The Rise of Long Run Losses, Intangible Deepening, and Demand Shifting Investment

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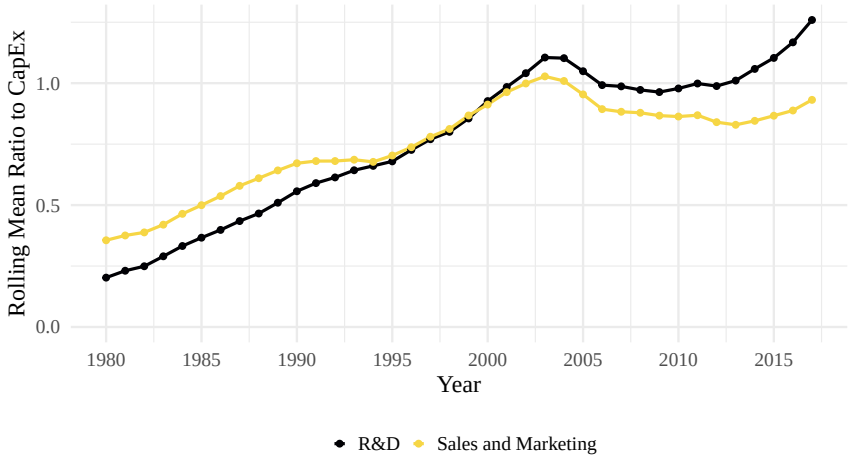
Motivation



Investment composition has changed...

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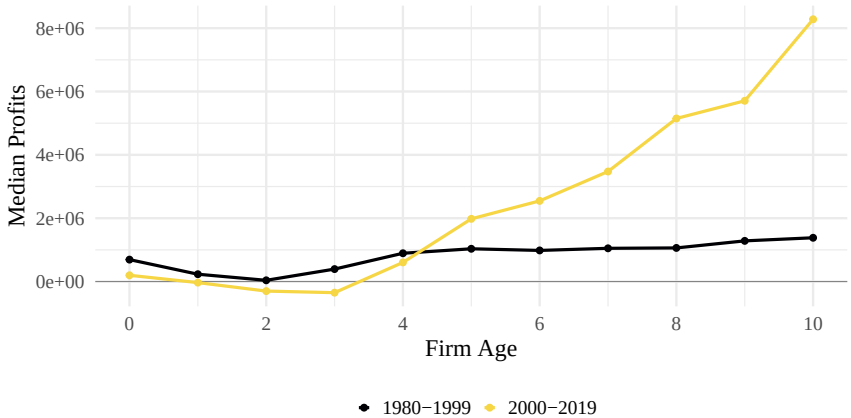

and firm growth path has changed...

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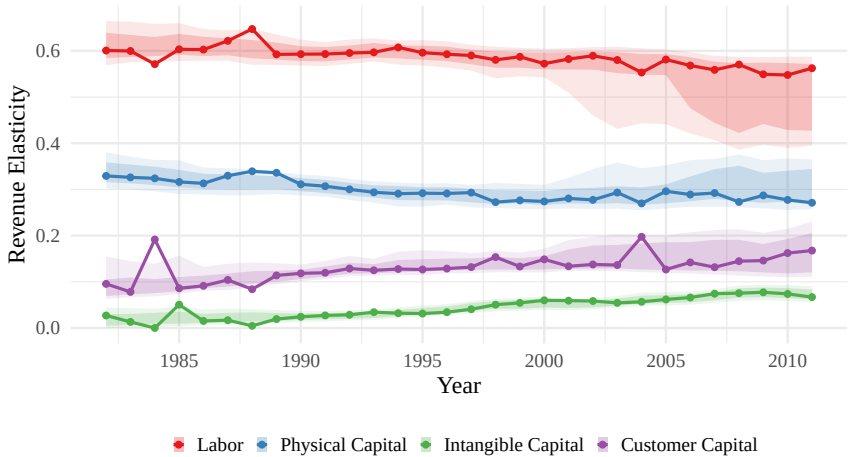

as production technology changed

Overview

Secular trends in US business dynamics...

1. Firms invest in sales and marketing + intangibles instead of traditional CapEx
2. Firms earn less for longer, as they invest to (try) to become "superstars"

...that accompanied estimated production technology change: *intangible deepening*

Develop model of heterogenous firms investing in 3 types of capital: physical and intangible capital (supply shifting), and customer capital (demand shifting).

- Intangibles are *non-rival*, links returns of intangible and customer capital.
- Model provides mapping from structural parameters to revenue elasticities; true production function estimation with customer capital.
- Matches secular trends and provides novel mechanism for rise of superstars
- Novel welfare implications of production technology change with customer capital

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   - Present model that rationalizes *increased loss persistence* + other trends.
   - Production function estimation with customer capital.
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   - First model with tangible, intangible, and customer capital; complementarity between intangible capital and customer capital due to production technology.
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   - Efficiency of customer allocation + how does it change with technology

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Empirical

Data and Estimation Details

Data: Compustat + Sales and Marketing (He, Mostrom, and Sufi 2024) + IRS SOI

- First direct measure of sales and marketing spending (imputed pre 1997)
- Profits = Sales - COGS - SG&A - R&D - CapEx (robust to other definitions)
- Intangible and Customer Capital stocks constructed using perpetual inventory method on R&D and S&M respectively (Eisfeldt and Papanikolaou 2014)

Production Function Estimation: Ackerberg, Caves, and Frazer 2015 (ACF)

- Endogeneity problem: unobserved productivity correlated with *static input* choices
- "Control function" approach, using lagged inputs as instruments for static inputs
- (Later: modify to estimate parameters that determine revenue elasticities)

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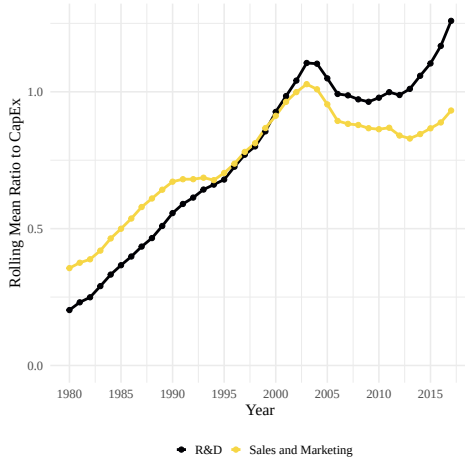
Motivating Trends: Recomposition of Spending

- Intangible and customer investment have risen relative to traditional CapEx
- Reflected in revenue elasticities
- Suggests change in production: intangible capital deepening



Investment Composition

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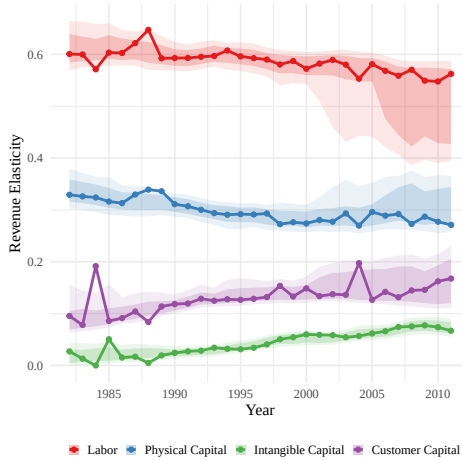

Revenue Elasticities, Rolling Windows

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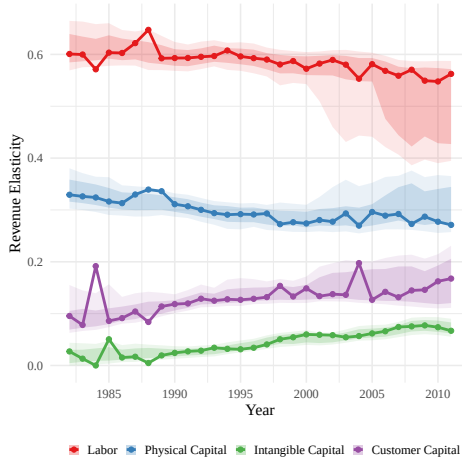

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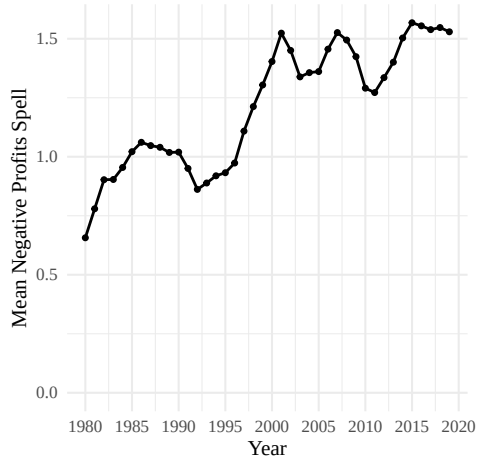
Motivating Trends: Firm Lifecycle

- Reported losses more persistent
- Losses = *growth*, not distress
- Persistent losses correlated with *intangible* investment
- Firms growing larger



Rise in Loss Persistence

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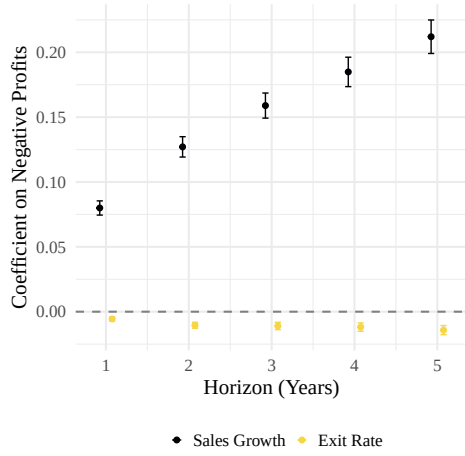
Age/Sector Composition | Persistence Across Cohorts

Corporate Income Tax Rate | Losses and Life-Cycle



Losses, Sales Growth and Bankruptcies

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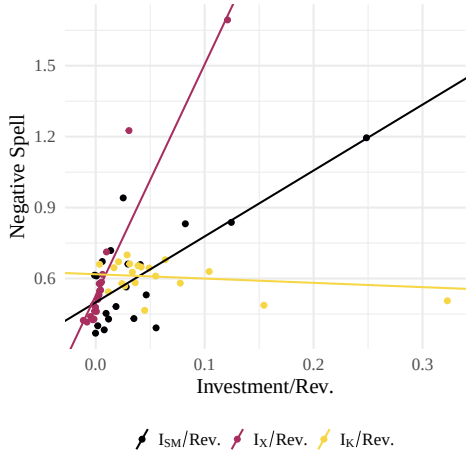

Loss Persistence and Investment

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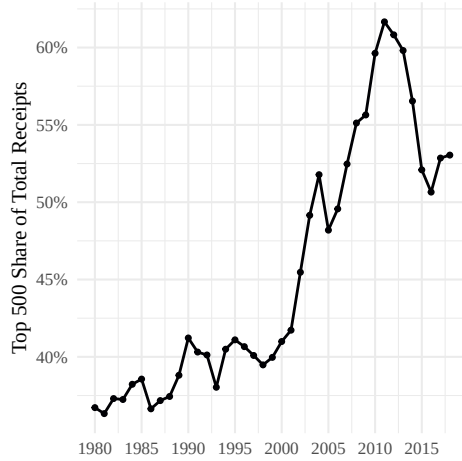

Compustat Top 500 Share (IRS SOI)

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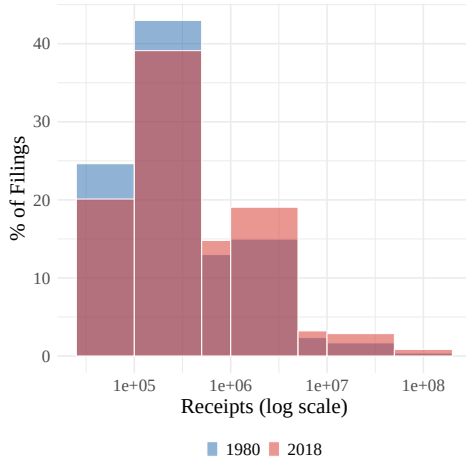

Spreading of Business Receipts (IRS SOI)

Theoretical

Household

- Unit continuum of HH members and firms producing differentiated goods
- HH members, indexed by j, maximize a CES aggregator of goods, indexed by i
- *Household members only consume goods they are "customers" of*, i.e. $j \in M_{it}$, the customer base of firm i (measure and set)
- Consumption bundle given by CES aggregator over varieties:

$$C_t = \left(\int_0^1 \int_0^1 \mathbf{1}_{j \in M_{it}} C_{ijt}^{\frac{\sigma-1}{\sigma}} \, dj \, di \right)^{\frac{\sigma}{\sigma-1}}; \quad C_{ijt} = \mathbf{1}_{j \in M_{it}} C_t P_{it}^{-\sigma} \rightarrow C_{it} = C_t M_{it} P_{it}^{-\sigma}$$

- Share parameters endogenized as customers *in fixed aggregate supply*. Intensive demand depends on price, extensive demand depends on customer base.

Evolution of Customer Base

- Each firm contacts all HH members, with probability of poaching increasing in sales and marketing labor $L_{a,it}$. Probability = measure of acquired customers a_{it}.
- Assume log odds are linear in sales and marketing labor $L_{a,it}$. Mapping to discrete choice: $V_{it} = \log \tilde{a}_{it}$, each HH member has type 1 taste shocks.

$$\tilde{a}_{it} = z_a L_{a,it}^{\alpha_a}, \quad a_{it} = \frac{\tilde{a}_{it}}{1+\tilde{a}_{it}} \iff \ln \frac{a_{it}}{1-a_{it}} = \ln z_a + \alpha_a \ln L_{a,it}$$

- Poaching is uniform, so every firm loses fraction $\Delta_t \approx \int_0^1 a_{it}\, di$ of its base:

$$M_{it+1} = (1-\Delta_t) M_{it} + a_{it}$$

- Timing: acquisition and attrition of customers is at *beginning* of period

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Firm Problem

- Given production technology and post acquisition customer base M_i', firms choose output/labor to solve *static* profit maximization problem.

$$\pi(M_i', K_i, X_i, Z_i) = \max_{Y_i} P(Y_i, M_i')Y_i - C(Y_i, M_i', K_i, X_i, Z_i)$$

- K and X have standard accumulation dynamics, with $i_{k,it} = L_{k,it}^{\alpha_k}$ and $i_{x,it} = L_{x,it}^{\alpha_x}$. Investment choices determined by *dynamic* problem with Bellman equation.

$$V = \max_{a_i, i_{k,i}, i_{x,i}} \left\{ \pi(M_i', K_i, X_i, Z_i) - W(L_{k,i} + L_{x,i} + L_{a,i}) + \tilde{\beta}\, \mathbb{E}[V(M_i', K_i', X_i'; Z_i')] \right\}$$

subject to $K_i' = (1 - \delta_k)K_i + i_{k,i}, \quad X_i' = (1 - \delta_x)X_i + i_{x,i}, \quad M_i' = (1 - \Delta)M_i + a_i$

- Solve at *steady state equilibrium*, stationary distribution with fixed C, W, Δ.

Firm Production Technology

- Production per-customer is CD in labor, physical capital and intangible capital.
- Physical capital and labor are spread across customers, while *the entire intangible capital stock serves every customer*.

$$Y_{ij} = Z_i K_{ij}^{\gamma_k} X_i^{\gamma_x} L_{ij}^{\gamma_l}, \quad \int_{j \in M_i} K_{ij} dj = K_i, \quad \int_{j \in M_i} L_j dj = L_i$$

- With symmetric allocation ($K_{ij} = \frac{K_i}{M_i}, L_{ij} = \frac{L_i}{M_i}$) + CRS technology, the total output for firm i is...

$$Y_i = \int_{j \in M_i} Y_{ij} dj = Z_i K_i^{\gamma_k} X_i^{\gamma_x} L_i^{\gamma_l} M_i^{1-\gamma_k-\gamma_l} = Z_i K_i^{\gamma_k} (M_i X_i)^{\gamma_x} L_i^{\gamma_l}$$

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Firm Profit Elasticities

- Profit elasticities largely determine investment behavior by FOCs of firms' dynamic problem, and given production technology they have simple closed forms

$$\epsilon_K^\pi = \frac{\gamma_k(\sigma-1)}{\kappa}, \quad \epsilon_X^\pi = \frac{\gamma_x(\sigma-1)}{\kappa}, \quad \epsilon_M^\pi = \frac{1}{\kappa} + \epsilon_X^\pi, \quad \text{where } \kappa = (1-\gamma_I)\sigma + \gamma_I$$

- Key consequence of non-rival intangibles: *co-movement of intangible and customer investment via intangible intensity of production*.
- Nice suggestive evidence: correlation of sales and marketing and R&D spending rates across time and across sectors (He, Mostrom, and Sufi 2024)

Cross-Sector Sales and Marketing and R&D | Cross-Sector Sales and Marketing and Firm Losses

Output Elasticities vs. Revenue Elasticities

- Model provides mapping from revenue elasticities to structural parameters

$$\epsilon_l^R = \frac{\gamma_l}{\mu}, \epsilon_k^R = \frac{\gamma_k}{\mu}, \epsilon_x^R = \frac{\gamma_x}{\mu}, \epsilon_m^R = \frac{1}{\sigma} + \frac{\gamma_x}{\mu}$$

- Modify ACF to estimate $\gamma_l, \gamma_k, \gamma_x, \sigma$; *true production function estimation with customer capital.*
- Recover rolling output elasticities
- And path of implied mark-up (we fix this in quantitative analysis)

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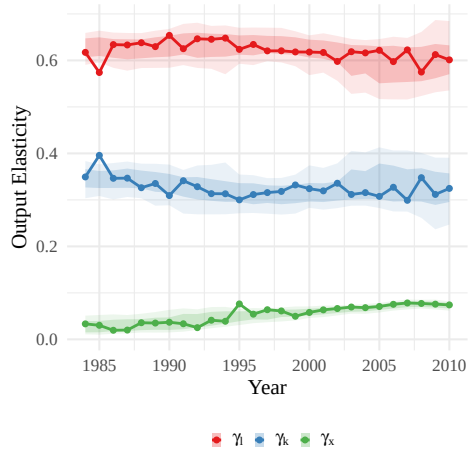

Output Elasticities, Rolling Windows

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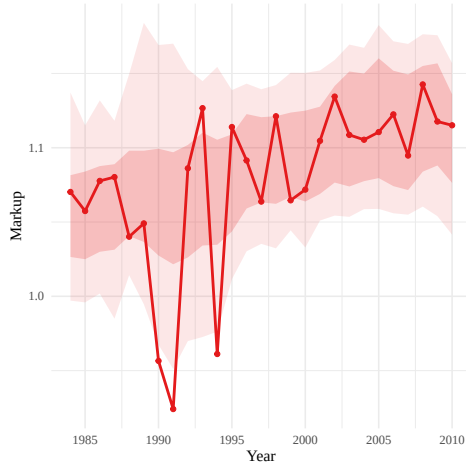

Mark-up, Rolling Windows

Quantitative

Solution Method

- Solve firm problem given aggregates, then iterate to stationary distribution and compute aggregates. Globally search for fixed point (C^*, W^*, Δ^*).
- Computational challenge: solve firm problem given steady state aggregates *quickly*
- Using time iteration to solve the firm problem (EGM poorly behaved)
  1. Given V_K, V_X, V_M, solve policies M', K', X'
  2. Plug policies into envelope conditions to update V_K, V_X, V_M
- Using grid $(N_Z, N_K, N_X, N_M) = (10, 50, 50, 50)$, 1.25 million grid points
- Three root-finding problems on a high-dimensional grid are costly, *but parallelizable*. Single solve goes from 2 minutes locally to 10-12 seconds on computing cluster (64 cores). Good use of Claude.

Calibration

- Set parameters to (1) standard values, (2) ACF estimates in baseline year
- Calibrate $\alpha_a, \alpha_k, \alpha_x$ to match investment shares in baseline year
- Solve for steady state equilibria corresponding to rolling-window estimated output elasticity path

Fixed Parameters

Parameter	**Value**
Standard Values	
Discount rate β	0.96
Depreciation rates δ_k, δ_x	0.10, 0.15
Estimated Values	
Entry/Exit rate θ	0.03
Persistence of productivity ρ_z	0.95
SD of productivity σ_z	0.09
Labor elasticity γ_L	0.62
Capital elasticity γ_K	0.35
Intangible elasticity γ_X	0.03
Substitution elasticity σ	10.49

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Targeted and Untargeted Moments

Moment	**Data**	**Model**
Targeted Moments		
Physical Investment Share	0.56	0.56
Customer Investment Share	0.26	0.26
Intangible Investment Share	0.18	0.18
Untargeted Moments		
Customer Turnover Rate	0.15	0.16

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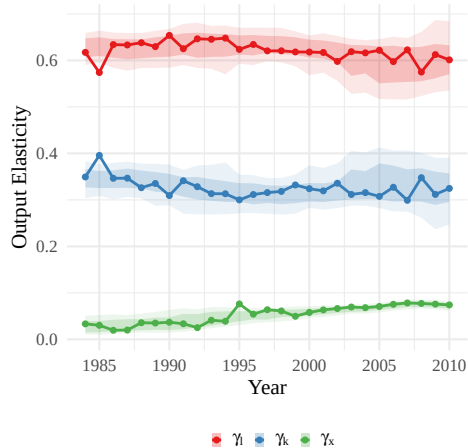

Output Elasticities, Rolling Windows

Matching Trends

- Given estimated production technology change, model gets...
- Most of intangible investment rise relative to CapEx ($\approx \frac{3}{4}$)
- Some of sales and marketing rise relative to CapEx ($\approx \frac{1}{3}$)
- Some of loss persistence rise ($\approx \frac{1}{4}$)
- Also spreading of sales distribution and increase in sales inequality (much lower than data, limited by markup)

How do we compute average negative spell?

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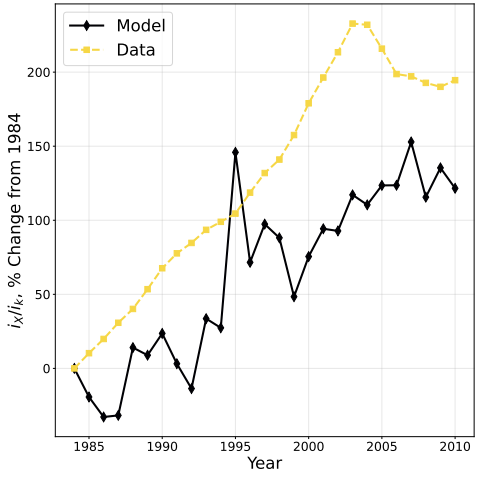

Rise of Intangible Capital

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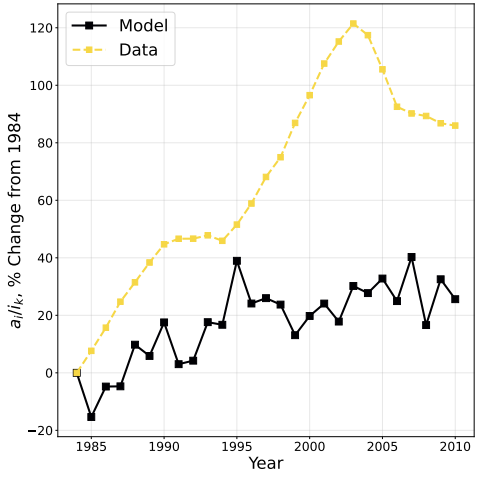

Rise of Customer Capital

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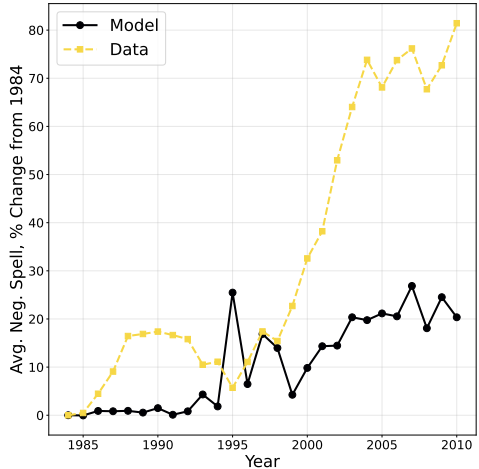

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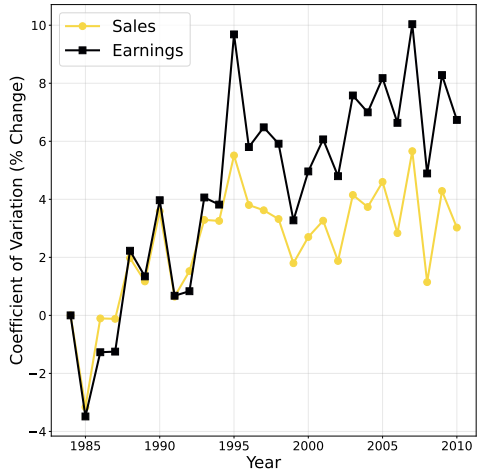
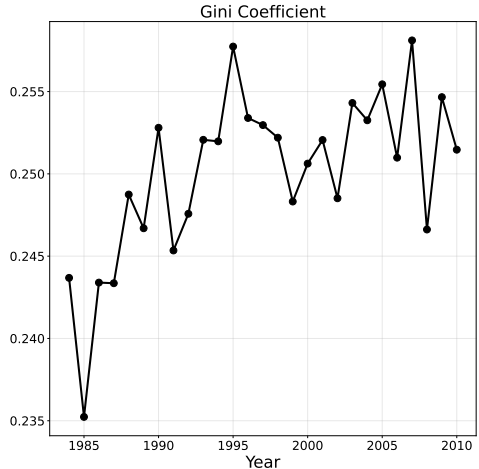


Spreading of Sales and Earnings Distribution

Matching Trends

- Given estimated production technology change, model gets...
- Most of intangible investment rise relative to CapEx ($\approx \frac{3}{4}$)
- Some of sales and marketing rise relative to CapEx ($\approx \frac{1}{3}$)
- Some of loss persistence rise ($\approx \frac{1}{4}$)
- Also spreading of sales distribution and increase in sales inequality (much lower than data, limited by markup)

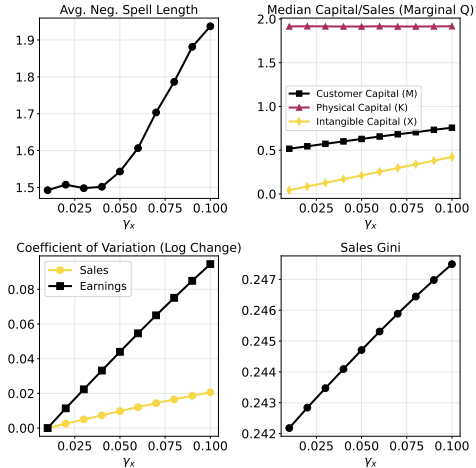
How do we compute average negative spell?



Rise in Sales Inequality

Why can we match trends?

- All empirical moments monotonic in output elasticities
- Raising γ_x raises returns to intangible + customer capital, relative to physical capital (and labor)
- Customer capital is business stealing; firms don't internalize that increased investment makes it more expensive for all firms to grow, raising negative profits at times of high growth (early in life cycle)



Moment Monotonicity in Output Elasticities

Why can we match trends?

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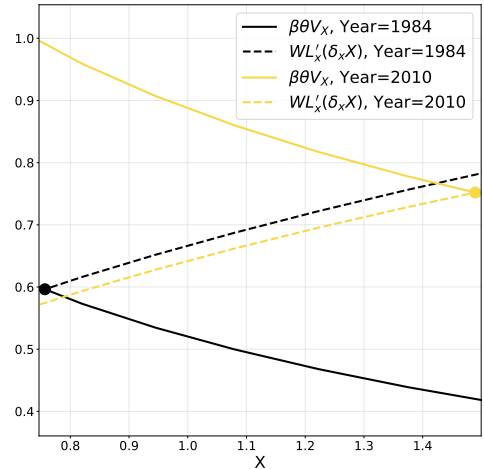

Maintenance Intersection, Intangible Capital

Why can we match trends?

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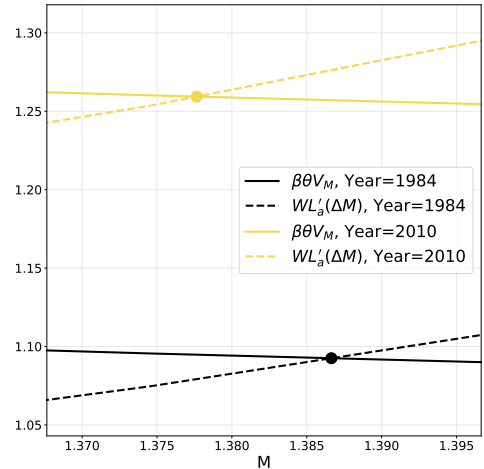

Maintenance Intersection, Customer Capital

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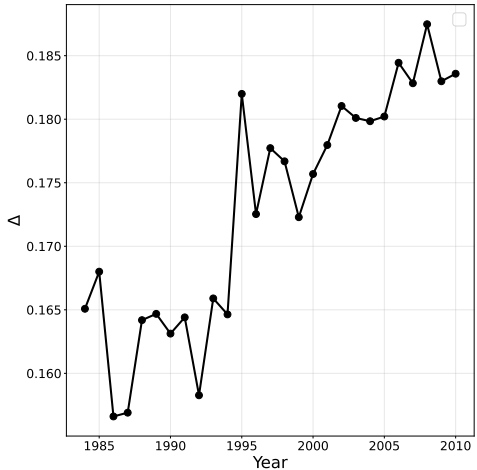

Maintenance Intersection, Customer Capital

Aggregate Implications

Setup

Two new interesting welfare questions arise in this setting:

1. Under or over-investment in customer capital? Under-investment from uninternalized HH surplus, over-investment from uninternalized business stealing
2. How far are we from *optimal customer allocation* across firms?

Can't answer these for now, but can consider how aggregate variables respond.

- Single factor of production for goods and capital, labor, in fixed supply ($L_{\text{tot}} = 1$)
- Provides a simple metric of composition of economy across equilibria:

  Labor $= L_s$, Physical Capital $= L_k$, Intangible Capital $= L_x$, Customer Capital $= L_a$

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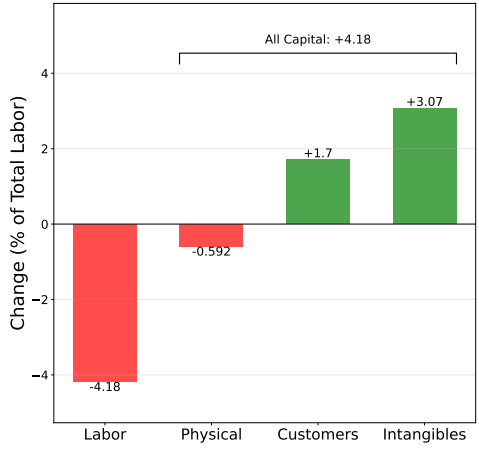
How do Aggregate Variables Respond to Intangible Deepening?

- Labor and physical capital fall, intangible and customer capital rise. Overall capital deepening
- Changes don't match output elasticities
- Customer-weighted TFP rises (but very sensitive)



Recomposition of Economy

How do Aggregate Variables Respond to Intangible Deepening?

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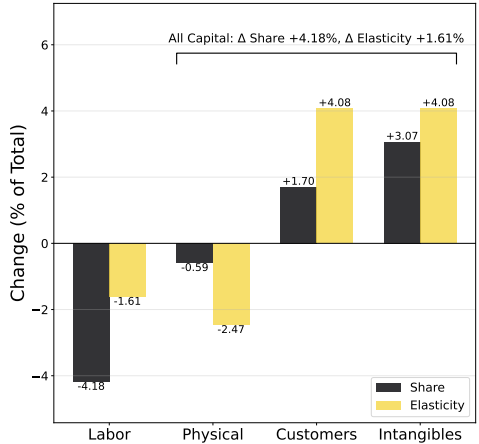

Recomposition vs. Output Elasticities

How do Aggregate Variables Respond to Intangible Deepening?

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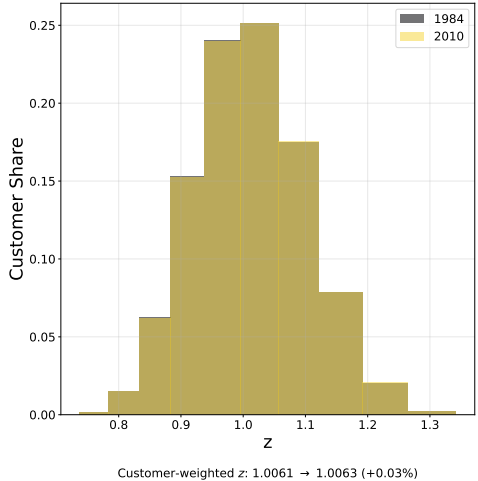

Customer Distribution by Productivity

Conclusion

- Document recomposition of investment, changing profit lifecycle + rise of loss persistence, and intangible deepening in revenue elasticities
- Develop model of firm dynamics with *supply and demand* shifting investment, and intangible+customer capital connection via non-rivalry
- Full production function estimation with customer capital, estimated path of production technology in model matches empirical trends
- Examine aggregate implications of intangible deepening in model with demand shifting investment

Next Steps

Immediate next steps:

1. Do real dynamics, i.e. use sequence space Jacobians to get perfect foresight transition path (Auclert et al. 2021)
2. Formalize welfare analysis, and decompose welfare change pre/post 2000

Longer term next steps:

1. Move from CES to a non-CES homothetic aggregator (Matsuyama 2025) like Kimball. Much higher sales concentration when returns to capital include higher mark-ups, and could connect intangible capital deepening to market power.
2. Formal tests of non-rivalry of intangibles, since this is the key assumption.

THANK YOU!

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THANK YOU!

Appendix: Corporate Income Tax Rate

Table 1: Corporate Income Tax Rate Regression

	Neg. Profits	Neg. Spell
Tax Rate	−0.00	−0.01*
	(0.00)	(0.01)
Num. obs.	171021	171021

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

State Corporate Income tax is from Robinson and Tazhitdinova 2025. Controlling for firm and sector:year fixed effects.

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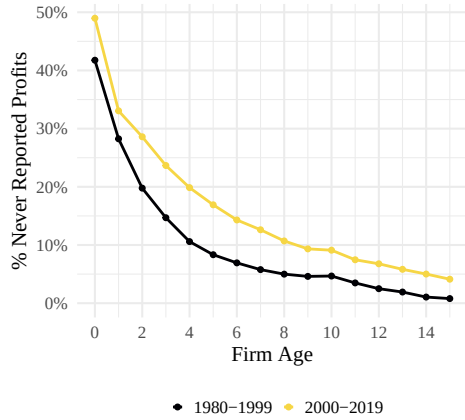
Appendix: Negative Spell is Life-Cycle Phenomena

- Rise in loss persistence is largely life-cycle
- More firms take longer to ever turn a profit



Rise in Loss Persistence

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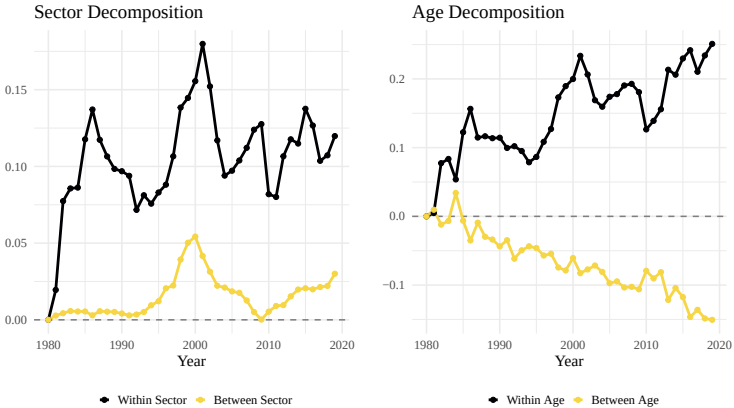
Appendix: Rise Not Driven by Age/Sector Composition



Decomposing Rise in Losses

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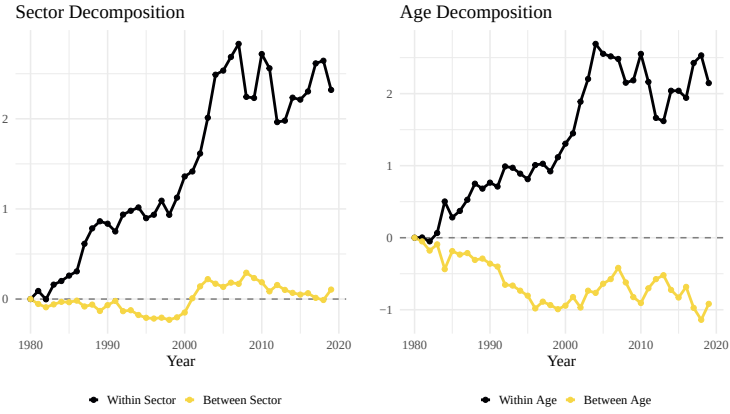
Appendix: Rise Not Driven by Age/Sector Composition



Decomposing Rise in Spell

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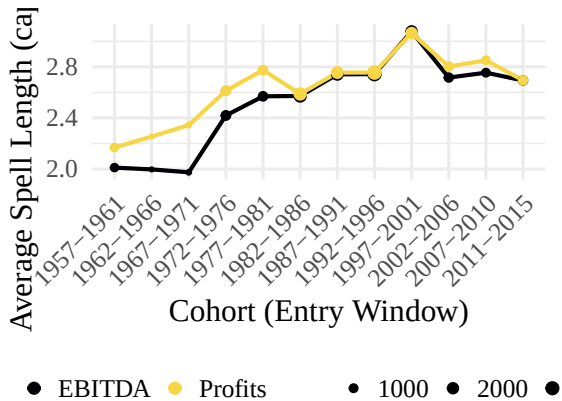
Appendix: Increased Persistence Across Cohorts



Increased Persistence of Losses Across Cohorts

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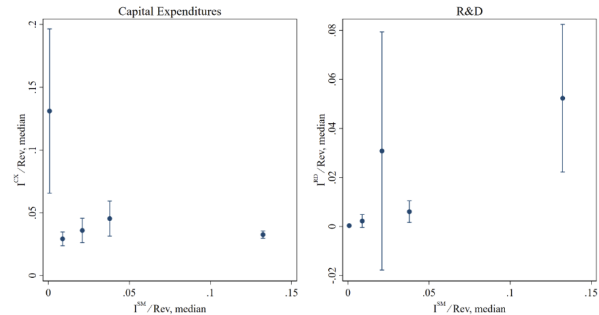
Appendix: Correlation R&D and Sales and Marketing

Figure 5: Comparison of I^{SM} with Capital Expenditures and R&D



Bin-scatter plots at the industry level for capital expenditures ($I^{CX}/_{Rev}$, left panel) and R&D ($I^{RD}/_{Rev}$, right panel) against sales and marketing expense ($I^{SM}/_{Rev}$), all scaled by revenue. Confidence bars are at the 90% level. See Appendix Figure A4 for full industry scatter plots.

Cross-Sector Sales and Marketing Correlation

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Appendix: Correlation Negative Profits and Sales and Marketing Spending

Cross-Sector Correlation with Sales and Marketing Spending

	EBITDA		
	Avg. Pct. Neg.	Avg. Neg. Spell	Std. Dev.
I^{SM}/Rev. (He et. al. 2025)	0.69^{***}	2.79^{***}	3.04^{***}
	(0.04)	(0.21)	(0.43)
Num. obs.	2514	2514	2514

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

- Negative earnings and earnings/sales spread positively correlated with sales and marketing spending across sectors, in each year (controlling for year fixed effects)

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Appendix: How do we calculate average negative spells?

- At equilibrium, look at what % of firms are losing money at each age (initiate cohort and iterate forward)
- Use age-conditional spell distribution to get average negative spell (stationary age distribution is well-defined)
- This works because negative earnings are *purely a life-cycle phenomena*; having mature firms that re-enter the red would complicate this

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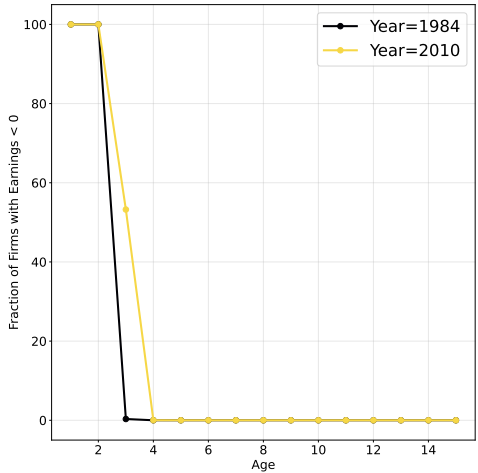

Negative Earnings as Lifecycle Phenomena

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