Reallocation of Intangible Capital and Secular Stagnation

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4. Increase in cross sectional productivity dispersion within industries (Kehrig, 2015).

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3. Build a more detailed model to show qualitative and quantitative results:
   - Decline in interest rates (caused by HH sector developments) stimulates capital production and increases output in a "tangible economy"
   - Decline in interest rates (caused by HH sector developments) **simultaneously with the rise in intangibles** has progressively stronger negative effects on capital reallocation, aggregate productivity and output. Simulations consistent with the 4 empirical trends mentioned before.

Related literature

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3. Financial frictions, heterogeneous agents, and misallocation

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Infinite-horizon, discrete-time economy

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- Are credit constrained, borrow to the limit, $\frac{\theta q K}{1+r}$ to buy qK to produce zK :

$$K = \frac{A(1+r)+Y}{q\left(1-\frac{\theta}{1+r}\right)} \quad \text{where} \quad q = \frac{z_u}{r+\xi} \text{ and } \xi > 0$$

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$$A(\theta = 0) > 0;\ A'(\theta) < 0;\ A(\overline{\theta}) < 0$$

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Low productivity firms are unconstrained, infinitely lived, and absorb $\overline{K} - K$ to produce $z^u\left(\overline{K} - K\right)$ with $z^u < z$

- Efficiency: share of $\overline{K}$ allocated to high-productivity firms

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- How does r affect the allocation of K?

$$\frac{dK}{dr} = \overbrace{\frac{A(\theta)}{q\left(1-\frac{\theta}{1+r}\right)}}^{\substack{\text{savings(A>0)} \\ \text{debt overhang channel(A<0)}}} + K\left[\overbrace{\frac{1}{r+\xi}}^{\text{capital price ch.}} - \overbrace{\frac{\theta}{(1+r-\theta)(1+r)}}^{\text{collateral value channel}}\right]$$

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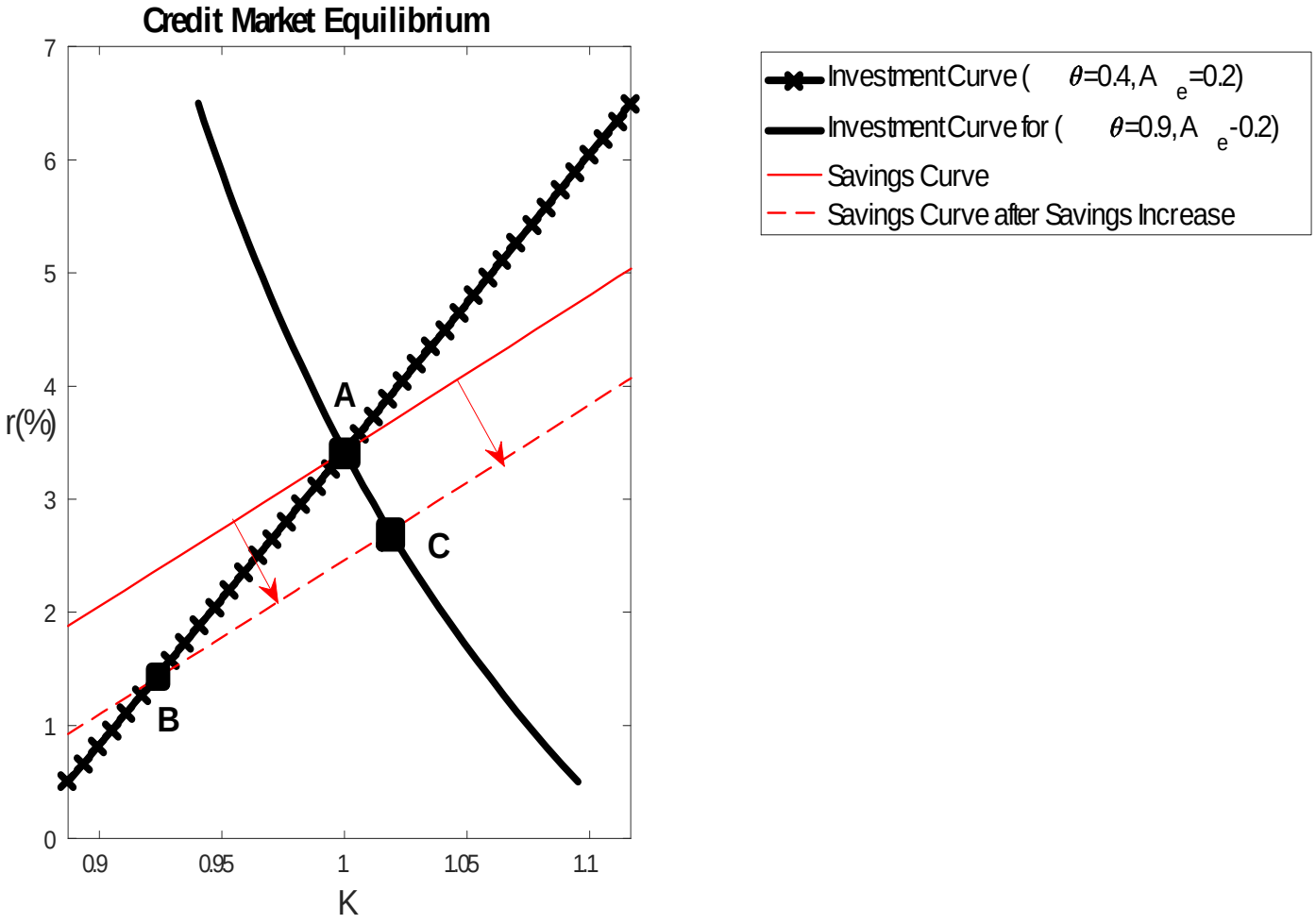
Graphical Intuition



- Demand for capital becomes upward sloping in interest rate with high intangibles reliance

2) Motivating empirical evidence

Declining Real Interest Rate

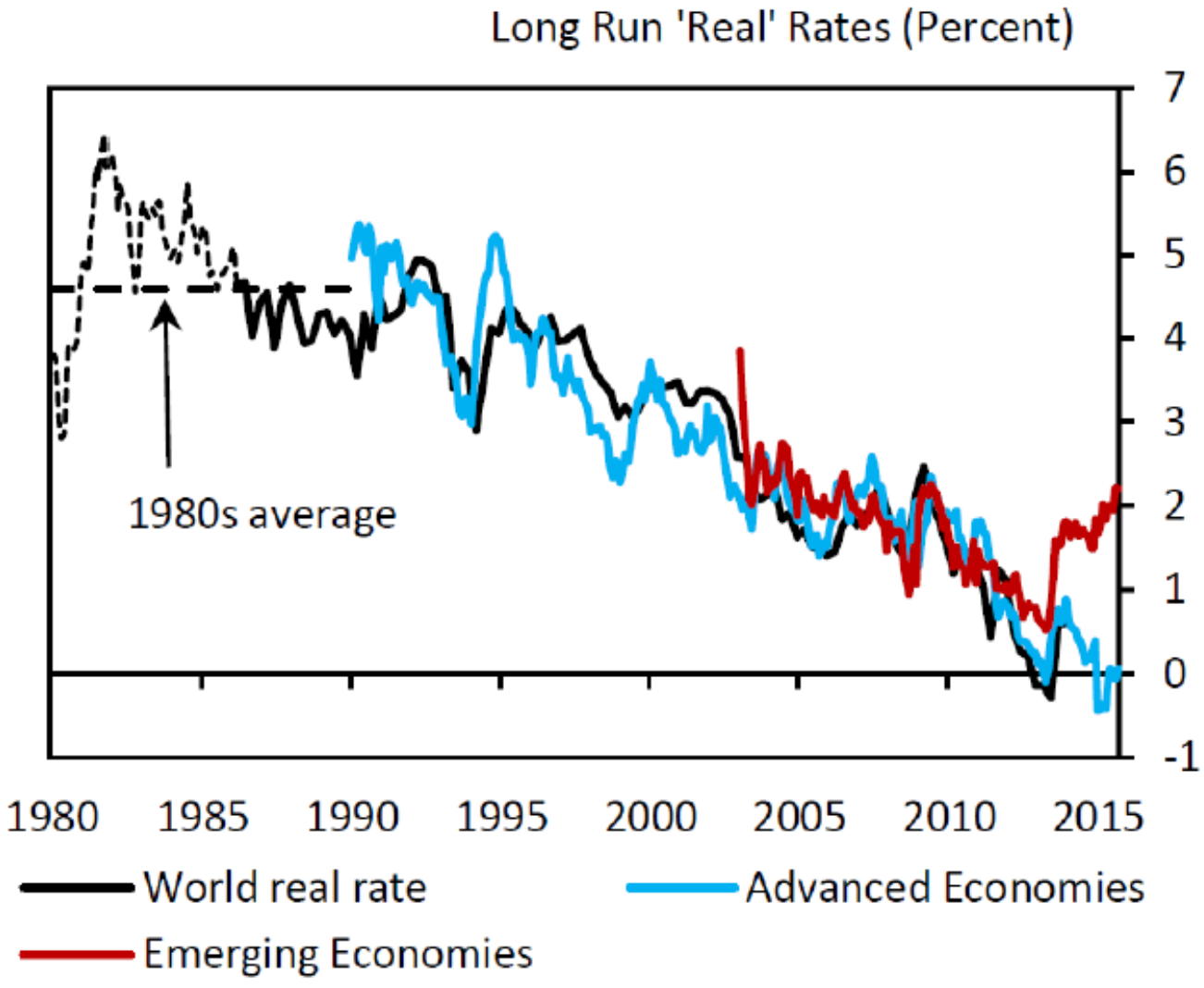


Figure: Source: Rachel and Smith (2015)

Rise in intangibles

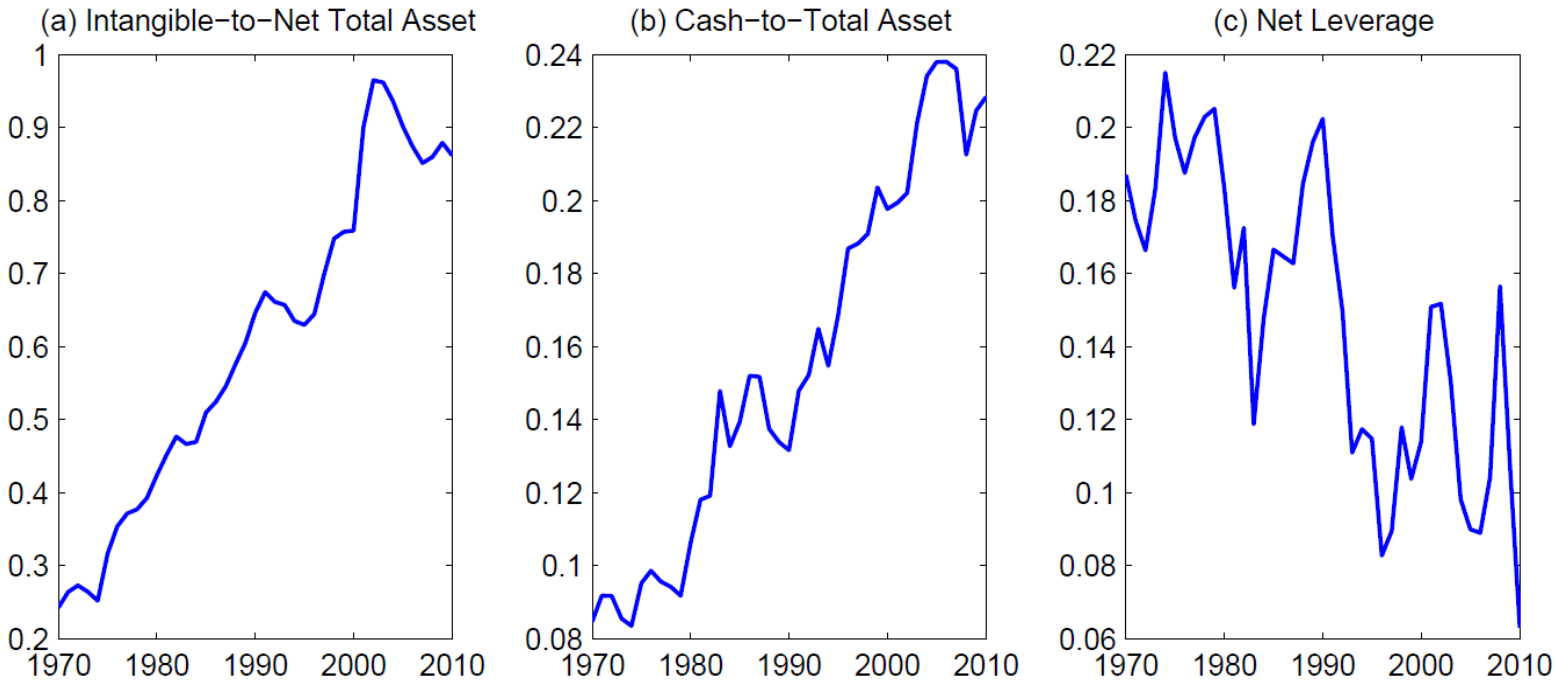


FIGURE: Rise in intangible intensity reduction in net leverage in U.S. non-financial listed firms (*Source: Falato, Kadyrzhanova and Sim (2014)*)

Rise in Corporate savings

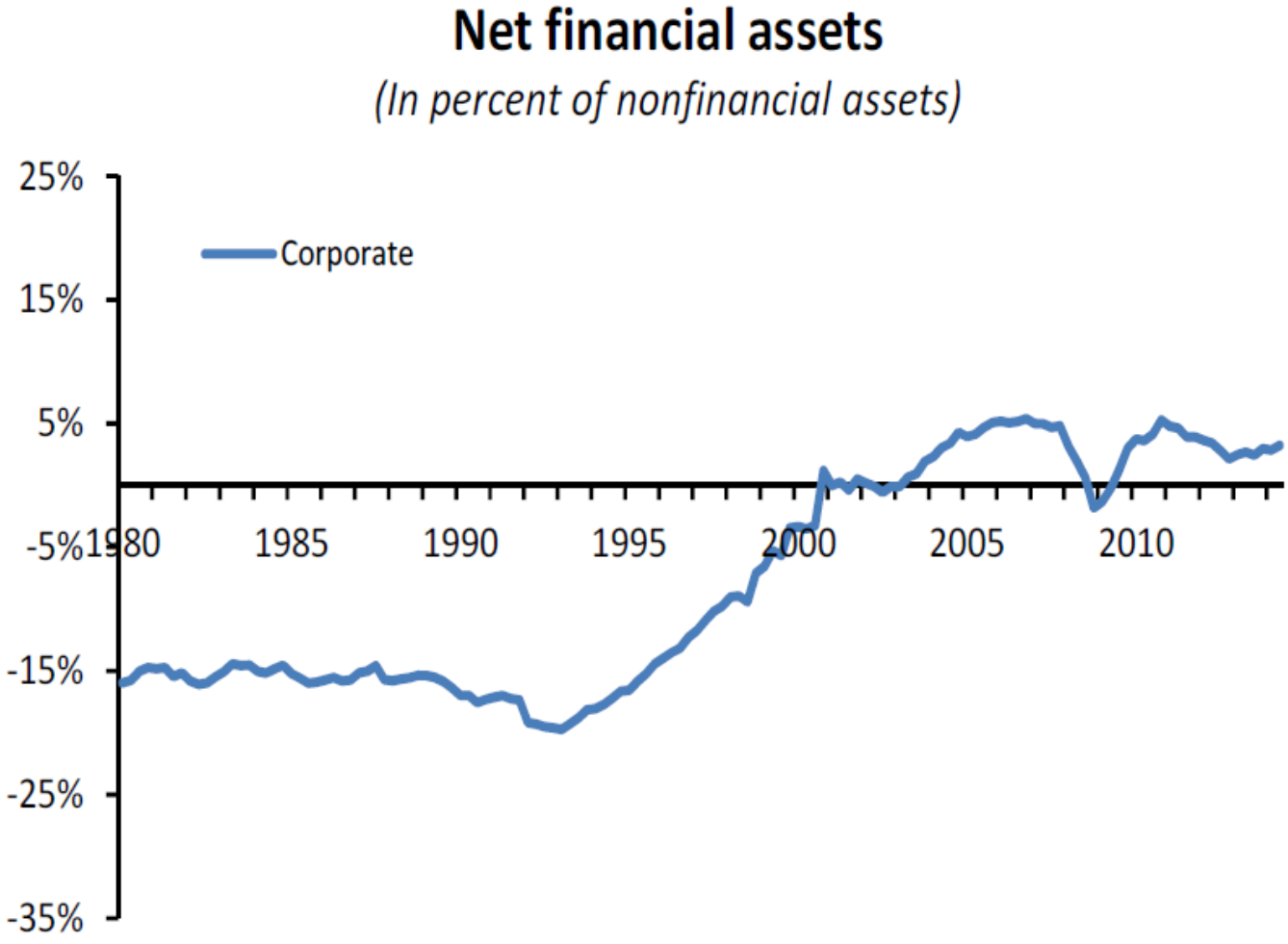


Figure: Net financial position of US non financial corporations (Quadrini 2016)

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  - Especially for innovative firms (R&D$>$0)
  - And especially for financially constrained firms.
- Begenau and Palazzo (2016) Increase in cash holdings of public firms is driven by young R&D intensive firms, which finance investment with internal finance (rationalized by a model with financial frictions).

Dispersion of productivity and Intangibles Intensity

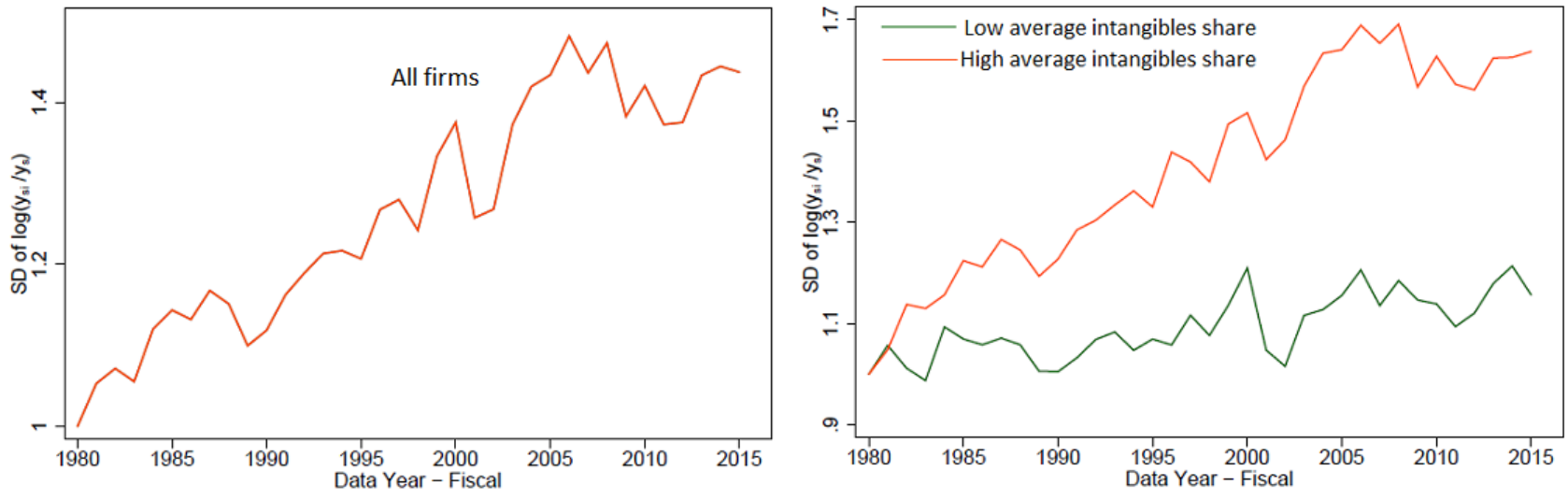

Figure: Within industry dispersion in firm-level labour productivity, Compustat Data

Similar picture for TFP

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- **Household sector**
  - Life-cycle with two types of households, young and old (measures H^y and H^o, $H^y + H^o = 1$)
  - Young households: remain young for N=40 years. Work (supply a measure 1 of specialized labour to each type of firm) and receive dividends.
  - Old households (N>40): cannot work, receive dividends , die with probability ϱ (Blanchard (1985) and Yaari (1965) framework))

FINAL GOOD PRODUCERS: HIGH PRODUCTIVITY FIRMS

- Produce consumption goods according to

$$y_t^p = z_t n_t^{(1-\alpha)} \left[\min \left(\frac{k_{T,t}}{1-\mu}, \frac{k_{I,t}}{\mu} \right) \right]^{\alpha},$$

where $\mu = \frac{k_{I,t}}{k_{I,t}+k_{T,t}}$ captures optimal intangible capital ratio

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- Maximize PV dividends paid out to shareholders:

$$d_t = y_t^p - w_t n_t + (1+r_t) a_{f,t} - a_{f,t+1} - \sum_{j=T,I} q_{j,t} \left(k_{j,t+1} - (1-\delta) k_{j,t} \right)$$

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- Financial constraints
  - Unable to issue equity: $d_t \geq 0$.
  - Can issue one-period riskless debt, subject to:

$$a_{f,t+1} \geq -\frac{\theta^T q_{T,t+1} (1-\delta) k_{T,t+1} + \theta^I q_{I,t+1} (1-\delta) k_{I,t+1}}{1+r_{t+1}}$$

  - $\theta^T > \theta^I$

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- If firm survives, **investment shock**: only fraction η of firms can purchase capital.

Productive Firms: Value Function

- Investing firm value function

$$V_t^+(k_{I,t}, a_{f,t}) = \max_{a_{f,t+1}, k_{I,t+1}} d_t + \frac{1-\psi}{1+r_{t+1}} \eta V_{t+1}^+(k_{I,t+1}, a_{f,t+1}) + \frac{1-\psi}{1+r_{t+1}} (1-\eta) V_{t+1}^-(k_{I,t+1}, a_{f,t+1}) + \frac{\psi d_{t+1}^{exit}}{1+r_{t+1}}$$

- Non-investing firm value function

$$V_t^-(k_{I,t}, a_{f,t}) = \max_{a_{f,t+1}} d_t + \frac{1-\psi}{1+r_{t+1}} \eta V_{t+1}^+(k_{I,t+1}, a_{f,t+1}) + \frac{1-\psi}{1+r_{t+1}} (1-\eta) V_{t+1}^-(k_{I,t+1}, a_{f,t+1}) + \frac{\psi d_{t+1}^{exit}}{1+r_{t+1}}$$

Investing Firms: Constrained Investment Choice

- Claim (check later) - in equilibrium marginal return of capital always higher than marginal cost:

$$\frac{\partial y^{p}_{t+1}}{\partial k_{I,t+1}} > \left(q_{T,t} \frac{1-\mu}{\mu} + q_{I,t} \right) - \frac{(1-\delta)\left(q_{T,t+1} \frac{1-\mu}{\mu} + q_{I,t+1} \right)}{1 + r_{t+1}}$$

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- Therefore, firms invest as much as possible, subject to a binding borrowing constraint:

$$\begin{aligned} k_{I,t+1} &= \frac{y^p_t - w_t n_t + (1+r_t) a_{f,t} + (1-\delta)\left(q_{T,t} \frac{1-\mu}{\mu} + q_{I,t} \right) k_{I,t}}{\left(q_{T,t} - \frac{\theta^T q_{T,t+1}}{1+r_{t+1}} \right) \frac{1-\mu}{\mu} + q_{I,t} - \theta^I \frac{q_{I,t+1}}{1+r_{t+1}}} \\ &= \frac{\text{Available wealth}}{\text{Downpayment}} \end{aligned}$$

Borrowing and Savings Choice

- Firms always retain all earnings $(d_t = 0)$

- Investing firms borrow as much as possible:

$$a^{+}_{f,t+1} = -\left(\theta^{T}\frac{q_{T,t+1}}{1+r_{t+1}}\frac{1-\mu}{\mu} + \theta^{I}\frac{q_{I,t+1}}{1+r_{t+1}}\right)k_{I,t+1} < 0$$

- And non-investing firms save as much as possible:

$$a^{-}_{f,t+1} = y^{p}_{t} + (1+r_t)a_{f,t} - w_t n_t$$

FINAL GOOD PRODUCERS - LOW PRODUCTIVITY FIRMS

- Production function:

$$y_t^u = z_t^{u,l} n_{ul,t}^{1-\alpha} k_{ul,t}^{\alpha} + z_t^{u,T} n_{uT,t}^{1-\alpha} k_{uT,t}^{\alpha}$$

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- They are the marginal buyers of capital and price it:

$$q_{l,t} = z_l^{u,l} \alpha \left(\overline{K}_t^l - K_{l,t} \right)^{\boldsymbol{\alpha-1}} + \frac{1-\delta}{1+r_{t+1}} q_{l,t+1},$$

$$q_{T,t} = z_t^{u,T} \alpha \left(\overline{K}_t^T - K_{T,t} \right)^{\alpha-1} + \frac{1-\delta}{1+r_{t+1}} q_{T,t+1},$$

Steady State

- Total amount of steady state intangible capital K_I held by the high productivity firms:

$$K_I = \frac{\overbrace{\eta(1-\psi)\left[\alpha z\left(\frac{K_I}{\mu}\right)+(1+r)A_f\right]+\eta\psi W_0}^{\text{aggregate internal funds available for investment by productive firms}}}{(Q-Q_\theta)\left[\delta+\psi(1-\delta)\right]-Q_\theta\eta(1-\delta)(1-\psi)},$$

$$Q = q_T\frac{1-\mu}{\mu}+q_I;\ Q_\theta = q_T\frac{\theta^T}{1+r}\frac{1-\mu}{\mu}+q_I\frac{\theta^I}{1+r}$$

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- The financial wealth of high productivity firms:

$$A_f = \frac{\overbrace{(1-\psi)\,\alpha z_t\left(\frac{K_I}{\mu}\right)^{\alpha}+\psi W_0}^{\text{retained earnings}}-\overbrace{\left(q_T\frac{1-\mu}{\mu}+q_I\right)\left[\psi+\delta(1-\psi)\right]K_I}^{\text{cost of replacing capital}}}{\left[1-(1-\psi)\,(1+r)\right]}$$

Steady State

- Prices of capital

$$q_I = \frac{\alpha z^{u,I}}{r+\delta} \frac{1}{\left(\overline{K}^I - K_I\right)^{\mathbf{1}-\boldsymbol{\alpha}}}, \tag{1}$$

$$q_T = \frac{\alpha z^{u,T}}{r+\delta} \frac{1}{\left(\overline{K}^T - K_T\right)^{\mathbf{1}-\boldsymbol{\alpha}}}, \tag{2}$$

- Supply of capital

$$\overline{K}^J = \frac{I^J}{\delta}, \text{ with } I^J = \varphi \left(\frac{q_J}{b^J}\right)^{\frac{1}{\varphi-1}} \tag{3}$$

for $J \in \{I, T\}$.

$$I^J = \varphi \left(\frac{q_J}{b^J}\right)^{\frac{1}{\varphi-1}} \tag{4}$$

Calibration

Parameter	Symbol	Value
Discount factor	β	0.95
Capital share, final good firms	α	0.4
Intangible share of total capital	μ	0.20
Unproductive firms, TFP tangible technology	$z_t^{u,T}$	10
Unproductive firms, TFP tangible technology	$z_t^{u,I}$	10
Years households remain young	N	40
Probability of death of old households	ϱ	0.25
Productivity parameter	z	25
Collateral value of tangible capital	θ^T	1
Collateral value of intangible capital	θ^I	0.6
Probability of an investment opportunity	η	0.07
Additional productivity of intangible capital	κ	0.25
Adjustment cost convexity	φ	4
Adjustment cost parameter (intangible)	b_I	0.00018
Adjustment cost parameter (tangible)	b_T	0.00004
Exit probability of high-productivity firms	ψ	0.19
Endowment of new firms	W_0	5
Depreciation of capital	δ	0.15
Share of dividends to young households	γ	50.2%

Note: θ^T, θ^I large, compensate for no equity issues.

Rise in Intangibles and Increase in Household Net Savings (U.S. 1970s-present)

1. Increase in firms' reliance on intangible capital

- Follow Corrado and Hulten (2010a), Falato et al (2013), Döttling and Perotti (2015):
  - from $\mu = 0.2$, 1970s ratio of intangible to tangible of 20%
  - to $\mu = 0.6$ 2010's ratio of intangible to tangible 60%
  - Shortcut for endogenous process of adoption of more productive technologies

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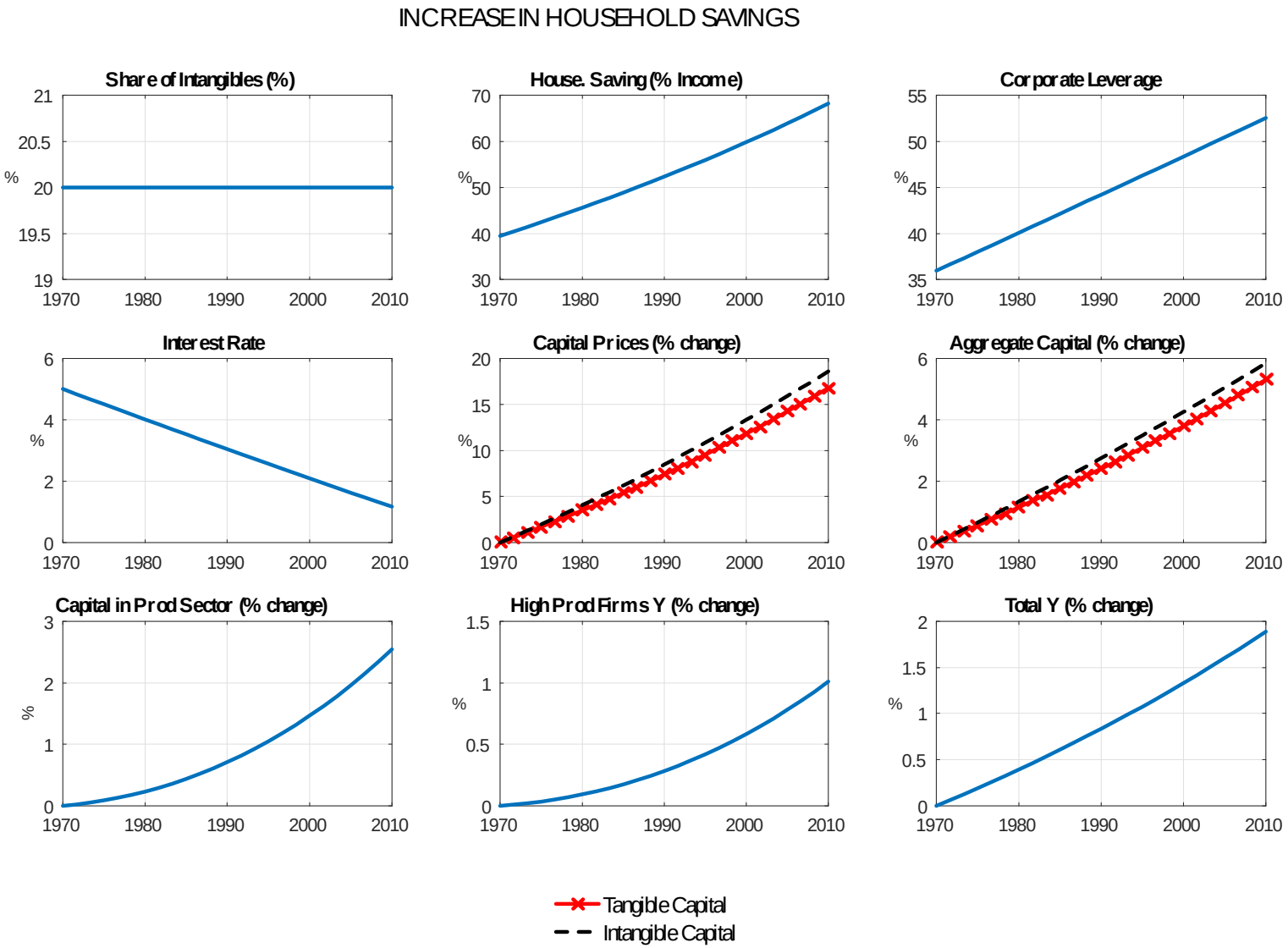
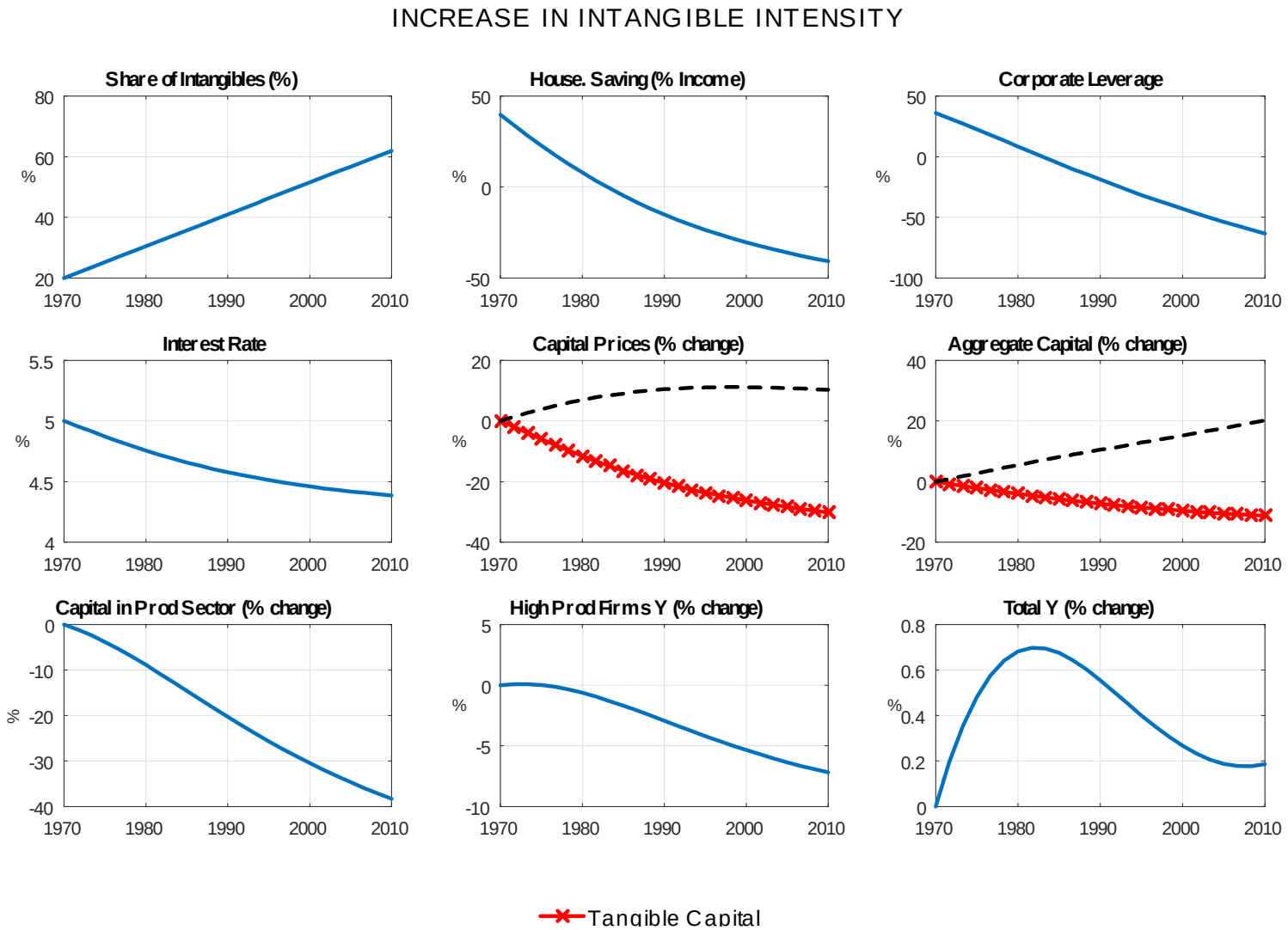
2. Household sector increase in net savings

- Captures demand side factors such as demographic forces, higher inequality, and higher saving by emerging market governments, over last three decades (Rachel and Smith, 2015)
- Increase in longevity and decrease in rate of time preference
- Achieve transition from 5% to 1% real interest rate

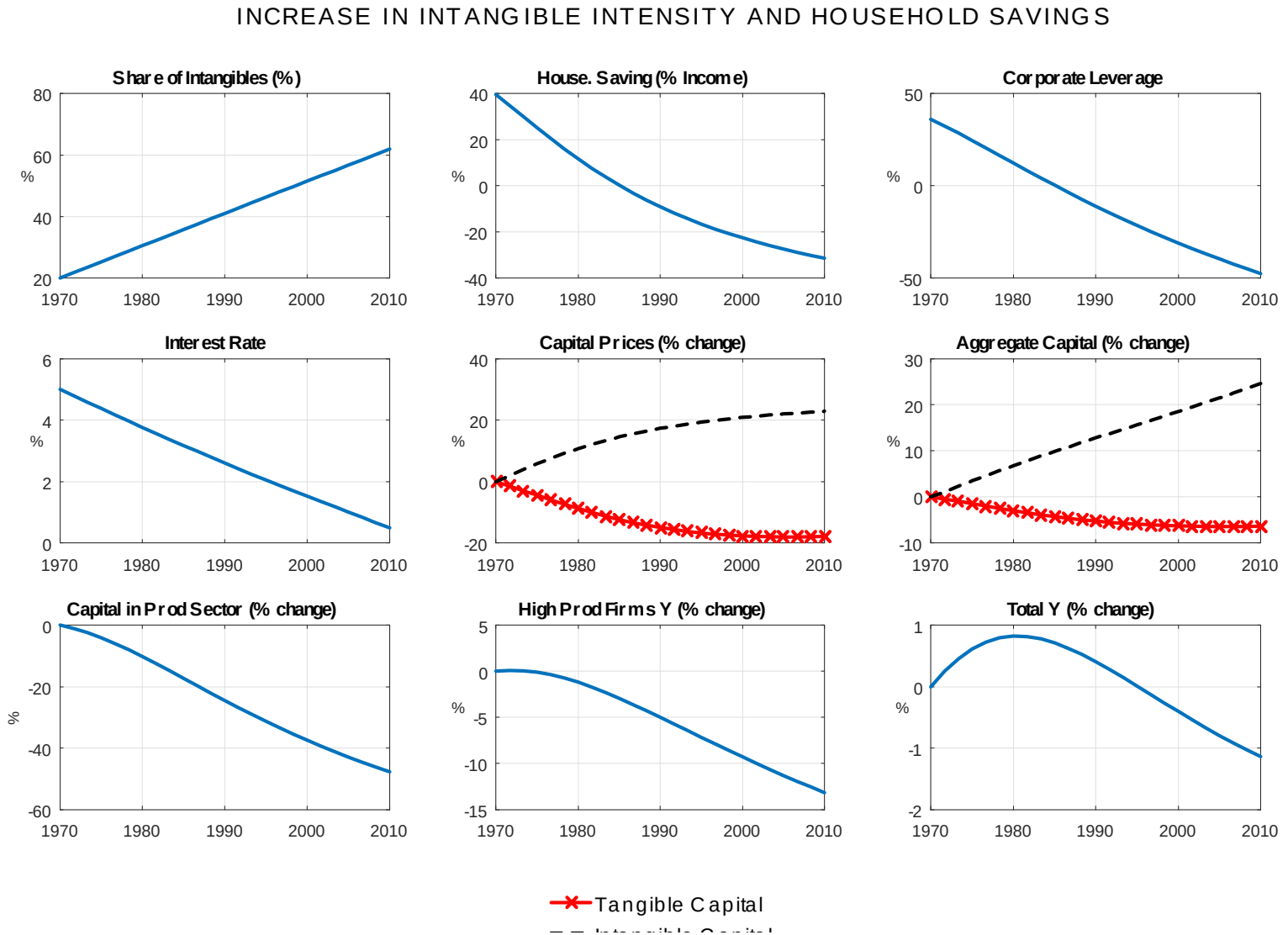
INCREASE IN HOUSEHOLD SAVINGS



RISE IN INTANGIBLES



Increase in Household Savings and Rise in Intangibles



MISALLOCATION

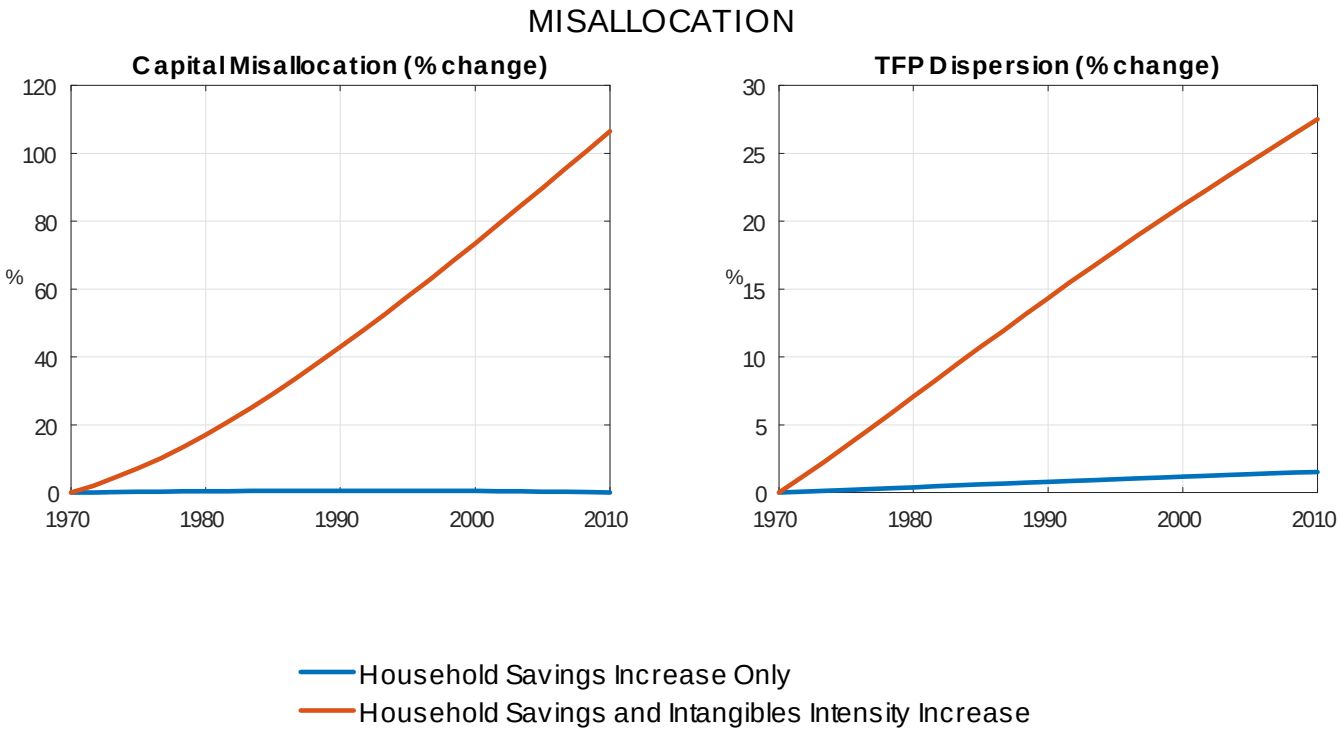


FIGURE: Misallocation the different simulation exercises.

Output growth

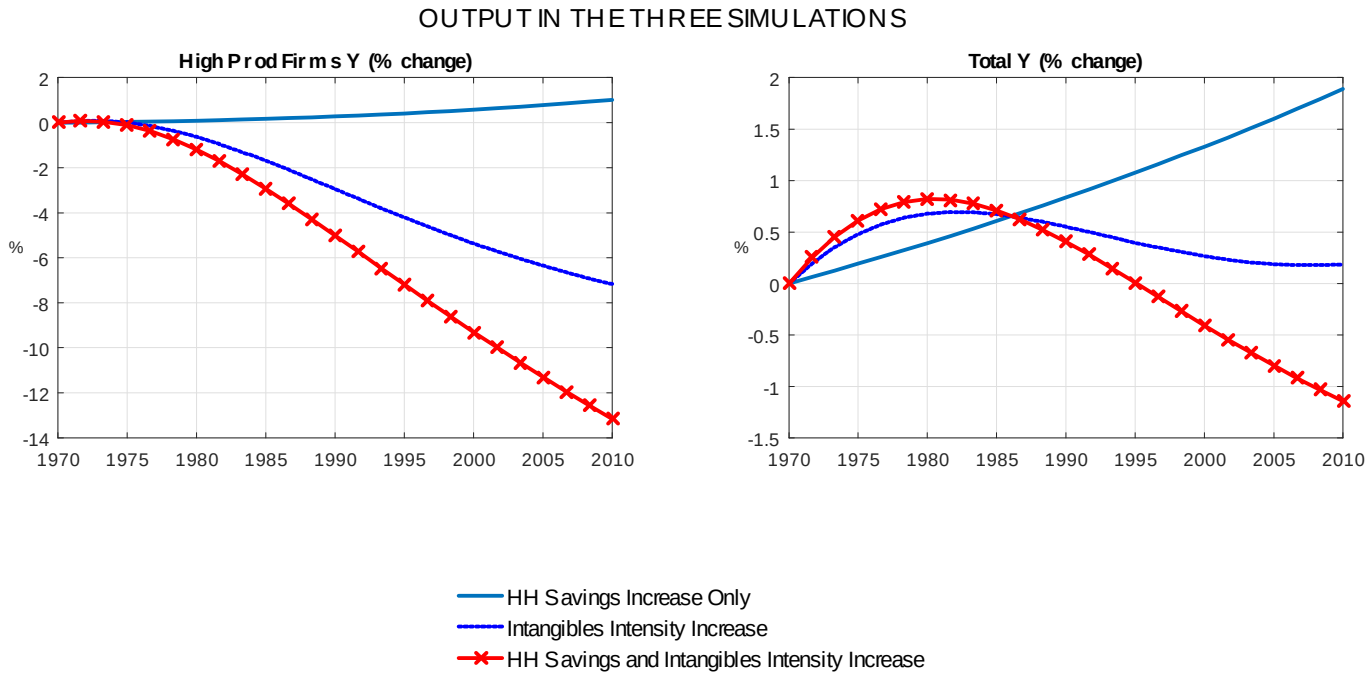


FIGURE: Summary of the three simulation exercises.

Output growth

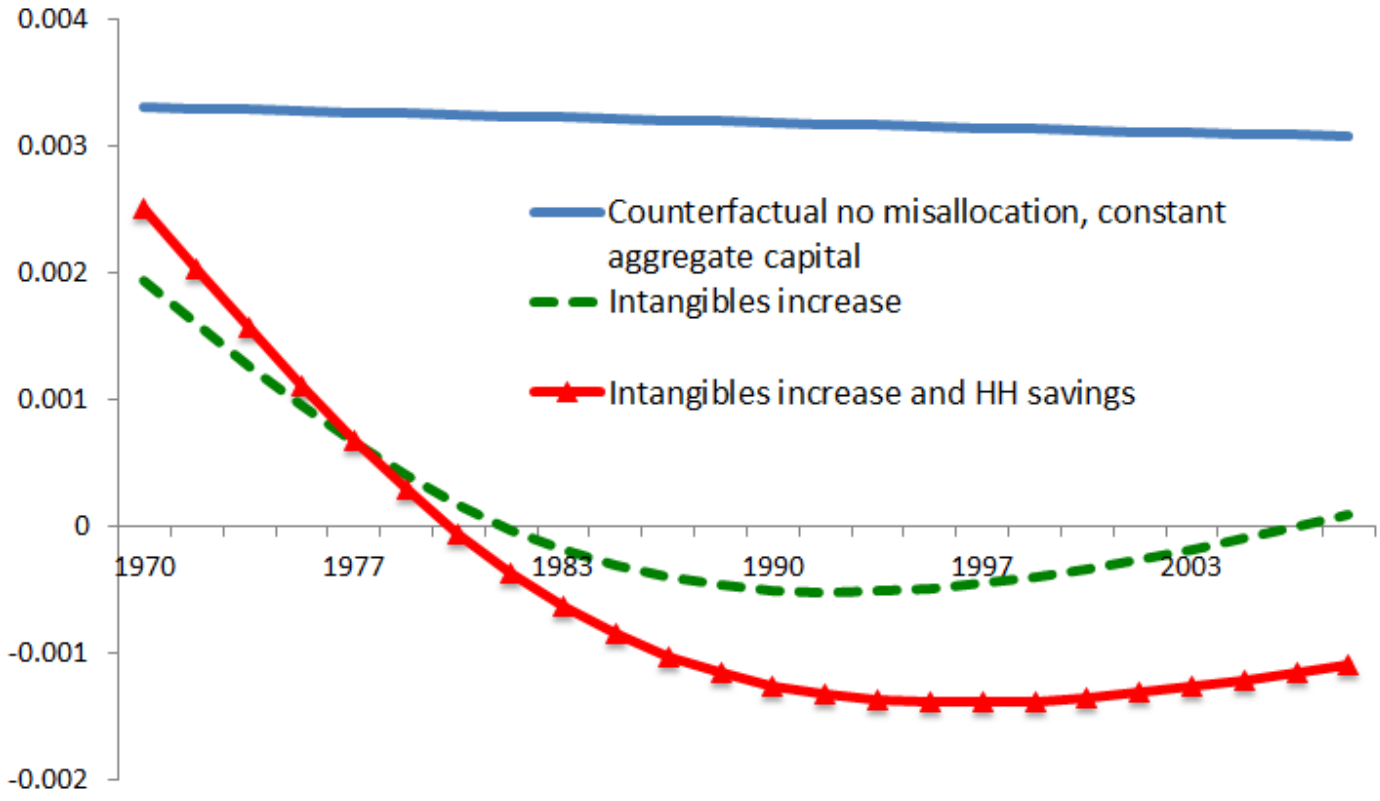


Figure: Aggregate output growth in the different simulation exercises.

Conclusion

- Changes in firms' financing behavior brought about by technological evolution might help explain the subpar growth associated with secular stagnation
- These changes interact with low interest rates behind secular stagnation to amplify negative effects
- Insights could be extended to develop interesting policy implications: negative externality in households' and firms' saving decisions might introduce a role for a fiscal policy that discourages such saving