Technological Change and the Evolution of Finance

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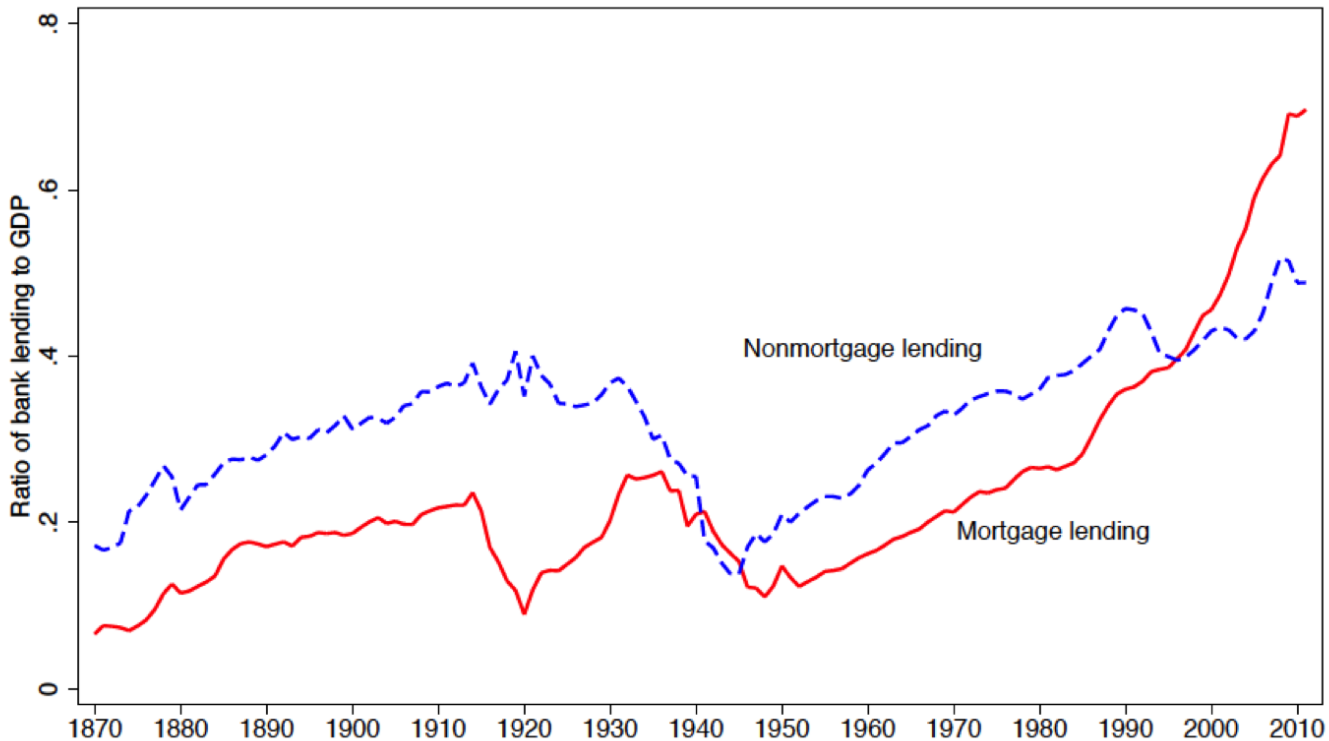
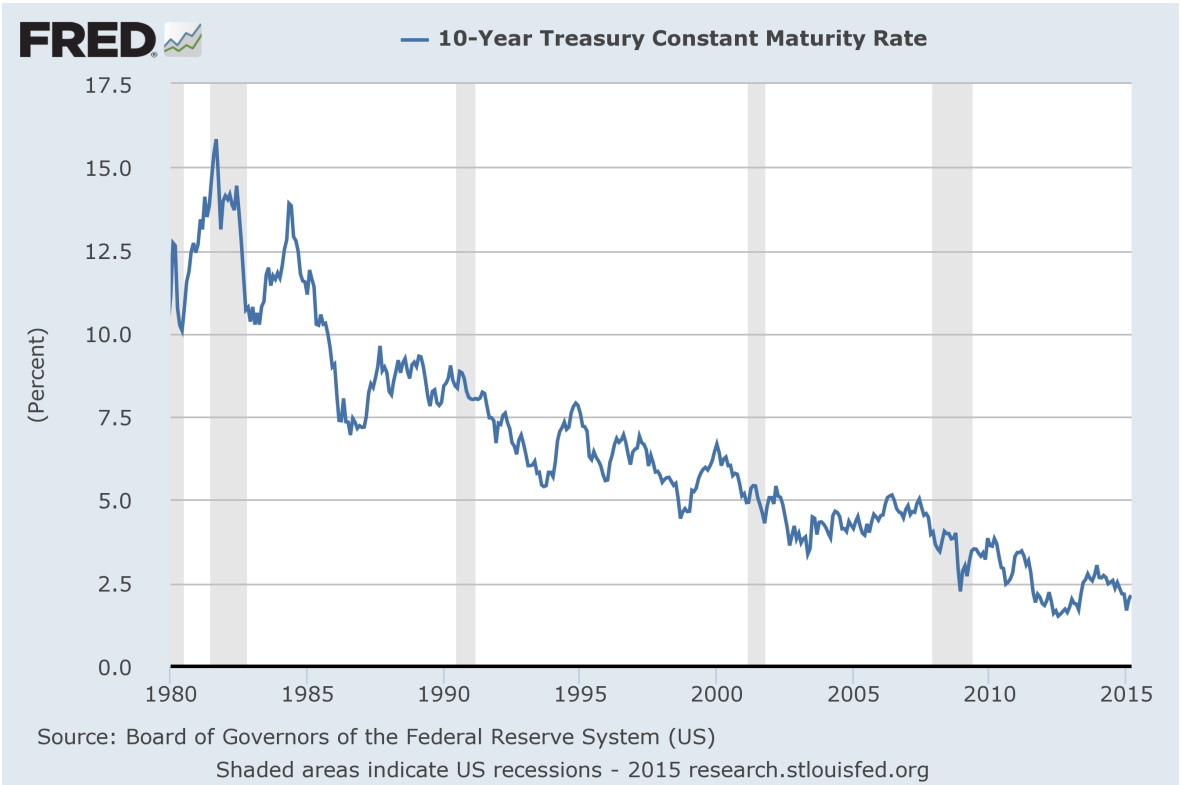
The Great Mortgaging

- Since 1980s strong growth in mortgage lending over GDP across OECD countries (Jorda Schularick Taylor, 2014)
- Often larger than corporate credit
- Strong (though volatile) trend in house prices



Falling interest rates

- Falling interest rates since 1980s
- Excess savings, secular stagnation (Summers, 2014)



Major technological change

- Increasing role of IT and human capital
- US firms increasingly invest in intangibles (Corrado Hulten 2010)

Table A1.1 Nonfarm Business Fixed Investment rates[1]

	1948-2007 (1)	1948-1972 (2)	1973-1994 (3)	1995-2007 (4)
1. Tangible	11.4	11.2	12.3	10.4
1a. ICT equipment	1.3	.6	1.6	2.0
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1d. Residential capital	1.1	1.3	1.1	.8
2. Intangible	8.6	5.9	9.2	12.8
2a. Computerized information[3]	.6	.1	.6	1.6
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(1) R&D (NSF/BEA)	1.4	.9	1.6	2.1
(2) Other R&D, etc.[4]	1.2	.5	1.3	2.2
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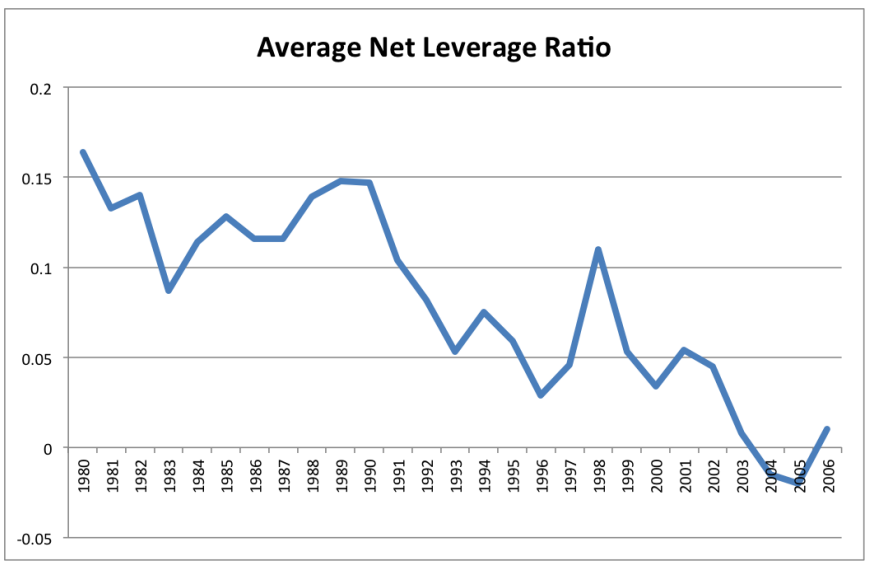
(1) Brand equity	1.6	1.6	1.5	1.8
(2) Firm-specific resources	3.2	2.3	3.4	4.6

Technological Change

Intangible capital & net leverage

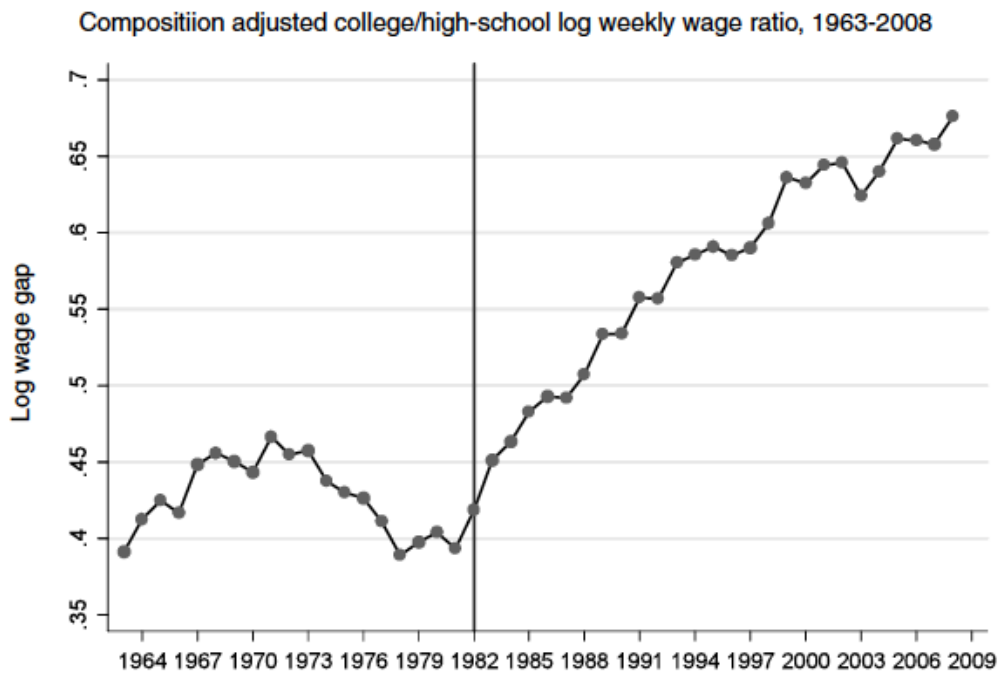
- Finance theory: external finance requires tangible pledge
- Steady drop in US corporate leverage
  - Related to lower CAPEX, increasing R&D (Bates et al. 2009)
  - Cross section net debt explained by intangibles (Falato et al. 2013)



Technological Change

Growing wage inequality

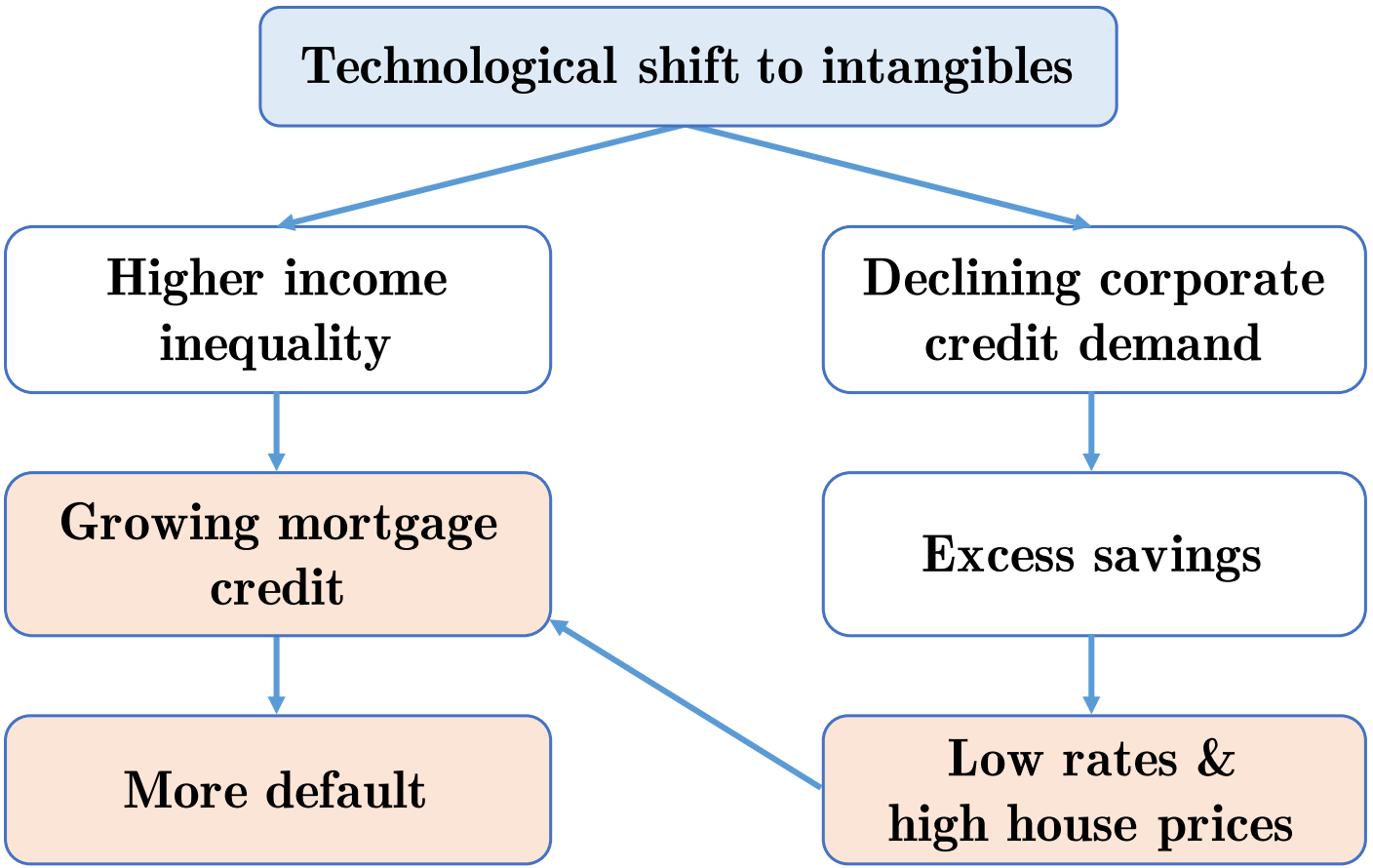
- Growing wage inequality (Acemoglu Autor, 2011)
- Explained by skill biased technological change



Framing

- Overlapping generations save for retirement:
- Four productive factors:
  - Physical capital, complementary with low-skill labor
  - Intangible capital, complementary with high-skill labor
- Outside finance requires tangible pledge
  - Only physical capital and houses can be funded externally

Contribution I: Technological Change and Finance



Contribution II: Policies on mortgage credit

- We compare prudential policies
- LTV limit
  - Lower house prices, less default
  - GE effect: redirects savings to production
- Subsidizing mortgages counterproductive
  - Higher house prices
  - Counterproductive

Related literature I

- Related empirical literature
  - Rise of household leverage, mortgage credit and housing wealth (e.g. Jorda et al. (2014), Turner (2015), Mian Sufi (2009), Rognlie (2015))
  - Skill biased technological change (e.g. Katz Murphy (1992), Autor et al. (2008), Acemoglu Autor (2011), Autor (2014), Akerman et al. (2015))
  - Increasing use of intangibles and decrease in net leverage (e.g. Corrado Hulten (2010), Bates et al (2009), Falato et al (2013), Hyytinen Pajarinen (2005), Hogan Hutson (2005))
- Inalienability of human capital
  - Hart and Moore (1994)
  - Bolton et al. (2015), Sun and Zhang (2015): inappropriability affects capital structure (employee equity compensation)

Related literature II

- Modelling savings based on OLG as in Samuelson (1958), Diamond (1965) and Tirole (1985)
  - Land unproductive store of value but not a bubble, as it yields utility
  - Giglio and Severo (2012): shift to intangibles creates condition for rational bubbles
- Secular stagnation (Summers, 2014, Eichengreen, 2015)
  - Explanations for low real rates: population growth, income inequality, global savings glut, debt overhang from crisis
  - Thwaites (2014): exogenous fall in price of capital goods
  - Here: depressed corporate borrowing due to technological change

Households

- Two goods, corn and land (or housing)
  - Land in fixed supply $\bar{L}$
  - Land price p_t
- Overlapping generations: wage at t, consume at $t+1$
  - forced to save for retirement
- Unit mass of households with utility: $U_t^i = c_{t+1}^i + v(L_t^i)$
  - Fraction ϕ high-skill, labor endowment $\tilde{h}$
  - Fraction $(1-\phi)$ low-skill, labor endowment $\tilde{l}$

Representative firm

- Representative firm with nested CES production function

$$Y_t = \left[\eta_t (H_t^{\alpha} h_t^{1-\alpha})^{\rho} + (1-\eta_t)(K_t^{\alpha} l_t^{1-\alpha})^{\rho}\right]^{\frac{1}{\rho}}$$

- η_t: stock of knowledge, captures technological change
- Physical capital K_t installed by firm
- Intangible capital H_t developed by creative skilled employees

Creation of intangible capital

- Fraction ε of high-skill has innovative talent
- Use human capital to create $H_{t+1} = \beta h_t$ intangibles for the firm
  - Intangibles investment realized next period
  - No external funding needed

External Finance

- Debt financing backed by tangible assets
  - HH borrowing backed by land ($\rightarrow$ mortgages m_t)
  - Firm borrowing backed by physical capital ($\rightarrow$ corporate debt d_t)
  - Require same return r_t
- Return to intangible hard to pledge (not appropriable)
- Innovators receive fraction ρ of returns
  - For now focus on $\rho = 1$

Household saving choice

- HHs maximize $c_{t+1} + v(L_t)$, wage income at t
- Save for retirement:
  - buy land, enjoy it by $v'(L_t^i)$, earn price increase
  - financial market, yields a return r_{t+1}
- FOC: compares returns from alternative investments:

$$\frac{(p_{t+1} - p_t) + v'(L_t^i)}{p_t} = r_{t+1}$$

Land market clearing

- Land purchase may be funded externally
- In equilibrium agents consume same amount of land: $L_t^i = \bar{L}$
- Households with $y_t^i \geq p_t \bar{L}$ invest in financial claims)
- Others take out a mortgage to buy a house (borrowers)

Financial market clearing

- Savings supply $(1-\alpha)Y_t$: income going to labor
- Intermediated via pledge of tangible assets
- Financial market clearing

$$\underbrace{(1-\alpha)Y_t}_{\text{savings}} = \underbrace{p_t\bar{L} + K_{t+1}}_{\text{savings vehicles}}$$

- Intangibles not a savings vehicle

Define technological progress

- Rise in knowledge η increases productivity:

$$\frac{\partial Y}{\partial \eta} > 0 \qquad \text{(H1)}$$

- Affects relative productivity (unlike Solow's residual)

$$Y_t = \left[\eta_t (H_t^{\alpha} h_t^{1-\alpha})^{\rho} + (1-\eta_t)(K_t^{\alpha} l_t^{1-\alpha})^{\rho}\right]^{\frac{1}{\rho}}$$

- Result: wage inequality widens: $\frac{q}{w} = \frac{\eta}{1-\eta}\frac{l}{h}$

Steady state: falling interest rates

Proposition 1

Technological progress (defined as H1) reduces steady-state interest rates: $\frac{dr}{d\eta} < 0$

- As firms move to intangibles, demand for corporate credit falls
- As a result, interest rates fall

Steady state comparative statics

- As $\frac{K}{Y}$ falls, $\frac{p}{Y}$ increase to absorb slack savings.
- Land prices rise to absorb slack savings: $p = \frac{v'(\bar{L})}{r}$
- Supply of mortgage funding rises, what about demand?
- (Later: outside equity, public debt) ▸ Case $\rho < 1$

Rising mortgage credit

- Mortgage demand
  - Low rates, high land prices
  - Income inequality
- Growth effect
  - Higher income dampens need to borrow

Steady state: rising mortgage credit

Proposition 2

Technological progress increases steady-state mortgage credit to GDP, i.e. $\frac{d(m/Y)}{d\eta} \geq 0$, *if and only if*

$$\frac{dY/d\eta}{Y} \leq \frac{1}{1-\eta}\left[1 + \frac{(1-\alpha)^2 r}{\alpha[(1-\phi)+\phi\varepsilon](p\bar{L}/Y)}\right] \qquad \text{(H2)}$$

- Under (H2) growth effect is dominated
- Low-skill workers need to leverage up

▸ Simulation

Mortgage default

- Introduce temporary, idiosyncratic "bad weather shocks" ξ_t^i
- $\mathbb{E}_t \xi_{t+1}^i = 0$
- $\xi_t^i > 0$ bad weather damages house, need to repair
- House trades at discount $p_t^i = p_t(1 - \xi_t^i)$
- HH with $\xi_t^i > \hat{\xi}_t^i$ default, where

$$\hat{\xi}_t^i = 1 - \frac{p_{t-1}}{p_t} LTV_{t-1}^i$$

Technological change and mortgage defaults

- Aggregate mortgage default is $\chi_t \equiv 1 - G(\hat{\xi}_t^l)$

Corollary 1

Technological progress that results in rising mortgage credit relative to GDP (i.e. satisfies (H2)) also produces increasing steady-state default ($\frac{d\chi_t}{d\eta} \geq 0$)

Is there a role for public policy?

- Falling interest rates boost house prices
- Increasing leverage and defaults
- Yet no case yet for limiting mortgage credit
- Economy dynamically efficient, no market failure
  - Controlling mortgage credit implies wealth redistribution
  - Reduces defaults and subsidizes output
  - Intervention as intergenerational political choice

Intergenerational redistribution via LTV limit

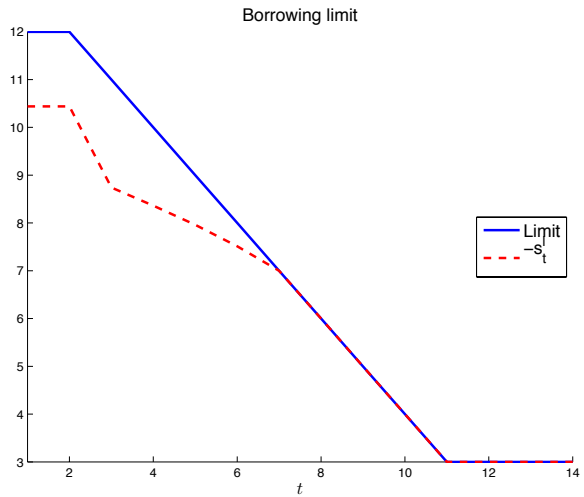
- Set $\bar{m}$ to maximize aggregate utility in steady state $\int_0^1 \mathbb{E}U^i di$
- FOC

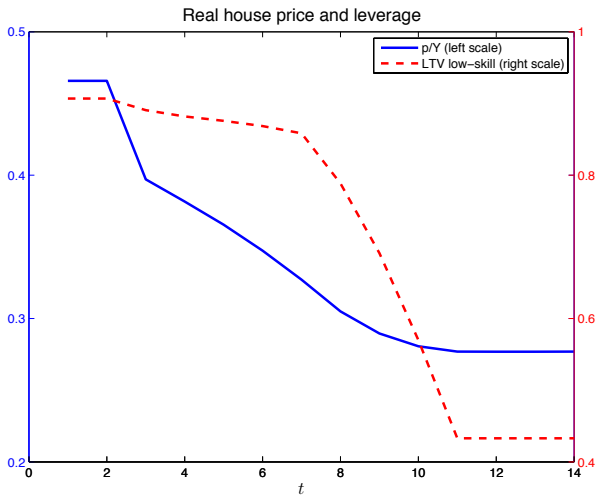
$$\underbrace{\int_0^1 v'(L^i)\frac{dL^i}{d\bar{s}}di}_{\text{land misallocation}} = \underbrace{-\frac{dY}{d\bar{s}}]}_{\text{output gain}}$$

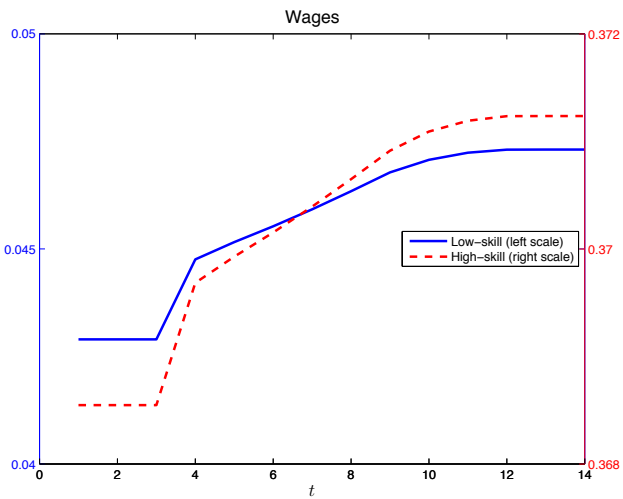
- In the long run, borrowing limit benefits all agents
- Low-skill workers benefit most: higher wages and lower rates
- However, current generation of homeowners loses out
- No welfare improvement without some market failure

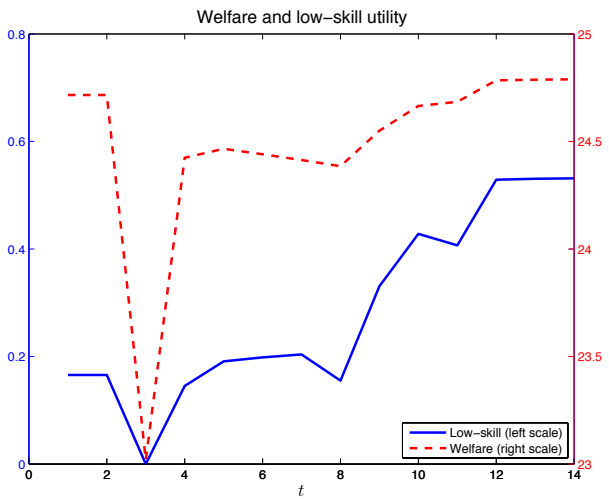
Limiting mortgage credit: simulated time path

Note: here abstracting from foreclosure cost









Welfare analysis

- Arguably, mortgage defaults have significant welfare costs
  - IMF (2003, 2009), Claessens et al. (2009): property price busts long lasting and result in large output losses
  - Mian and Sufi (2014), Mian Rao and Sufi (2013): housing downturn of 2007 responsible for drop in aggregate demand and high unemployment.
- Assume deadweight loss from default $C(\chi_t)$, for generation $t-1$
- We show that there exists inter-generational transfer scheme $\{x_{T+t}\}_{t=0}^{\infty}$ s.t. all generations are better off (e.g. pension)

Public policy II: mortgage subsidy

- Subsidy $\tau_t < r_t$ on mortgages
  - Effective interest rate reduces to $(r_t - \tau_t)$
- Transfer from rich lenders to poor borrowers
- However, GE effects divert savings to land
  - Opposite of LTV limit
  - Less capital investment, lower wages
  - Low-skill workers affected particularly

Conclusion

- Technological change triggers endogenous developments
  - Shift to intangibles, declining corporate credit demand
  - Rising income inequality
- Two trends combine to explain low rates, high asset prices, growth in mortgage credit
- General equilibrium effects motivate LTV limit
- Mortgage subsidy counterproductive

Intangible capital

- US firms increasingly use intangible inputs (Corrado Hulten, 2010)

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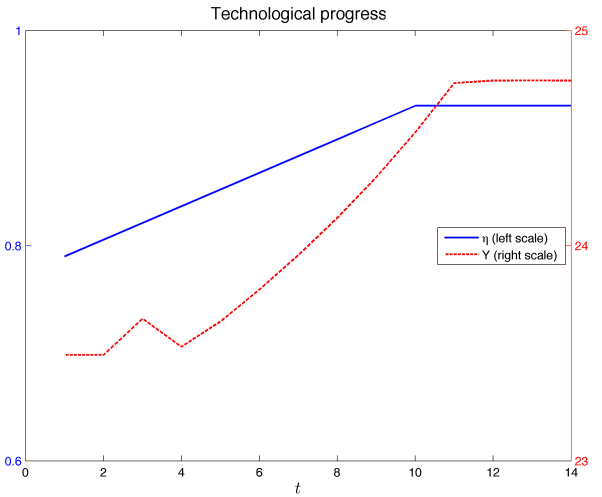
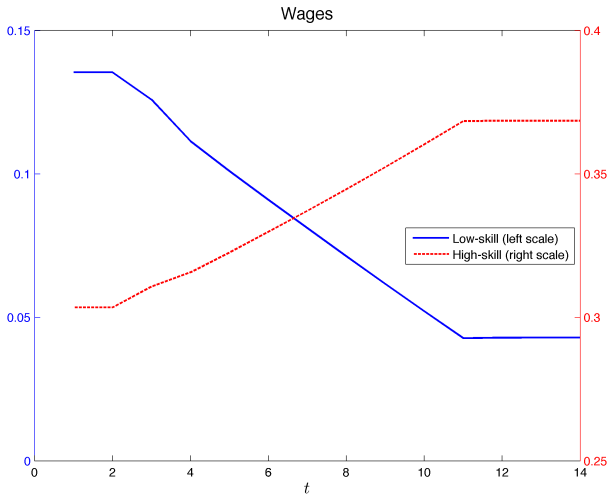
Calibration exercise

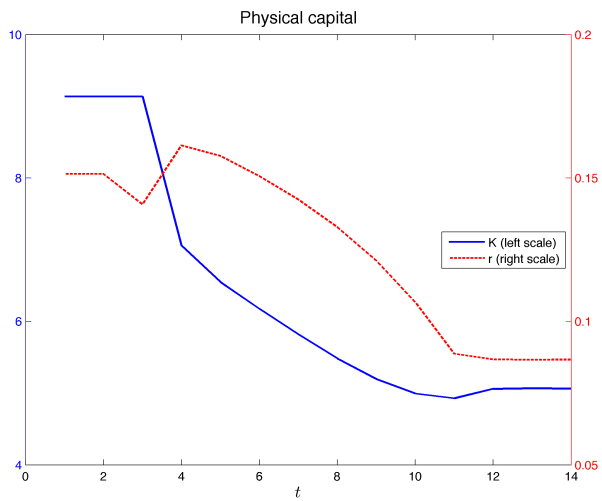
- Calibrate parameters to the US economy in 1980
- Change η over time, target intangible-tangible investment ratios of Corrado and Hulten (2009)

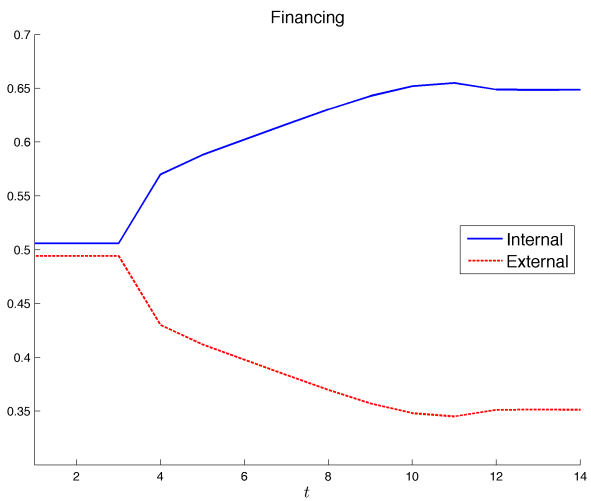
Parameter	**Calibration method**
$\alpha = 0.33$	Income share capital
$\phi = 0.17$	Fraction of population Bachelor degree or higher
$\rho = 0.7/1.7$	Elasticity of substitution high-skill/low-skill $= 1.7$
$\varepsilon = 0.18$	Fraction of population self-employed
$\bar{L} = 1$	Normalization
$\tilde{I} = 25, \tilde{h} = 305,$	Target steady state interest rate, wage gap
$\underline{\eta} = 0.79$	and tangible-intangible ratio 1980
$\bar{\eta} = 0.93$	Target steady state tangible-intangible ratio in 2000s

Simulated time path of technological change









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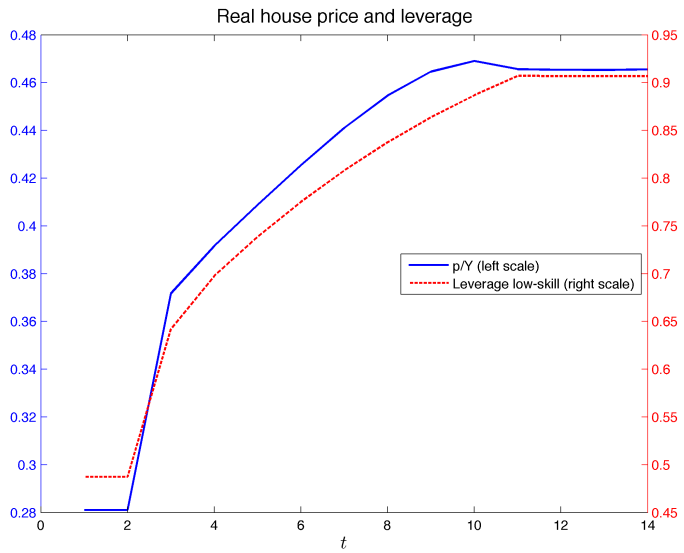

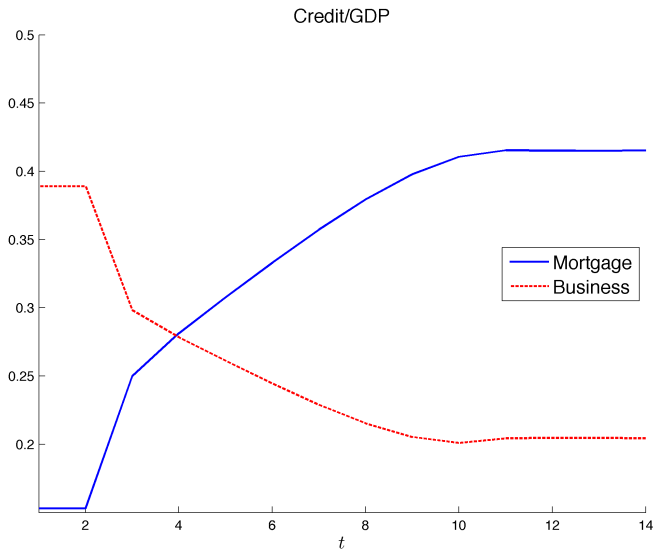

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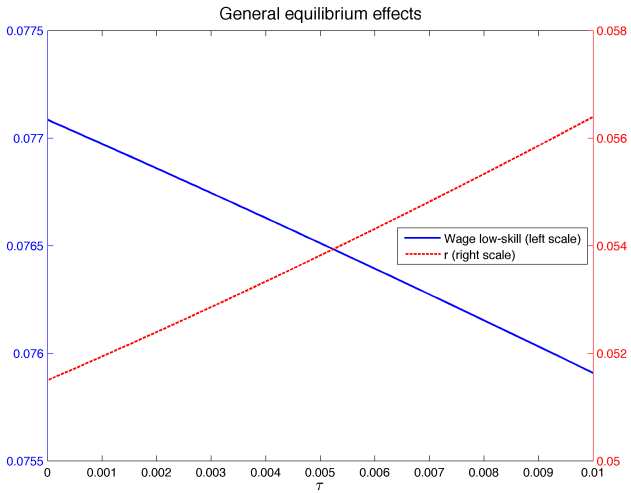
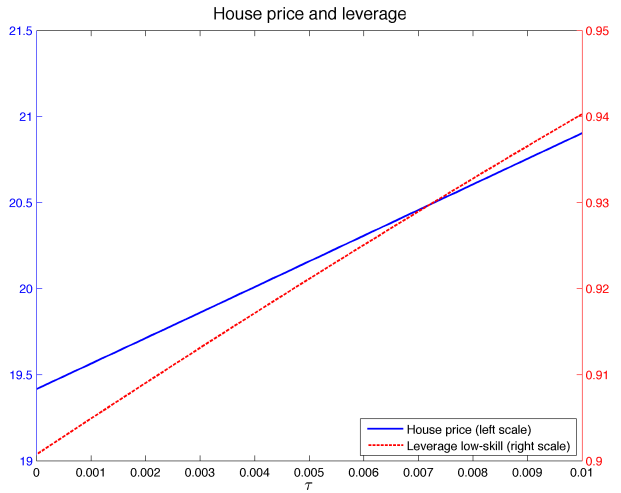
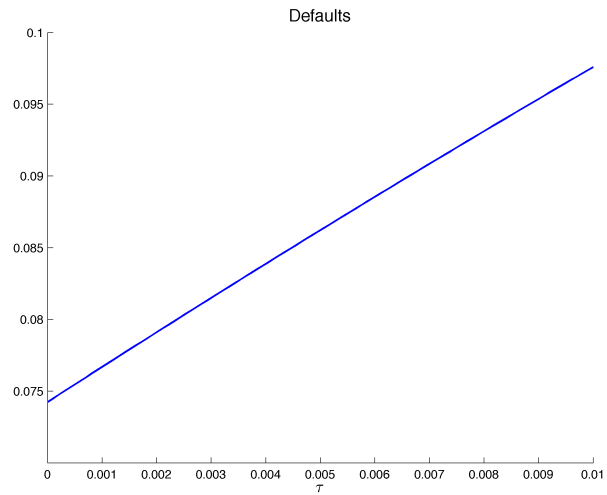
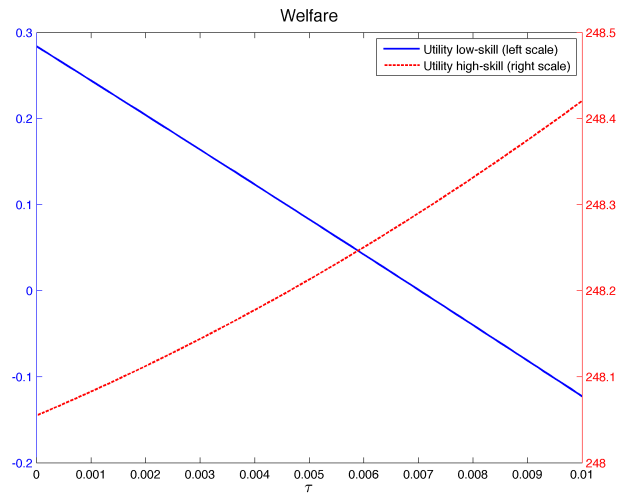
Comparing across steady states







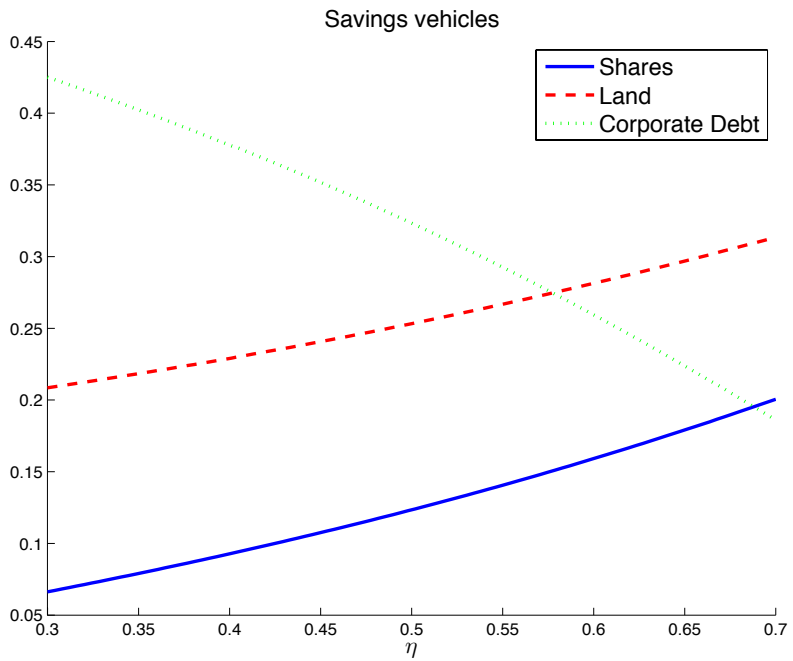


Extension: shares as savings vehicle

- If $\rho < 1$, return to intangibles partially appropriable by firm
- Return can be partially promised to equity, additional savings vehicle
- Steady state share price $f = (1 - \gamma)\frac{HR}{r}$

Extension: shares as savings vehicle

- Now shares absorb some of the savings



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