

- Household $i$'s after-tax income in period $t$ at age $j$ is

$$y_{t,j}^i = \begin{cases} (1 - \tau^{ss} - \tau) w_t e_{t,j}^i & \text{for } j \leq J_w \\ b_{t,j}^i & \text{for } j > J_w \end{cases}$$

where $w_t$ is the wage rate per unit of efficiency labor supply; and the efficiency units are given by:

$$e_{t,j}^i = \lambda^i \varepsilon_j z_t^i \epsilon_t^i,$$

- $\lambda^i$ is skill-specific component
- $\varepsilon_j$ is life-cycle income profile
- $z_{t,j}$ is a persistent shock that follows transitions $\pi(z_{t+1}|z_t)$
- $\epsilon_{t,j}$ is a transitory shock drawn from log-normal distribution

# Social Security

- Social security benefit each period is determined as

$$b^i_{t,j} = \theta[\omega y^i_{t-j+J_w,J_w} + (1-\omega)\bar{y}_{t-1}],$$

  where

  - $\theta$ is the replacement rate at the time of retirement.
  - $y_{t-j+J_w,J_w}$ is the pre-retirement wage;
  - $\bar{y}_{t-1}$ is the "social average wage" in the previous year
  - $\omega$ and $1-\omega$ are respective weights on pre-retirement wage and current social average wage

- Assume that a constant social security tax $\tau^{ss}$ is determined to balance the government's intertemporal budget on social security.

# Prior to Housing Reform

- Before housing reforms, the government owned all apartments.
- The government assigns to each household an apartment whose size is determined by household's skill type: more skilled households are assigned larger houses.
- No households born before period 1 own any house. The households pay a rental rate determined by the government.
- The economy is in the pre-reform steady state. The households' idiosyncratic shocks are assumed to be perfectly insured in the pre-reform era.

# Housing Privatization

- The government first sold all the rental apartments owned by them to absentee rental companies when housing reform starts.
- When housing reform starts, all households can choose to rent a commercial apartment $h_R \in \mathcal{H}_R = \{h_R^1, h_R^2, ...h_R^{N_R}\}$ that provides housing service $s = h_R$ at the market rental rate $\rho_t$, where $\mathcal{H}_R$ is the set of size options among the rental units;
- All households can also choose to purchase an owner-occupied apartment $h_O \in \mathcal{H}_\mathcal{O} = \{h_O^1, h_O^2, ...h_O^{N_O}\}$ at market price $p_t$.
- An owner-occupied apartment provides housing service $s = \zeta h$, with $\zeta \geq 1$ .

# Major Housing Reforms

- **Subsidized Purchase of Reformed Houses** Assume all households born before year 1994 are eligible to purchase the house they currently rent at a discounted price (reformed house). The discounted price depends on their age in 1994: Illustration

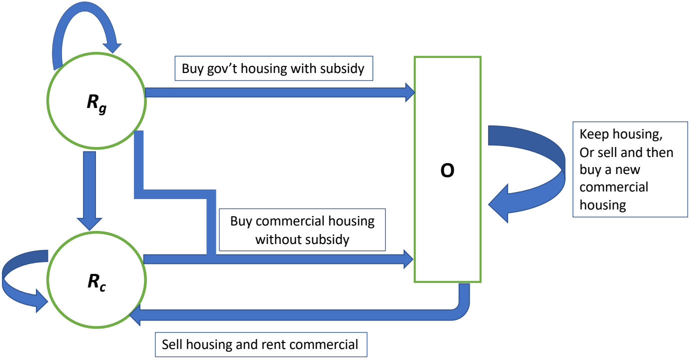
$$p_{gt,j} = p_t \left[ 1 - \frac{\min[\text{Age in 1994, } J_w]}{J_w} \times 65 \times 0.9\% \right]$$

- **Elimination of Government Rental Houses** The government declared to eliminate the rental-discounted houses for household born after period 1998.
- **Access to mortgage market** Residential mortgages with 30% down payment rate were officially introduced.

# Differences b/w Renting and Owning

- Set of size options for commercial rental units ($\mathcal{H}_R$) and owner-occupied units ($\mathcal{H}_O$) may be different, e.g., commercial rental units tend to be smaller on average than owner-occupied units.
- There are additional utility from owning than renting a home, we assume that an owner-occupied apartment provides housing services $s = \zeta h$, with $\zeta \geq 1$ reflecting the idea that owning a home allows one to access the local amenities, e.g. attending public schools, or to customize the apartment to one's own liking, while renting does not.
- From 1998 forward, home buyers can borrow via mortgages subject to down payment requirements $(30\%)$, while renters do not have this option.
- Owner-occupied houses carry a maintenance cost per period, $\delta_h p_t h_t$, expressed in units of the numeraire good, and we assume that the maintenance fully compensates for any physical depreciation of the dwelling.
- When a household sells its home of size $h_t$ in period $t$, it incurs a variable transaction cost $\tau_s p_t h_t$ that is proportional to the value of the house transactions; renters can adjust their sizes freely.

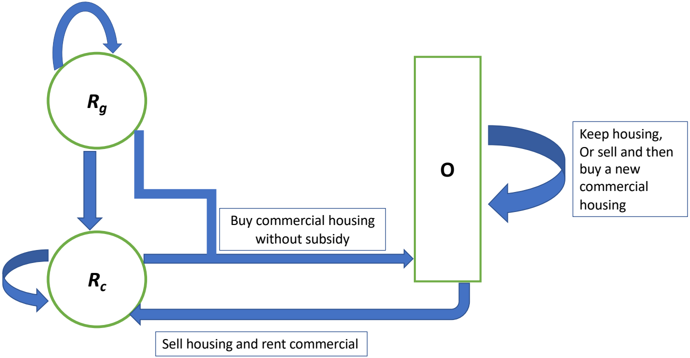
# Housing Options for Initial Cohorts Before 1994




value function for renters of reformed houses

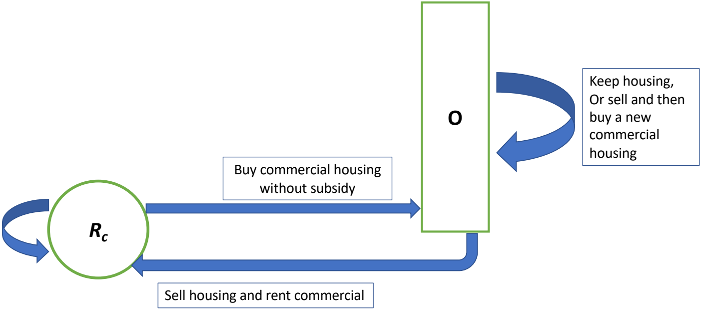
value function for renters of commercial houses

# Housing Options for Cohorts 1994-1997




value function for buyers of reformed houses | value function for buyers of commercial houses

# Housing Options for Cohorts On or After 1998




value function for owners of reformed houses

value function for owners of commercial houses

# Production Sectors

- **Final goods sector:**

$$Y_t = A_t N_{ct}$$

- **Residential construction sector** sells apartments at price $p_{ht}$ produced from new land $L_{ht}$ issued by the government and labor $N_{ht}$ using a constant return to scale technology:

$$Y_{ht} = A_{ht} L_{ht}^{1-\alpha} N_{ht}^{\alpha}.$$

- Absentee rental companies buy apartments from construction sector and lease them to renters at price $\rho_t$. No-arbitrage condition implies:

$$p_t = \rho_t + \frac{1-\delta_h}{1+r} p_{t+1}.$$

# Government

- Government imposes social security payroll tax $\tau_{ss}$ to balance intertemporal budget constraint of social security system:

$$\tau^{ss}\sum_{t=1}^{\infty}\frac{\sum_{j=1}^{J_w} w_t\mu_{t,j}\int_i e_{t,j}^i di}{(1+r)^t}=\sum_{t=0}^{\infty}\frac{\sum_{j=J_w+1}^{J}\mu_{t,j}b_{t,j}}{(1+r)^t},$$

- Government chooses income tax $\tau$ to balance between the present value of housing subsidy and the present value of wage income tax:

$$\sum_{t=1}\frac{1}{(1+r)^t}\sum_{j=1}^{J}\sum_i\left[\int(p_t-p_{g,t}(j))h_g^i\mathbf{I}^{B_g}(\mathbf{x}_t^R)d\mu_{t,j}^{R_g}(\mathbf{x}_t^R)\right.$$
$$\left.+\int(1-\omega)\rho_t h_g^i\mathbf{I}^{R_g}(\mathbf{x}_t^R)d\mu_{t,j}^{R_g}(\mathbf{x}_t^R)\right]$$
$$=B_0+\tau\sum_{t=1}\frac{1}{(1+r)^t}\sum_{j=1}^{J_W}w_t\mu_{t,j}\sum_i\mathbb{E}e_{t,j}^i,$$

where $B_0$ denotes the government's initial asset position.

# Equilibrium

- Given government policies $\langle r_m, \theta, \nu, \gamma, \omega, p_{g,t}(j)\rangle$, and a sequence of aggregate variables $\langle A_t, L_t, n_t\rangle_{t=1}^{\infty}$, a dynamic equilibrium of our model consists of quantities $\langle N_{ct}^*, N_{ht}^*, L_{h,t}^*\rangle$, prices $\langle p_t^*, \rho_t^*, w_t^*, p_{Lt}^*\rangle$, taxation policies $\langle \tau, \tau^{ss}\rangle$, household value functions $\mathbb{V} \equiv \langle V_t^{R_g}, V_t^{R_c}, V_t^{B_g}, V_t^{B_c}, V_t^{O_g}, V_t^{O_c}\rangle$ and associated policy functions $\mathbb{P}^* \equiv \langle \mathbf{I}^{*B_g}(\cdot), \mathbf{I}_{R_g}^{*R_g}, \mathbf{I}_{R_g}^{*R_c}, \mathbf{I}^{*B_c}(\cdot), \mathbf{I}^{*S_g}(\cdot), \mathbf{I}^{*S_c}(\cdot), \mathbf{I}_O^{*R_c}(\cdot), \mathbf{I}^{*T_c}(\cdot), c_t^*(\cdot), a_t^*(\cdot), \mathbf{b}_t^*(\cdot), h_t^*(\cdot), m_t^*(\cdot)\rangle$, and distributions of the state variables among renters and owners of government-owned and commercial houses $\boldsymbol{\mu}_t \equiv \langle \mu_t^{R_g}, \mu_t^{R_c}, \mu_t^{O_g}, \mu_t^{O_c}\rangle$, measured at the beginning of period $t$, that satisfy the following conditions:

# Equilibrium

1. Given the prices $\langle p_t^*, \rho_t^*, w_t^* \rangle$ and the household value functions $\mathbb{V}$, the household policy functions $\mathbb{P}^*$ solve the households' recursive problems.
2. The household value functions $\mathbb{V}$ are consistent with the households' policy functions $\mathbb{P}^*$ and the evolution of the state variables.
3. Given $\langle A_t, L_t \rangle$ and prices $\langle p_t^*, \rho_t^*, w_t^*, p_{Lt}^* \rangle$, the demand for labor $N_{ht}^*$ and the demand for land $L_{h,t}^*$ solves the problem of profit maximization of construction firms.
4. The labor market clears at the wage rate $w_t^* = A_t$, i.e., $N_{ct}^* + N_{h,t}^* = N_t$.
5. The land market clears in each period, i.e., $L_{ht}^* = L_t$, for all $t$ where $L_t$ is the exogenous land supply.

# Equilibrium

6. Given the households' policy functions and state distributions, and the new housing supply from construction firms, housing price $p_t$ clears the housing market in each period.
7. The no-arbitrage condition between housing price $p_t^*$ and rental rates $\rho_t^*$ is satisfied all all period $t$.
8. The social security tax $\tau^{ss}$ balances the intertemporal budget of the social security system.
9. The evolution of state variables, encapsulated by $\boldsymbol{\mu}_t$, is consistent with exogenous stochastic processes including income shocks and aging/death processes and all endogenous household decision rules $\mathbb{P}^*$.

details

# Calibration Strategy

- Model is calibrated to Chinese economy during 1994-2015.
- In both initial and final steady state, the economy is growing on its balanced growth path.
- Initial steady state denotes the pre-1994 period where the government allocates houses across households for subsidized rent.
- At the final steady state, all those cohorts who are eligible for either purchase subsidies or rental discount have exited the economy, and all exogenously fed-in series have stabilized.
- To solve for the transition path, we need to detrend the model by variables in the final steady state. Detrend Algorithm

# Parameterization

- Each period is five years. $J = 14$, $J_w = 8$ corresponding to entering labor force at age 21, rentiring at age 60 and exiting at age 90.
- Conditional age-specific survival probabilities $\{\psi_j\}_{j=1}^{J}$ are from Imrohoroglu and Zhao (2018).
- Life-cycle income profile is from He, Ning and Zhu (2018).
- Two types of households in terms of skill endowment, $\lambda^L$ and $\lambda^H$, high school dropouts and high school graduates or higher.
- The persistent and transitory labor efficiency shocks follow:

$$\ln(z_t) = \rho_z \ln(z_{t-1}) + \epsilon_t, \epsilon_t \sim \mathcal{N}(0, \sigma_v^2)$$
$$\ln(\epsilon_t) \sim \mathcal{N}(0, \sigma_\epsilon^2),$$

with $\rho_z, \sigma_\epsilon$ and $\sigma_e$ from Fan, Song and Wang (2010).

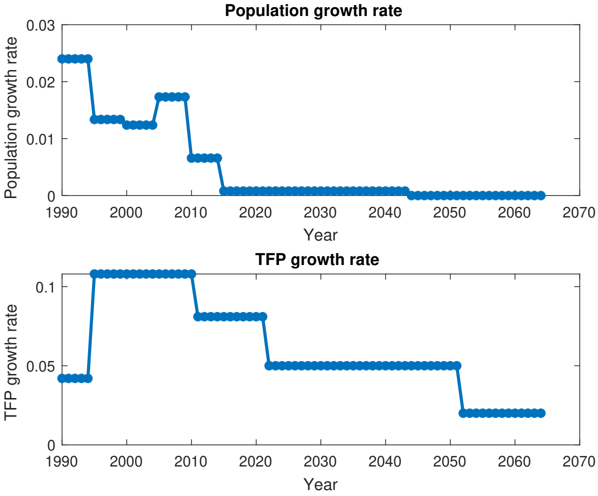
# Population Dynamics

- In the initial steady state, the population growth rate is set to be 2.4%, which is the average working-age population growth rate in 1995.
- Between 1995 and 2020, the population growth rate is UN working-age population growth rate.
- Between 2021-2045, the projected growth rate is 0.088 percent
- After 2045, the projected population growth rate is set to be zero.

# TFP Growth Rates

- We calibrate TFP process for non-durable goods production, $\{z_t\}_{t=0}^{T}$ to match the urban hourly wage growth rate.
- At the pre-reform steady state, the TFP grow rate is set to be 4.2%, which is the average growth rate of urban wage rate growth rate between 1980-1993.
- Between 1994-2010, the wage growth rate is 10.8%.
- Between 2010-2020, the wage growth rate is 8.1%.
- Between 2021-2050, assume the wage growth is 5.0 percent.
- After 2050, assume that the wage growth at 2 percent per year.

# Exogenous Series



# Parameterization: Pre-determined Parameter

| Description | Parameter | Value | Sources |
|---|---|---|---|
| Life time | $J$ | 14 | Age 21-90 |
| Working time | $J_w$ | 7 | Age 21-60 |
| Depreciation rate | $\delta_h$ | 0.02 | OECD estimates |
| Replacement rate | $\theta$ | 0.6 | Song et al. (2015) |
| Discount Factor | $\beta$ | 0.90 | standard |
| auto-corr.of persistent shock | $\rho$ | 0.84 | He et al. (2017) |
| std. dev.of persistent shock | $\sigma_v$ | 0.055 | He et al. (2017) |
| std. dev.of transitory shock | $\sigma_\epsilon$ | 0.055 | Fan et al. (2010) |
| Minimum Down Payment Ratio | $\gamma$ | 0.3 | government policy |
| Interest Rate for Savings | $r$ | 0.02 | Government policy |
| Mortgage Interest Rate | $r_m$ | 0.06 | Government policy |
| Land share | $\alpha$ | 0.7 | Wang et al. (2012) |
| Seller Transaction Cost | $\tau_s$ | 0.12 | Guren et al.(2020) |
| Conditional survival prob | $\{S_j\}$ | | Imrohoroglu and Zhao (2018) |
| Life-cycle income profile | $\{\varepsilon\}_j$ | | He et al. (2017) |
| Initial TFP level | $A_1$ | 1.3 | normalize average wage in 2005 to be |
| Land supply | $\ell_0$ | 1 | normalization |

# Parameterization: Jointly Determined Parameter

| Para | Description | Value | Target | Data | Model |
|---|---|---|---|---|---|
| $\zeta$ | util. premium owning | 1.65 | own'p rate in 2000 | 0.697 | 0.713 |
| $\iota$ | coef. on IV bequest | 0.85 | own'p rate of old in 2000 | 0.634 | 0.60 |
| $\underline{b}$ | "luxury" par. on IV bequest | 0.12 | own'p rate of old in 2000 | 0.634 | 0.60 |
| $\phi$ | coef. on housing service | 5.6 | expend. share on rents | 0.20 | 0.20 |
| $\underline{h}$ | subsistence housing service | 0.17 | price elas. of rental demand | -0.8 | -0.8 |
| $h_1^g$ | size small reform house | 9.1 | price to income ratio | 9.0 | 9.0 |
| $h_2^g$ | size large reform house | 12.7 | share reform h'owners2000 | 0.513 | 0.486 |
| $\lambda^H$ | Skill premium | 1.49 | Own'p rate of skilled 2000 | 0.749 | 0.738 |
| $B_0$ | Initial gov assets | 5.3 | payroll tax | 0.1 | 0.1 |
| $A_{ht}$ | Construction TFP | Figure | Housing price dynamics | | |

# Model Fit by Year

| | 2000 | | 2005 | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| Ownership | 0.697 | 0.713 | 0.753 | 0.741 |
| Pop share own ref. house | 0.513 | 0.486 | 0.431 | 0.344 |
| Pop share own com. house | 0.184 | 0.227 | 0.322 | 0.397 |

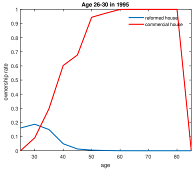
# Model Fit by Skill

| | 2000 | | 2005 | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| Overall | 0.697 | 0.713 | 0.753 | 0.741 |
| Unskilled | 0.672 | 0.692 | 0.738 | 0.691 |
| Skilled | 0.749 | 0.738 | 0.793 | 0.800 |

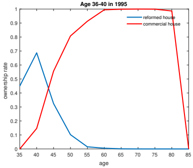
# Model Fit by Age

| | 2000 | | 2005 | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| 21-30 | 0.570 | 0.603 | 0.545 | 0.630 |
| 31-60 | 0.705 | 0.728 | 0.777 | 0.738 |
| 61-90 | 0.634 | 0.600 | 0.736 | 0.658 |

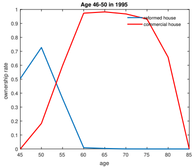
# Ownership over Life Cycle among Initial Cohorts



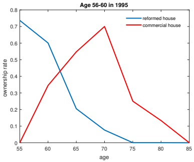

(a) Cohort born 1965-1969




(b) Cohorts born 1955-1959

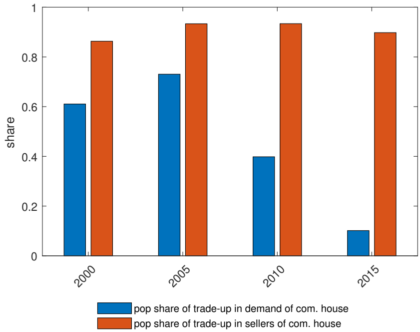



(c) Cohort born 1945-1949

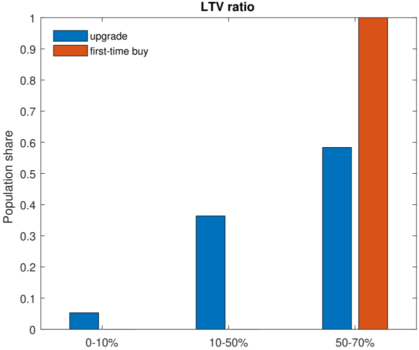



(d) Cohort born 1935-1939

# Trade-up Mechanism At Work



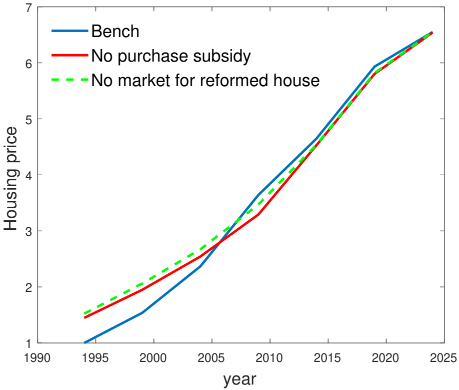

(a) Trade-up in demand and supply



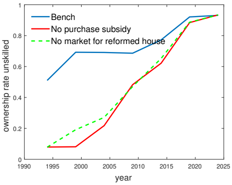

(b) LTV distribution

# Role of Housing Reform

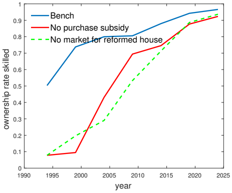
- To assess the role of housing reform in 1994, we either remove purchase subsidy to those born before 1994, or completely eliminate the housing reform in 1994 (laissez-fair housing privatization reform).
- Housing reform “trap” initial cohorts into owners of reformed houses. Without it, they rent larger commercial houses.
- Prevalent trade-up around 2010s.



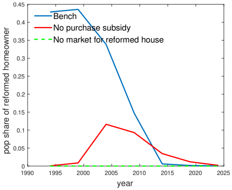
# Ownership Rates



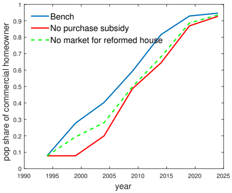

(a) Unskilled




(b) Skilled



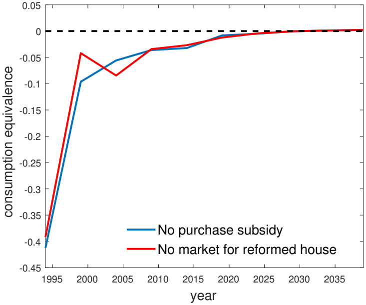

(c) Reformed House



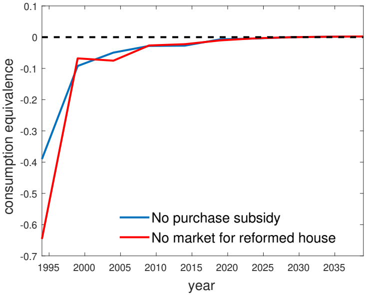

(d) Commercial House

# Welfare among Newborns

- Consuption equivalence value is defined as the uniform percentage change in expected consumption in each period over the remainder of an individual's lifetime that makes the individual indifferent between the benchmark and the counterfactual scenario.
- Housing reform $\Longrightarrow$ more owners of initial cohorts $\Longrightarrow$ more bequests $\Longrightarrow$ newborn benefit more




(a) Unskilled




(b) Skilled

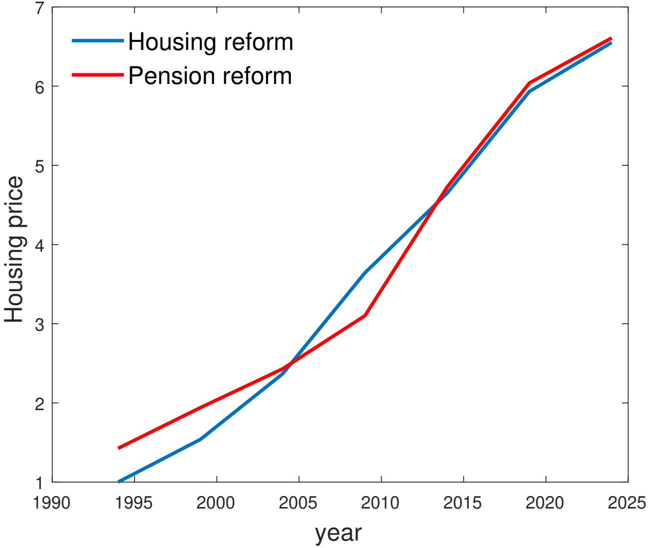
Bequests

# Counterfactual I: Alternative Pension Reform

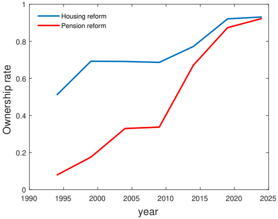
- Remove housing purchase subsidy to initial cohorts
- Replace by a higher replacement rate $\theta$ so that the average welfare among initial cohorts are the same as in the housing reform. $\theta$ is found to be $0.72 > 0.6$ in the pension reform.
- Due to downward-rigidity, the same replacement rate is carried over to all future cohorts.

| | Income tax | Social Security tax |
|---|---|---|
| Baseline | 0.100 | 0.231 |
| No purchase subsidy | 0.065 | 0.231 |
| No 94 reform | 0.064 | 0.231 |
| Pension reform | 0.066 | 0.270 |
| Baseline slow down | 0.100 | 0.231 |
| Pension reform slow down | 0.100 | 0.270 |

# Housing Prices



# Ownership Rates

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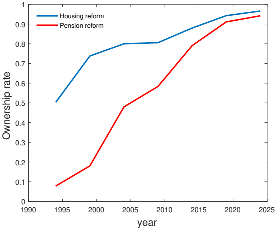
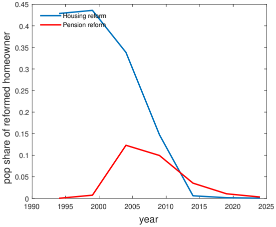
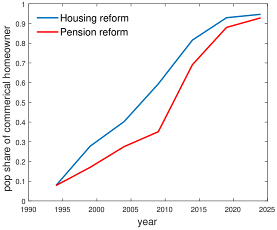



(b) Skilled

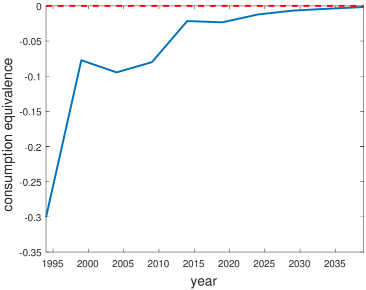



(c) Reformed Houses

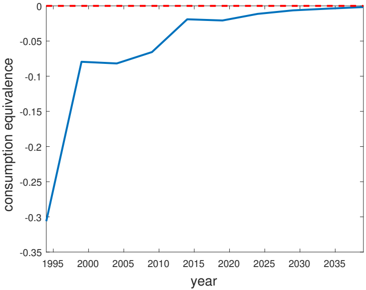



(d) Commercial Houses

# Welfare Comparison

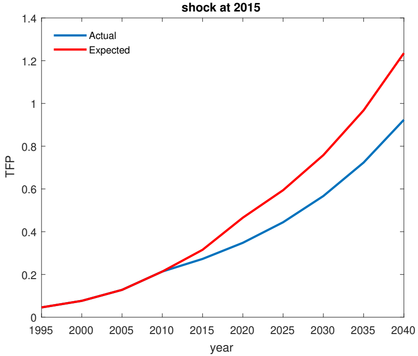



(a) Unskilled

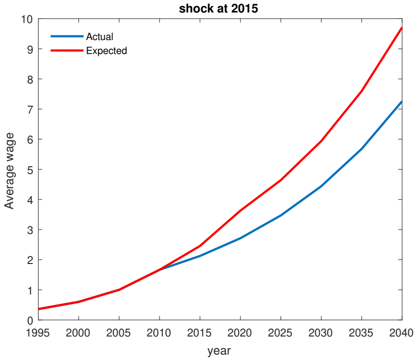



(b) Skilled

# Counterfactual II: Unexpected Slowdown from 2010




(a) TFP




(b) Average Wages

# Government Budget

| | Housing Reform | Pension Reform |
|---|---|---|
| tot subsidy | 6.753 | 4.430 |
| per-capita subsidy | 0.834 | 0.547 |
| tax income | 5.662 | 3.727 |
| per-capita tax income | 0.699 | 0.460 |
| pension deficit | 0.313 | 0.365 |
| per-capita pension deficit | 0.039 | 0.045 |
| total deficit | 1.404 | 1.069 |
| per-capita deficit | 0.173 | 0.132 |
| tot deficit/tax income | 0.248 | 0.287 |

* Per-capita denotes average among all working cohorts in 2005, whose average wage is normalized to 1 in the calibration.

# Government Budget if Pension Did Not Depend on Social Average Wage

| | Housing Reform | Pension Reform |
|---|---|---|
| tot subsidy | 6.413 | 4.526 |
| per-capita subsidy | 0.792 | 0.559 |
| tax income | 5.662 | 3.727 |
| per-capita tax income | 0.699 | 0.460 |
| pension deficit | 0.489 | 0.570 |
| per-capita pension deficit | 0.060 | 0.070 |
| total deficit | 1.240 | 1.370 |
| per-capita deficit | 0.153 | 0.169 |
| tot deficit/tax income | 0.219 | 0.368 |

* Per-capita denotes average among all working cohorts in 2005, whose average wage is normalized to 1 in the calibration.

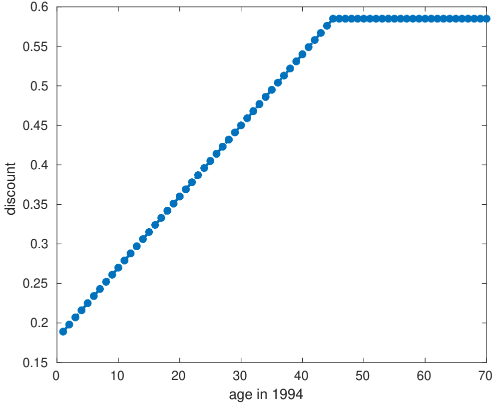
# Conclusion

- Propose a new channel of intergenerational transfer in a fast growing economy like China: the government subsidizes earlier cohorts for house purchase when privatizing housing market.
    - The initial generations may sell the houses to reap the capital gain to finance retirement consumption even though they largely miss the chance to enjoy rising wage income.
- Develop a quantitative framework to incorporate the channel together with heterogeneous households, financial constraint, mortgage structure and housing market.
- All future cohorts are better off with the 1994 housing reform than without!
- Parental bequests played an important role

# Discussions

- Difference between housing assets vs. financial assets: USSR vs. China
- Partial average wage indexing: Germany and UK
- Relevant for other countries?

# Housing Subsidy Illustration

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# Value Function: Renter of Reformed Houses

$$V_t^{R_g}(y,z,j) = \max_{c,a'} u(c,h_g)$$

$$+\beta\psi_{j+1}\mathbb{E}\left[\max\left\{V_{t+1}^{R_g}(y',z',j+1), V_{t+1}^{O_g}(y',z',j+1),\right.\right.$$

$$\left.\left.V_{t+1}^{R_c}(y',z',j+1), V_{t+1}^{O_c}(y',z',j+1)\right\}\right]$$

s.t. $c + a' + \omega\rho_t h_g = y$

$$y' = \begin{cases} (1-\tau_t^{ss}-\tau_t)\lambda w_t \varepsilon_j z\epsilon + a(1+r) + \mathcal{T}_t(y') & \text{for } j \leq J_w \\ b + a(1+r) + \mathcal{T}_t(y') & \text{for } j > J_w \end{cases}$$

$$a' \geq 0$$

Back

# Value Function: Renter of Commercial Houses

$$V_t^{R_c}(y,z,j) = \max_{c,a',h_R\in\mathcal{H}_R} u(c,h_a) + \beta\psi_{j+1}\mathbb{E}\Big[\max\left\{V_{t+1}^{R_c}(y',z',j+1), V_{t+1}^{O_c}(y',z',j+1)\right\}\Big]$$

s.t. $\quad c + a' + \rho_t h_a = y$

$$y' = \begin{cases} (1-\tau_t^{ss}-\tau_t)\lambda w_t \varepsilon_j z'\epsilon' + a(1+r) + \mathcal{T}_t(y') & \text{for } j \le J_w \\ b + a'(1+r) + \mathcal{T}_t(y') & \text{for } j > J_w \end{cases}$$

$$a' \ge 0$$

Back

# Value Function: Buyer of Reformed Houses

$$V_t^{B_g}(y,z,j) = \max_{c,a',d'} u(c,\zeta h_g) + \beta\psi_{j+1}\mathbb{E}\Big[\max\big\{V_{t+1}^{O_g}(y^{\text{own}'}, z', \zeta h_g, d', j+1),$$

$$V_{t+1}^{R_c}(y^{\text{sell}'}, z', j+1), V_{t+1}^{O_c}(y^{\text{sell}'}, z', j+1),\big\}\Big]$$

s.t. $\quad c + a' + p_g h_g = y + d'$

$$y^{\prime\text{own}} = \begin{cases} (1-\tau^{ss}-\tau)\lambda w_t \varepsilon_j z\epsilon + a(1+r) & \text{for } j \le J_w \\ b + a(1+r) & \text{for } j > J_w \end{cases}$$

$$y^{\prime\text{sell}} = \begin{cases} (1-\tau^{ss}-\tau)\lambda w_t \varepsilon_j z\epsilon + a(1+r) + p_t h_g - d(1+r_m) + \mathcal{T}_t(y^{\text{sell}'}) & \text{for } j \\ p_t h_g - d(1+r_m) + a'(1+r) + b + \mathcal{T}_t(y^{\prime\text{sell}}) & \text{for } j > J_w \end{cases}$$

$$d' \le (1-\gamma)p_g h_g$$

$$a' \ge 0$$

Back

# Value Function: Buyer of Commercial Houses

$$V_t^{B_c}(y,z,j) = \max_{c,a',d',h_c \in \mathcal{H}_O} u(c,\zeta h_c) + \beta\psi_{j+1}\mathbb{E}\Big[\max\{V_{t+1}^{O_c}(y^{\text{own}'}, z', \zeta h_c, d', j+1),$$

$$V_{t+1}^{R_c}(y^{\text{sell}'}, z', j+1), V_{t+1}^{O_c}(y^{\text{sell}'}, z', j+1)\}\Big]$$

$$\text{s.t.} \quad c + a' + p_t h_c = y + d'$$

$$y^{\text{own}'} = \begin{cases} (1-\tau_t^{ss}-\tau_t)\lambda w_t \varepsilon_j z\epsilon + a(1+r) & \text{for } j \le J_w \\ b + a(1+r) & \text{for } j > J_w \end{cases}$$

$$y^{\text{sell}'} = \begin{cases} (1-\tau_t^{ss}-\tau_t)\lambda w_t \varepsilon_j z\epsilon + a(1+r) + p_t h_c - d(1+r_m) + \mathcal{T}_t(y^{\text{sell}'}) & \text{for } j \\ p_t h_c - d(1+r_m) + a(1+r) + b + \mathcal{T}_t(y^{\text{sell}'}) & \text{for } j > J_w \end{cases}$$

$$d' \le (1-\gamma)p_t h_c$$

$$a' \ge 0$$

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# Value Function: Owner of Reformed Houses

$$V_t^{O_g}(y, z, h_g, d, j) = \max_{c, a', m} u(c, \zeta h_g)$$

$$+ \beta \psi_{j+1} \mathbb{E}\Big[ \max \left\{ V_{t+1}^{O_g}(y^{\text{own}'}, z', \zeta h_g, d', j+1), V_{t+1}^{R_c}(y^{\text{sell}'}, z', j+1), V_{t+1}^{B_c}(y^{\text{sell}'}, z', j+1) \right\} \Big]$$

s.t. $\quad c + a' + \delta_h p_t h_g + m = y$

$$m \geq \frac{r_m (1 + r_m)^{J+1-j}}{(1+r)^{J+1-j} - 1} d$$

$$d' = d(1 + r_m) - m$$

$$y'^{\text{own}} = (1 - \tau_t^{ss} - \tau_t) \lambda w_t \varepsilon_j z \epsilon + a(1 + r)$$

$$y'^{\text{sell}} = (1 - \tau_t^{ss} - \tau_t) \lambda w_t \varepsilon_j z \epsilon + a(1 + r) + p_t h_g - d(1 + r_m) + \mathcal{T}_t(y'^{\text{sell}})$$

$$a' \geq 0$$

Back

# Value Function: Owner of Commercial Houses

$$V_t^{O_c}(y, z, h, d) = \max_{c, a', m} u(c, \zeta h)$$

$$+ \beta \psi_{j+1} \mathbb{E}\left[ \max \left\{ V_{t+1}^{O_c}(y^{\text{own}'}, z', \zeta h, d', j+1), V_{t+1}^{R_c}(y^{\text{sell}'}, z'), V_{t+1}^{B_c}(y^{\text{sell}'}, z') \right\} \right]$$

s.t. $\quad c + \chi_t + a' + \delta_h p_t h + m = y$

$$m \geq \frac{r_m (1 + r_m)^{J+1-j}}{(1+r)^{J+1-j} - 1} d$$

$$d' = d(1 + r_m) - m$$

$$y^{\text{own}'} = (1 - \tau_t^{ss} - \tau_t) \lambda w_t \varepsilon_j z \epsilon + a(1+r)$$

$$y^{\text{sell}'} = (1 - \tau_t^{ss} - \tau_t) \lambda w_t \varepsilon_j z \epsilon + a(1+r) + p_t h - d(1 + r_m) + \mathcal{T}_t(y^{\text{sell}'})$$

$$a' \geq 0$$

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# Equilibrium Details

- Denote the vector of individual states for homeowners and renters as $x^h := y, z, h, m, i$ and $x^n := y, z, i$.
- Let $\mathbb{I}^{b_k}$, $\mathbb{I}^{s_k}$, $k \in \{c, g\}$ be the decision to buy a house among renters, and the decision to sell a house among owners.
- Define $g^{t_g}$ to be the decision to trade up the current reformed house for a commercial house among owners of reformed houses.
- Housing market clears at price $p$.

$$\sum_{j=1}^{J}\Big[\int h_a(1-\mathbb{I}_j^{b_c}(x^n))d\mu_{t,j}^{R_c} + \int h_g(1-\mathbb{I}_j^{b_g}(x^n))d\mu_{t,j}^{R_g} + \int \delta_a h_g(1-\mathbb{I}_j^{s_g}(x$$

$$+\sum_{j=1}^{J}\Big[\int h\mathbb{I}_j^{b_c}(x^n)d\mu_{t,j}^{R_c} + \int h\mathbb{I}_j^{b_c}(x^n)d\mu_{t,j}^{R_g} + \int h\mathbb{I}_j^{b_c}(x^h)d\mu_{t,j}^{O_g} + \int \delta_h h(1-\mathbb{I}$$

$$= H_{a,t-1}(1-\delta_a) + \int h_g\mathbb{I}_j^{s_g}(x^h)d\mu_{t,j}^{O_g} + \int h\mathbb{I}_j^{s_c}(x^h)d\mu_{t,j}^{O_c} + Y_{ht},$$

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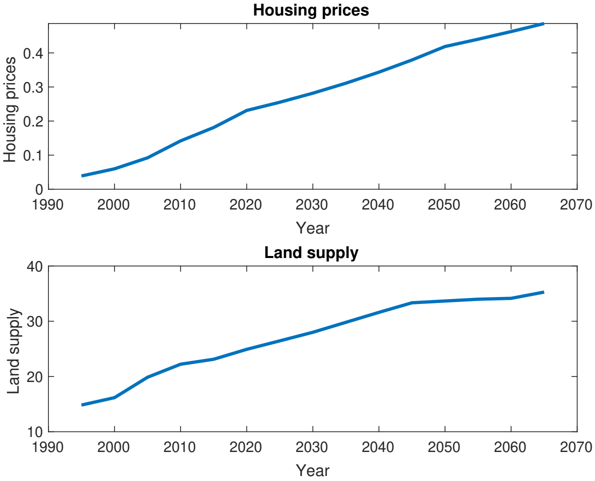
# Construction TFP and Housing Prices

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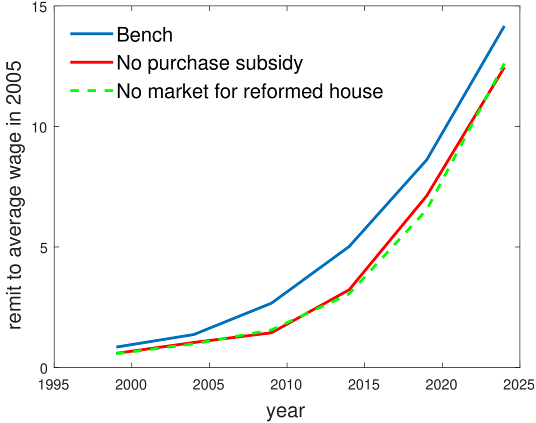
# Bequests

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# Detrend

- The growth rate of housing investment and housing price at BGP is:

$$1 + g_I = [(1+g)(1+n)]^{\alpha}$$
$$1 + g_p = [(1+g)(1+n)]^{1-\alpha}$$

- For individual variables, we detrend as follows

$$\begin{aligned} \widehat{c}_{t,j} &= c_{t,j}(1+g)^{T+j-t-1} \\ \widehat{h}_{t+1,j+1} &= h_{t+1,j+1}(1+g_h)^{T+j-t-1} \\ \widehat{b}_{t,j} &= b_{t,j}(1+g)^{T+j-t-1} \\ \widehat{y}_{t,j} &= y_{t,j}(1+g)^{T+j-t-1} \end{aligned}$$

- For aggregate variables, we detrend as follows

$$\begin{aligned} \widehat{w}_t &= w_t(1+g)^{T-t} \\ \widehat{p}_t &= p_t(1+g_p)^{T-t} \\ \widehat{I}_t &= I_t(1+g_I)^{T-t} \\ \widehat{L}_t &= L_t \\ \widehat{H}_t &= H_t\,(1+g_I)^{T-t} \\ \widehat{\rho}_h &= \rho_h(1+g_p)^{T-t} \\ \widehat{\tilde{H}} &= \tilde{H}'\,(1+g_I)^{T-t} \\ \widehat{Y}_t &= Y_t\,[(1+g)(1+n)]^{T-t} \end{aligned}$$

# Computation Algorithm

Given government policy, $\{\tau_t, b_t\}_{t=1}^{\infty}$, discount housing policy, land supply, $\{H_t\}_{t=1}^{\infty}$, and interest rate $\{r_t\}_{t=1}^{\infty}$ and wage rate $\{w_t\}_{t=1}^{\infty}$ on the path, and the initial distribution of household on the state space (initial state).

1. Choose the number of transition periods $T$.
2. De-trend the economy by the time $T$ variables.
3. Provide an initial guess for income tax rate $\tau$.
4. Given all policy variables, solve for the final steady state housing price that clear the housing market by bisection method.
5. Provide an initial guess for housing price on the path, $\{p_t\}_{t=0}^{T}$, and solve household's problem backwards:
   At period $t$, compute the value functions and policy functions for the new born at $t$, which has a perfect foresight.

# Computation Algorithm

6. Compute the transition path: Compute the optimal path for consumption, housing, and saving by forward induction given the initial state in period $t = 1$. In initial state, households receive assignment of public housing from the government, $\bar{H}$. The bequests for period $t$ newborn are collected from the household passing away at period $t$.

7. Aggregate household's net housing demand each period. Check if housing market in each period is clear. If not, update the guess of $\{p_t\}_{t=1}^{T}$, and go to step 5.

8. Aggregate government tax revenue, housing sale revenue, pension expenditure on the path. Combined with government's deficit/surplus in the steady state, check whether government's intertemporal budget is balanced. If not, update the guess of $\tau$, and go to step 4.

9. Check whether $p_T$ is close enough with the final steady state housing market price. If not, increase T, and go to step 2.

Back

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