Das House-Kapital

Annual Meeting of the Canadian Economics Association

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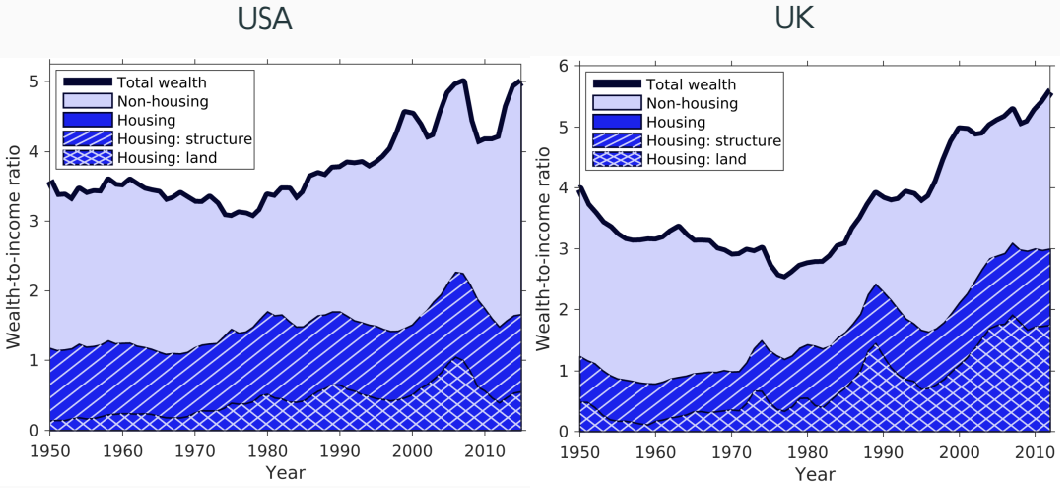
University of St.Gallen, Swiss Institute for Empirical Economic Research, Globalization of Real Estate Network

Housing has become the largest asset class



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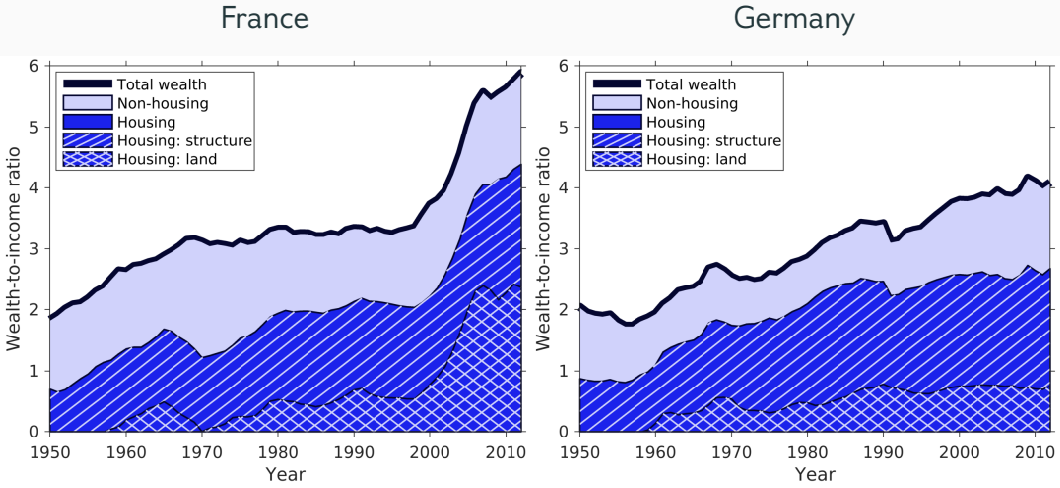

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  - Driven by construction boom and rising demand for residential land
  - Key: elastic long-term supply of structures, inelastic long-term supply of land

Macroeconomic relevance of rising housing wealth-income ratio

- Affordability: representative household must devote a higher multiple of income to purchase the existing housing stock

Quigley & Raphael (2004), Albouy et al. (2016)

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- Affordability: representative household must devote a higher multiple of income to purchase the existing housing stock — Quigley & Raphael (2004), Albouy et al. (2016)
- Financial sector: rising (housing) wealth-income ratio
  - Contributes to an increase in the financial sector — Gennaioli et al. (2014)
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  - Leads to more private debt via mortgage loans — Jordà et al. (2016)
- Functional income distribution: capital income recipients benefit — Piketty & Zucman (2014)
  - Increase in the aggregate capital income share driven by housing — Rognlie (2015)
  - Housing capital income share $=$ housing yield $\times$ housing wealth-income ratio
  - Housing yield: stable (Jorda et al., 2019) $\Rightarrow$ housing wealth-income ratio $\uparrow$

Related literature

- Early literature: Ricardo (1817); Nichols (1970)
- Housing wealth, house and land prices: Davis & Heathcote (2007); Piketty & Zucman (2014); Rognlie (2015); Stiglitz (2015); Knoll, Schularick, & Steger (2016)
- Short term: Davis & Heathcote (2005); Hornstein (2009), Iacoviello & Neri (2010); Favilukis et al. (2017); Kaplan et al. (2019), Greenwald & Guren (2019); ...
- Long term: Hansen & Prescott (2002); Borri & Reichlin (2018); Herkenhoff et al. (2018); Miles & Sefton (2018); Bonnet et al. (2019)
  - + Fixed quantity of overall land and endogenous land allocation
  - + Three stocks: capital, residential structure, and fixed land (residential land and non-residential land)
  - + Housing stock: two-dimensional object (reproducible structures and non-reproducible land)

Plan for today

Facts

Model

Results: steady state

Results: transition

A house is a bundle of structure and land

- We decompose housing wealth as follows

Davis & Heathcote (2007)

$$\frac{\text{housing wealth}}{\text{income}} =$$

datasources

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- Our data covers four developed economies: USA (1950–2015), UK (1950–2012), France (1960–2012), and Germany (1960–2012)

datasources

Stylized facts on housing & macro in the long run

1. Wealth: Wealth-income ratio ↑, housing wealth-income ratio ↑↑
2. Prices: Real house price ↑↑, construction cost ↑, residential land prices ↑↑↑
3. Quantities: House quantity ↑↑, residential structures ↑↑↑, residential land ↑
4. Land share: Residential land value as share of housing wealth ↑
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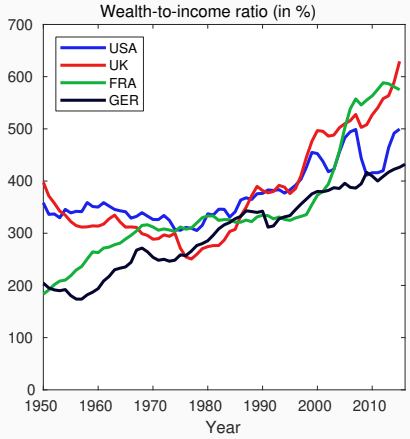

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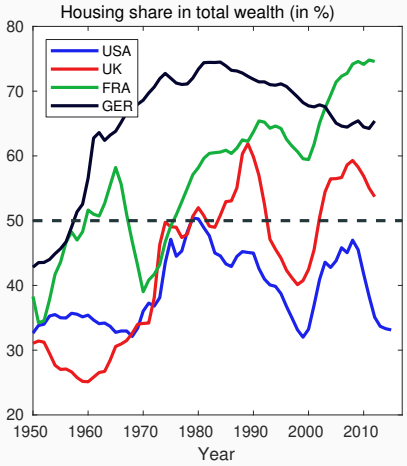

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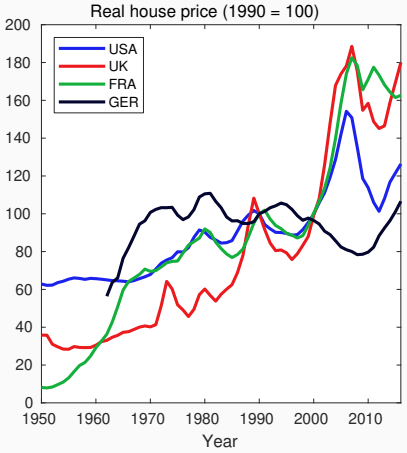

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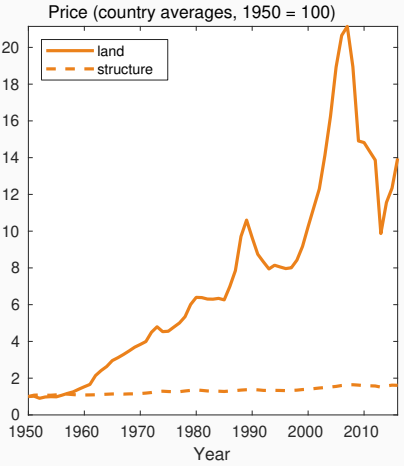

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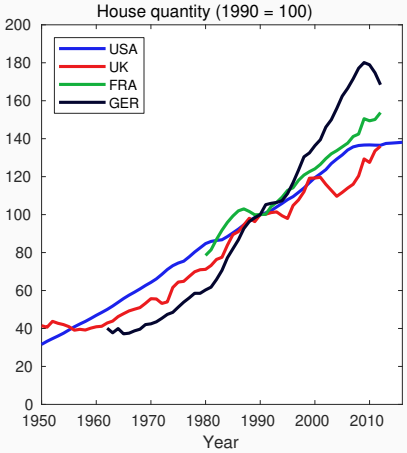

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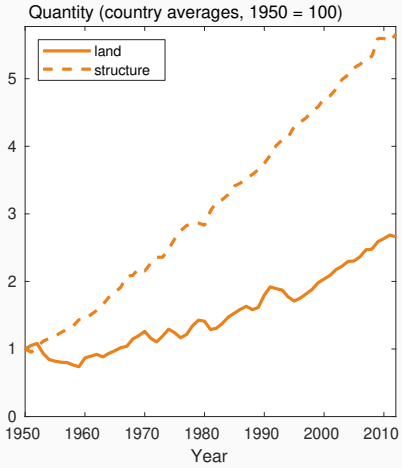

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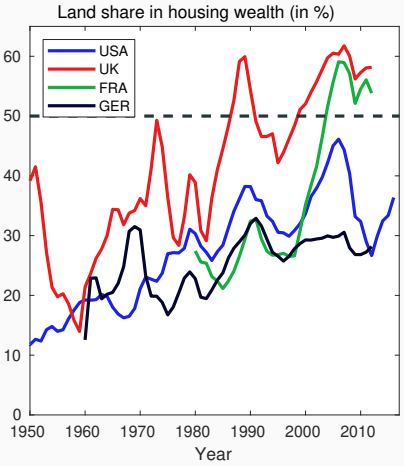

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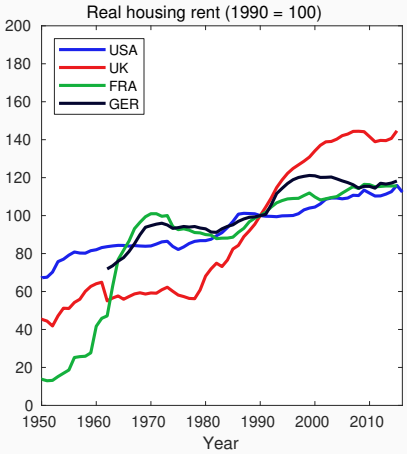

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Model: households

Representative household chooses $\{C_t\}_{t=0}^{\infty}$ and $\{S_t\}_{t=0}^{\infty}$ to maximize

$$U = \int_0^{\infty} e^{-\rho t} L_t \frac{\left[\left(\frac{C_t}{L_t}\right)^{1-\theta}\left(\frac{S_t}{L_t}\right)^{\theta}\right]^{1-\sigma} - 1}{1-\sigma} dt, \tag{1}$$

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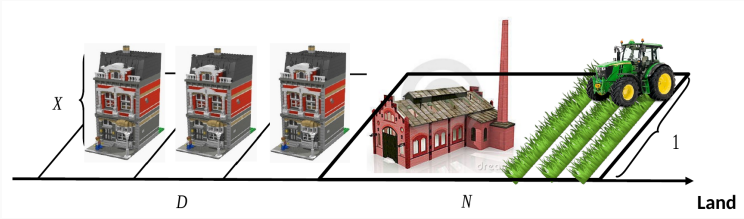
subject to

$$\dot{W}_t + C_t + q_t S_t = r_t W_t + w_t L_t + \Pi_t^D, \quad W_0 = given, \quad NPGC. \tag{2}$$

Notes: The measure of households is normalized to one. Each household consists of measure L_t members. Each household member supplies one unit of labor inelastically such that labor supply per household is L_t. Households maximize "the sum" of per-capita utility.

Model: production sectors



Numeraire sector

$$Y = K^{\alpha} \left(B^{Y} L^{Y}\right)^{\beta} N^{1-\alpha-\beta}$$

Y problem | H problem | D problem | X problem

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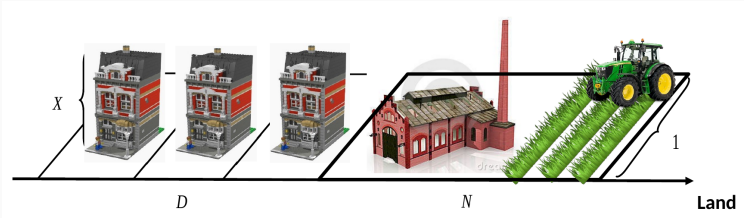

Housing sector

- Property management firms: demand structure X and land D to build housing H to rent out to households ($H = S$)

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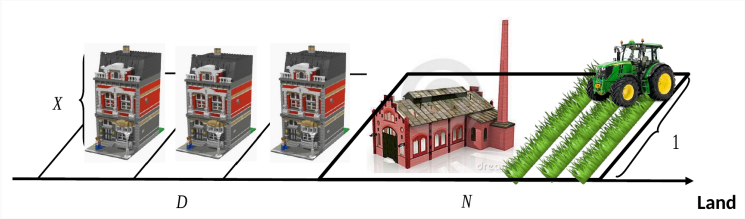

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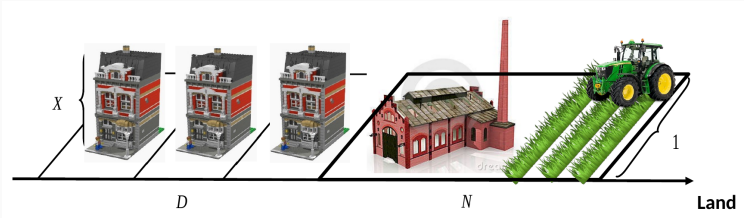

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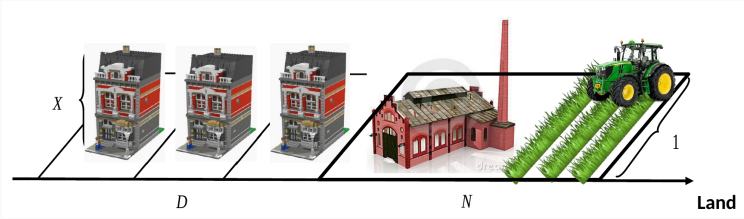

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Resource constraints

- Labor: $L^Y + L^X + L^D = L$
- Land: $D + N = Z$

Y problem | H problem | D problem | X problem

Model: asset market

- House price

(derived from $P^D D + P^X X = P^H H$)

$$P^H = \frac{D}{H} P^D + \frac{X}{D} P^X \tag{3}$$

- Wealth consists of 3 assets

$$W = \underbrace{P^H H}_{\text{housing wealth}} + \underbrace{P^N N + K}_{\text{non-housing wealth}} \tag{4}$$

- No-arbitrage conditions hold in equilibrium

$$r = \frac{\dot{P}^H + R^H}{P^H} = \frac{\dot{P}^N + R^N}{P^N} \tag{5}$$

equilibrium

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→ Steady state

→ Analytical

2) Why has **housing wealth** been growing faster than **income**?

→ Transitions

→ Quantitative

Why do house prices grow in the long-term?

Proposition 2

The house price grows in the long-term at the rate

$$\mathfrak{g}_{PH} = \left[1 - \eta + \eta\left(\psi^H - \psi^Y\right)\right]\frac{1-\psi^Y}{1-\eta\psi^Y}g^Y - (1-\eta)\frac{1-\psi^H}{1-\eta\psi^Y}g^X \gtreqless 0,$$

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- Differential technological progress: If $\psi^Y = \psi^H \equiv \psi$, growth rate simplifies to

$$\mathfrak{g}_{PH} = \frac{(1-\eta)(1-\psi)}{1-\eta\psi}\left(g^Y - g^X\right)$$

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- What about house prices before 1950?
  - Largely constant Knoll, Schularick, & Steger (2017)
  - Our theory: pronounced technological growth in construction sector ($g^X \uparrow$) and high land intensity in non-housing sector ($\psi^Y \downarrow$)

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- Other stylized facts?
  - Replicate growth rates of prices and quantities of residential land and residential structures, as well of rent steady state growth rates
  - But: Housing wealth-income ratio (and share of land in housing wealth) constant in steady state

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Specifically, we ask:

1) Can the calibrated model replicate the empirical evolution of housing wealth?

2) Why has the housing wealth-income ratio been increasing?

3) Is this explanation compatible with observations on prices, quantities, and the other stylized facts?

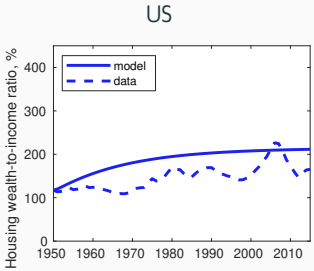
Calibration strategy

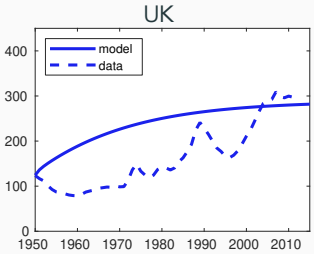
The model is calibrated separately to the US, UK, France, and Germany over post WWII period at an annual frequency

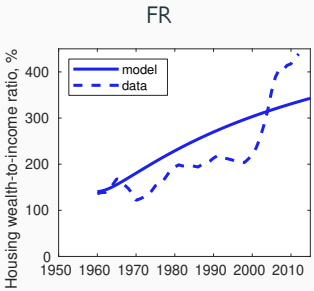
- We do not impose that the economy is in steady state
- Transition due to initial states K_0, X_0, and D_0, and exogenous transitory population growth L_t
- Some parameters are calibrated outside the model and 10 parameters are calibrated jointly inside the model by matching 10 moments along transition

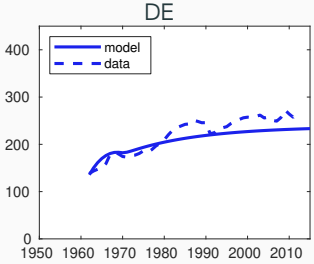
exogenous parameters | endogenous parameters | targeted moments

1) Replication: housing wealth-income ratios









- Replicate 80, 67, and 76 % of the increase in housing wealth-income ratio for UK, France, and Germany
- Over-predict increase by 38 % in US (but: US has not fully recovered from bust in 2015)

2) Why has the housing wealth-income ratio been increasing?

	(1) baseline	(2) alternative	(3) alternative	(4) alternative
		investment $K_0 = \widetilde{K}$	land development $D_0 = \widetilde{D}$	construction $X_0 = \widetilde{X}$
$\frac{P^H H}{NNP}$	1.8 (0.00)	1.7 (0.03)	1.7 (0.08)	0.8 (1.01)
$P^H H$	9.7 (0.00)	6.5 (3.19)	9.3 (0.41)	4.9 (4.80)
NNP	5.9 (0.00)	4.1 (1.87)	5.9 (-0.01)	6.9 (-0.97)
$\frac{P^D D}{NNP}$	1.8 (0.00)	1.1 (0.70)	1.3 (0.49)	1.3 (0.48)
P^D	4.7 (0.00)	2.0 (2.75)	8.1 (-3.41)	4.0 (0.72)
D	2.3 (0.00)	2.3 (-0.02)	1.0 (1.31)	2.3 (-0.03)
$\frac{P^X X}{NNP}$	1.8 (0.00)	1.9 (-0.11)	1.8 (0.00)	0.7 (1.04)
P^X	2.4 (0.00)	1.7 (0.70)	2.4 (-0.01)	5.9 (-3.47)
X	4.3 (0.00)	4.4 (-0.10)	4.3 (0.01)	0.9 (3.46)

Notes: Initial states K_0, D_0, and X_0 start 77, 60, and 81 percent below their respective steady state values.

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- Construction boom contributes to rising housing wealth-income ratio through direct effect on X
- Capital accumulation raises residential land prices through housing demand effect and inelastic land supply

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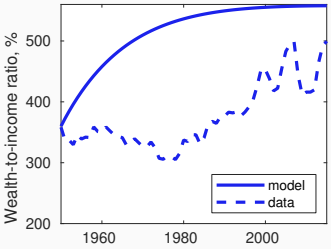

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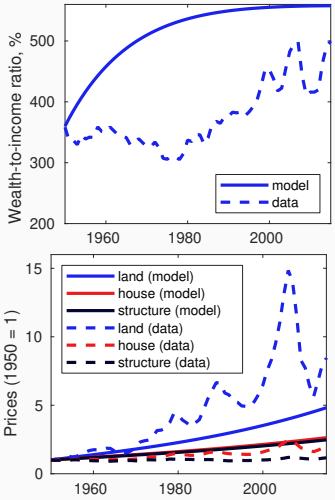

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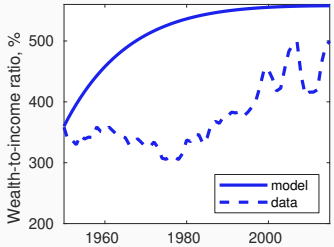

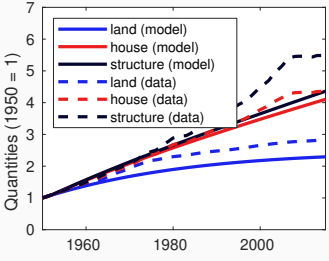

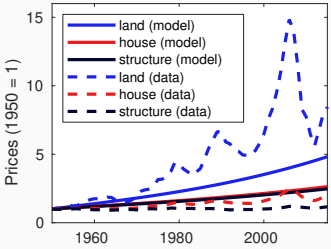

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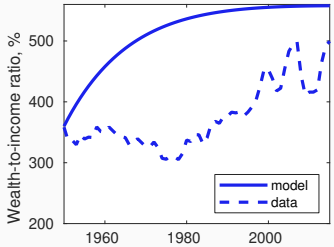

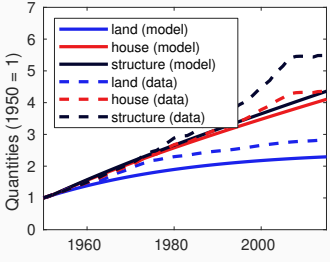

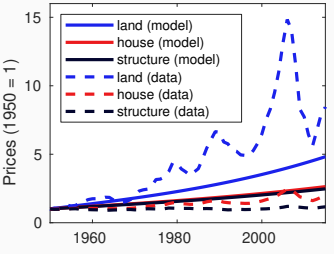

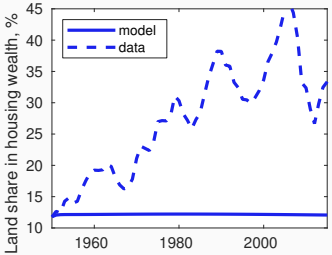

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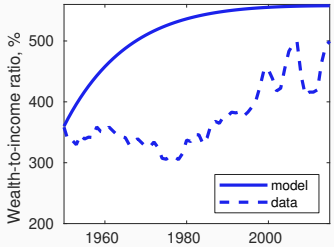
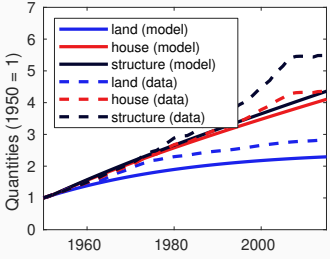
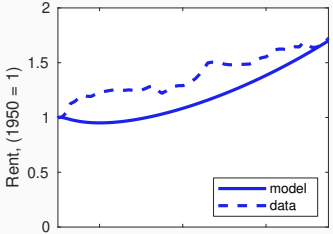
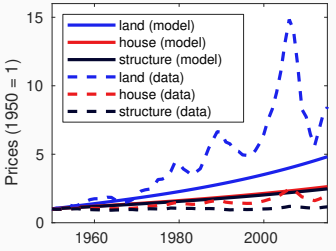
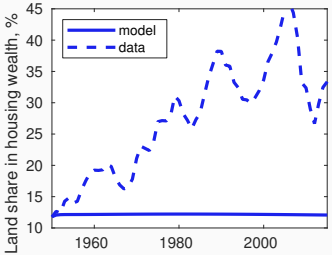


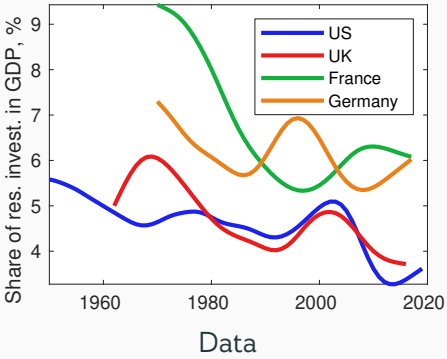








Is the construction boom plausible? Residential investment over time



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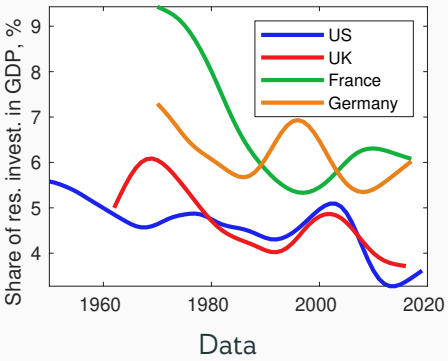

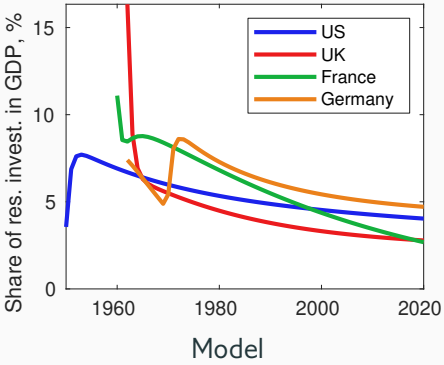

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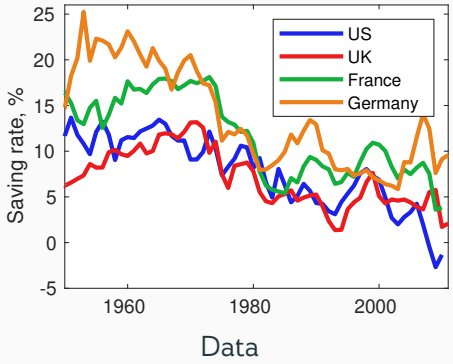
Is capital accumulation plausible? Saving rates over time



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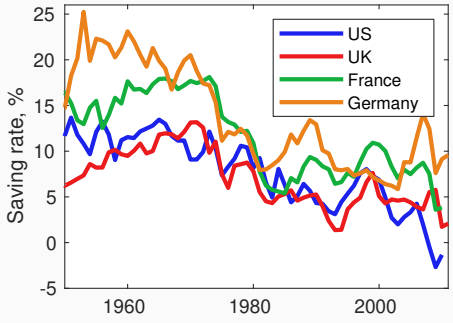
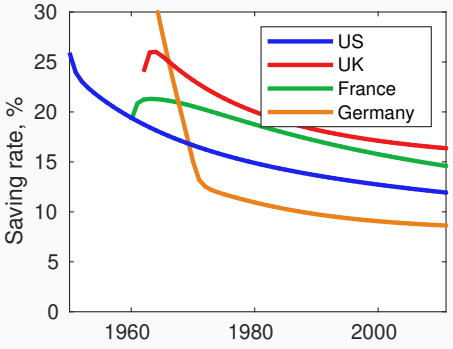


Data



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Discussion: extensions and alternative explanations

CES technology in housing production

- Generalize: $H(X, D) = \left[\gamma X^{\frac{\chi-1}{\chi}} + (1-\gamma) D^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}$
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Declining real interest rate

- Increase house price if rents do not change
- Interest rate is endogenous
- Interest declines monotonously along transition

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Appendix

Datasources

- Total wealth: Piketty & Zucman (2014), updated, from `www.wid.world`
- US nominal housing wealth and residential structure wealth: updated online appendix of Davis & Heathcote (2007)
- Nominal housing wealth and residential structure wealth for UK, FR, and DE: from Moritz Schularick, Luis Bauluz, and Filip Novokmet
- Non-housing wealth and land wealth: residual
- NNP: `www.wid.world`
- House, land, and structure price data, US: Davis & Heathcote (2007)
- House, land, and structure price data, FR, UK, DE: Knoll, Schularick, & Steger (2017), online appendix
- Quantity indices: quantity index $= \frac{\text{value index}}{\text{price index}}$.
- Housing rent and interest rate: Jordá et al. (2019), downloaded at `http://www.macrohistory.net/`

back

Stylized facts: numbers

Fact #	Variable	US 1950–2015	UK 1950–2012	FR 1960–2012	DE 1962–2012
	wealth-to-income ratio	1.39	1.4	2.2	1.88
1	housing wealth-income ratio	1.42	2.4	3.2	1.93
	non-housing wealth-income ratio	1.38	0.9	1.2	1.79
	house price	1.9	4.0	6.0	1.6
2	residential land price	8.4	9.6	32.2	2.3
	residential structure price	1.2	2.1	1.1	1.4
	house quantity	4.4	3.3	2.2	4.2
3	residential land quantity	2.8	2.1	1.6	3.5
	residential structure quantity	5.5	4.3	6.3	4.3
4	land's share in housing wealth	2.8	1.5	3.8	1.2
5	housing rent	1.7	3.1	2.8	1.6

Firm problem: numeraire

Mass one of identical firms that act under perfect competition and maximize

$$\max_{K,L^Y,N} K^{\alpha}\left(B^Y L^Y\right)^{\beta} D^{1-\alpha-\beta} - (r+\delta^K)K - wL^Y - R^N N \tag{6}$$

FOC

$$r = \alpha\frac{Y}{K} - \delta^K, \qquad w = \beta\frac{Y}{L^Y}, \quad \text{and} \quad R^N = (1-\alpha-\beta)\frac{Y}{N}$$

Aggregate capital stock evolves according to

$$\dot{K}_t = I_t^K - \delta^K K_t$$

back

Firm problem: property management

Mass one of identical firms that act under perfect competition and maximize

$$\max_{\{I_t^D, I_t^X\}_{t=0}^{\infty}} \int_0^{\infty} e^{-\hat{r}_t} CF_t \mathrm{d}t \tag{7}$$
$$\text{s.t. } \dot{X}_t = I_t^X - \delta^X X_t$$
$$\dot{D}_t = I_t^D,$$

where

$$CF_t \equiv q_t X_t^{\gamma} D_t^{1-\gamma} - P_t^X I_t^X - P_t^D I_t^D \quad \text{and} \quad \hat{r}_t \equiv \int_0^t r_\tau \mathrm{d}\tau$$

back

Firm problem: real estate development (I/II)

Mass one of identical firms take prices as given and face the production function

$$I^D = f(Z^D, L^D) = \begin{cases} \min\left\{Z^D, \sqrt{\frac{2}{\xi} L^D}\right\} & \text{if } Z^D \geq 0 \\ \max\left\{Z^D, -\sqrt{\frac{2}{\xi} L^D}\right\} & \text{if } Z^D < 0 \end{cases}$$

Cost minimization

$$\min_{Z^D, L^D} P^N Z^D + w L^D$$

subject to

$$f(Z^D, L^D) = I^D$$

yields the cost function

$$\mathcal{C}(I^D; P^N, w) = P^N I^D + w \underbrace{\frac{\xi}{2}\left(I^D\right)^2}_{=\mathcal{L}^D(I^D)} \tag{8}$$

Firm problem: real estate development (II/II)

Profit maximization

$$\max_{I^D} P^D I^D - \mathcal{C}(I^D; P^D, P^N, w) \tag{9}$$

FOC

$$I^D = Z^D = \frac{P^D - P^N}{\xi w} \quad \text{and} \quad L^D = \frac{\left(P^D - P^N\right)^2}{2\xi w^2}$$

Profits

$$\Pi^D = \frac{(P^D - P^N)^2}{2\xi w} = wL^D$$

back

Firm problem: construction sector

Mass one of identical firms that act under perfect competition and maximize

$$\max_{M,L^X} P^X \underbrace{M^\eta \left(B^X L^X\right)^{1-\eta}}_{=I^X} - M - wL^X \tag{10}$$

FOC (interior solution)

$$w = (1-\eta)\frac{P^X I^X}{L^X} \quad \text{and} \quad 1 = \eta \frac{P^X I^X}{M}$$

back

Equilibrium

A competitive equilibrium of the model are sequences $\{C_t, S_t, W_t, q_t, w_t, r_t, \Pi_t^D, Y_t, K_t, L_t^Y, N_t, R_t^N, H_t, R_t^H, X_t, D_t, P_t^X, CF_t, I_t^D, L_t^D, P_t^D, P_t^N, P_t^H, I_t^X, M_t, L_t^X\}_{t=0}^{\infty}$ for given initial capital, residential land, and residential structures $\{K_0, D_0, X_0\}$ and a population sequence $\{L_t > 0\}_{t=0}^{\infty}$ such that

- households maximize eq. (1) subject to eq. (2) and a no-Ponzi game condition;
- firms in the construction sector and the numeraire sector, land developers, and property management firms maximize profits as given by eqs. (6), (7), (9) and (10), taking eq. (8) and prices as given;
- rental market clears: $H_t = S_t$;
- labor market clears: $L_t^X + L_t^Y + L_t^D = L_t$;
- land market clears: $D_t + N_t = Z$;
- asset markets clear eq. (4);
- the house price is given by eq. (3);
- there are no arbitrage opportunities between assets, as described by eq. (5);

The market for the numeraire good clears by Walras' law.

back

Back-of-the-envelope calculation on determinants of rising house prices

- Assume US has been growing along its steady state path over 1950–2015
- Growth rate of house prices depends on five parameters: g^Y, g^X, ψ^Y, ψ^H, and η
- Take $\eta = 0.556$ and $\psi^Y = 0.15$ from the main calibration
- Set g^Y, g^X, and ψ^H such that we match the average annual growth rates of 2.8, 1, and 0.3 percent for NNP, the house price, and the price of residential structures
- First, we shut down the differences in long-run land intensities by setting elasticity $\psi^H = \psi^Y \Rightarrow$ House price growth reduces to 0.52 instead of previously 1.00 %
- Second, we additionally shut down the differences in technological progress by setting $g^X = g^Y \Rightarrow$ House price growth rate drops to 0

$\Rightarrow$ Differences in long-run land intensities capture 52 % of long-term increase in house prices, differences in sector specific technological change 48 %

back

Steady state growth rates

Variables	Growth rate
$r, \frac{P^H H}{NNP}, \frac{W}{NNP}, \frac{P^D D}{P^H H}, L^D, L^X, L^Y, N, D$	0
$Y, K, M, w, R^N, P^N, P^D, C, NNP, W$	$\frac{\beta}{1-\alpha} g^Y$
X, I^X	$\eta \frac{\beta}{1-\alpha} g^Y + (1-\eta) g^X$
P^X	$(1-\eta)\left(\frac{\beta}{1-\alpha} g^Y - g^X\right)$
S, H	$\gamma\eta \frac{\beta}{1-\alpha} g^Y + \gamma(1-\eta) g^X$
q, P^H	$(1-\gamma\eta) \frac{\beta}{1-\alpha} g^Y - \gamma(1-\eta) g^X$

Stylized facts in steady state

In the economy's steady state equilibrium

1. the wealth-income ratio, the housing wealth-income ratio, and the non-housing wealth-income ratio are constant,
2. the price of residential land, the house price, and the price of residential structures grow at strictly positive rates, and the price of residential land grows at a higher rate than the house price, which in turn grows at a higher rate than the price of residential structures iff $g^Y > 0$ and $-\frac{\eta}{1-\eta}\left(1-\psi^Y\right)g^Y < g^X < \left(1-\psi^Y\right)g^Y$,
3. quantities of residential structures grow at a strictly positive rate which is larger than the growth rate of residential land iff $g^X > -\frac{\eta}{1-\eta}\left(1-\psi^Y\right)g^Y$,
4. the share of land wealth in housing wealth, given by $\frac{P^D D}{P^H H}$, is constant, and
5. rents grow at a strictly positive rate if and only if $g^X < \frac{1-\psi^Y}{1-\psi^H}\frac{1-\eta+\eta\left(\psi^H-\psi^Y\right)}{1-\eta}g^Y$ or if $g^X < \left(1-\psi^Y\right)g^Y$.

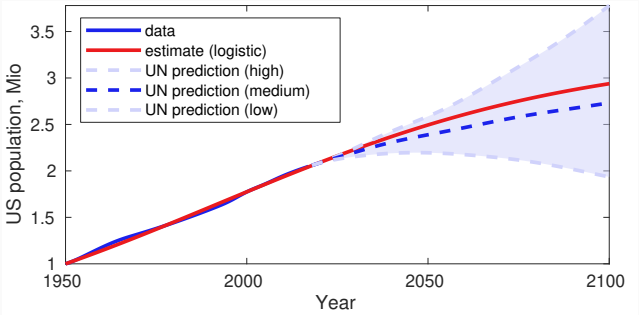
back

Calibrated outside the model (US)

Parameter	Value	Explanation/Target
θ	0.18	housing expenditure share
σ	$10/3$	intertemporal elasticity of substitution
δ^K	$\ln(1+0.056)$	capital depreciation rate
δ^X	$\ln(1+0.015)$	structure depreciation rate
β	0.613	labor income share in Y sector
$\{L_t\}_{t=0}^{\infty}$	logistic difference equation	population dynamics

back

Population dynamics



back

Endogenously calibrated parameters (US)

#	Parameter	Explanation	Value
1	ρ	time preference rate	0.040
2	g^Y	labor efficiency growth in numeraire sector	0.020
3	K_0/K^*	initial capital stock	0.227
4	γ	structures' elasticity in H	0.906
5	η	materials' elasticity in I^X	0.556
6	g^X	labor efficiency growth in construction sector	-0.014
7	X_0/X^*	initial stock of residential structures	0.191
8	α	capital elasticity in Y	0.275
9	ξ	intensity of convex adjustment cost in land development	759.05
10	D_0/D^*	initial stock of residential land	0.403

Notes: Initial states, K_0, D_0, X_0, are expressed relative to their respective final steady state values (normalized).

back

Targeted moments (US)

	Moment	Data	Model
1	$\frac{W}{NNP}$, in 1950	3.6	3.6
2	$\frac{NNP_{2015}}{NNP_{1950}}$	6.0	6.0
3	$\frac{P^H H}{NNP}$, in 1950	1.2	1.2
4	$\frac{P^D D}{P^H H} \times 100$, in 1950	11.8	11.8
5	$\frac{L^X}{L} \times 100$, long run	2.5	2.5
6	$\frac{q_{2015}}{q_{1950}}$	1.7	1.7
7	$\frac{I^H}{GDP} \times 100$, in 1950	5.6	5.6
8	$\frac{R^N N}{NNP} \times 100$, in 1950	10.0	10.0
9	Half-life of D, in years	22.6	22.6
10	$\frac{X_{2015}/D_{2015}}{X_{1950}/D_{1950}}$	1.9	1.9

back