Intangible Capital, Tangible Misallocation

Stepan Gordeev

March 5, 2020

Summary

1. Role of intangible assets in production is rising
    - Tangible K: buildings, machines...
    - Intangible K: IT, brand value, organizational structure...
    - $\frac{\text{intangible K}}{\text{tangible K}}$ in the US: 0.20 $\rightarrow$ 0.52 since 1948
2. Misallocation in the US is rising

- **This Paper:** role of intangibles in generating observed misallocation
- **Data:** US Compustat 1987-2017
- **Misallocation Measurement:** Hsieh and Klenow '09 + intangibles

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Preview of Results

1. Ignoring intangibles leads to **overestimation** of both the level and growth of misallocation
    - Corrected misallocation is 35% lower
    - Corrected **misallocation has not increased** in the last two decades
2. Intan-intensive sectors have 75% **higher misallocation** than tan-intensive sectors
    - Uncertain intangible productivity + variable markups can generate one third of the difference

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- **Role of Intangibles:** Corrado and Hulten (2010), Haskel and Westlake (2017), McGrattan (2017), Chen (2014), Peters and Taylor (2017), Döttling and Perotti (2017)
- **Misallocation:** Hsieh and Klenow (2009), Restuccia and Rogerson (2008), David and Venkateswaran (2017), Bils, Klenow, and Ruane (2018)
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Outline

1. Data
2. Estimating Misallocation
3. Potential Mechanisms
4. Variable Markup Model
5. Conclusion

Data

Data Overview

- Annual traded firm balance sheets from Compustat
  - 1987-2017
  - Sectoral output, tangible, and intangible investment deflators from BLS
- Production: $y = ak_T^{\alpha_T} \quad v^{1-\alpha_T}$
- Measure variable input v with cost of goods sold
- Construct tangible capital stock $k_{T,f,t}$ from PPE investment $x_{T,f,t-1}$

$$k_{T,f,t} = (1 - \delta_{T,f})k_{T,f,t-1} + x_{T,f,t-1}$$

  - Implied firm-specific depreciation $\delta_{T,f}$
- Construct intangible capital stock $k_{I,f,t}$ using method from Falato, Kadyrzhanova and Sim (2013) and Peters and Taylor (2017)
  - Consists of 3 components

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Intangible K Components

1. **Knowledge capital**

   $x_{\text{know},f,t}$ is R&D investment, $\delta_{\text{know}} = 0.15$

   $$\textsc{Knowledge}_{f,t} = (1 - \delta_{\text{know}})\textsc{Knowledge}_{f,t-1} + x_{\text{know},f,t-1}$$

   $\textsc{Knowledge}_{f,1} = \frac{x_{\text{know},f,1}}{\delta_{\text{know}}}$

2. **Organizational capital**

   $x_{\text{org},f,t}$ is "sales, general and administrative expense", $\delta_{\text{org}} = 0.2$, weight investment by 0.3

   $$\textsc{Organization}_{f,t} = (1 - \delta_{\text{org}})\textsc{Organization}_{f,t-1} + 0.3 \cdot x_{\text{org},f,t-1}$$

3. **External purchases**

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Intangible K

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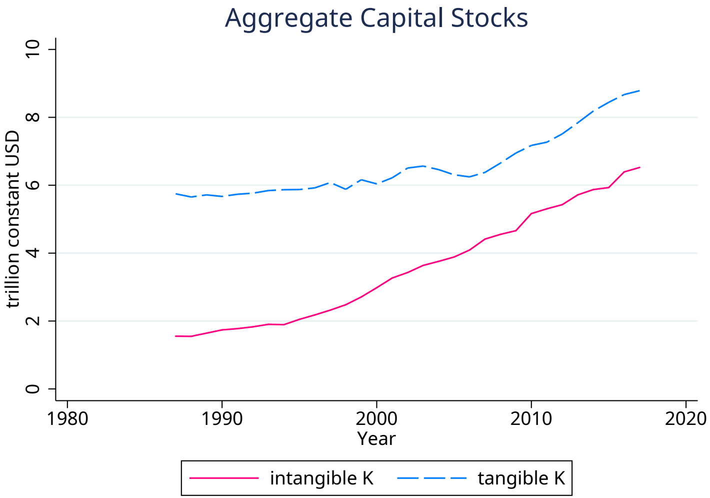
$$k_{I,f,t} = \textsc{Knowledge}_{f,t} + \textsc{Organization}_{f,t} + \textsc{External}_{f,t}$$

Aggregate Intangibles



Components

Estimating Misallocation

Overview

- HK+I: Hsieh and Klenow (HK) with an additional input: intangible K_I
- Final good Y produced competitively from S intermediates

$$Y = \prod_{s=1}^{S} Y_s^{\theta_s}$$

- Intermediate Y_s produced competitively from varieties of F_s firms

$$Y_s = \left(\sum_{f=1}^{F_s} y_{s,f}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- Assume $\sigma = 3$

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Variety Producer

- Each variety (s, f) produced by monop. competitive firm using
  - variable input $v_{s,f}$ (paid w)
  - tangible capital $k_{T,s,f}$ (paid return r_T)
  - intangible capital $k_{I,s,f}$ (paid return r_I)
- Subject to distortions $(1-\tau_{Y,s,f})$, $(1+\tau_{T,s,f})$, and $(1+\tau_{I,s,f})$

$$\max_{p_{s,f}, v_{s,f}, k_{T,s,f}, k_{I,s,f}} (1-\tau_{Y,s,f}) p_{s,f} y_{s,f} - w v_{s,f} - (1+\tau_{T,s,f}) r_T k_{T,s,f} - (1+\tau_{I,s,f}) r_I k_{I,s,f}$$

s.t.

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Estimable Expressions

- Express firm f's productivity $a_{s,f}$ with observables:

$$a_{s,f} \propto \frac{\left(p_{s,f} y_{s,f}\right)^{\frac{\sigma}{\sigma-1}}}{k_{T,s,f}^{\alpha_{T,s}} k_{I,s,f}^{\alpha_{I,s}} v_{s,f}^{1-\alpha_{T,s}-\alpha_{I,s}}}$$

- Revenue productivity reflects distortions:

$$\mathrm{tfpr}_{s,f} \propto \frac{(1+\tau_{T,s,f})^{\alpha_{T,s}}(1+\tau_{I,s,f})^{\alpha_{I,s}}}{(1-\tau_{Y,s,f})}$$

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Reallocation Gain

- Distorted sectoral TFP:

$$\mathrm{TFP}_s = \left(\sum_{f=1}^{F_s} \left(a_{s,f} \frac{\mathrm{TFPR}_s}{\mathrm{tfpr}_{s,f}} \right)^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

- Efficient sectoral TFP if equalize distortions:

$$\mathrm{TFP}_{s,\mathrm{eff}} = \left(\sum_{f=1}^{F_s} a_{s,f}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

- Reallocation gain:

$$\mathrm{GAIN}_s = \frac{\mathrm{TFP}_{s,\mathrm{eff}}}{\mathrm{TFP}_s}$$

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Factor Shares

- Cannot identify distortions and factor shares separately, assume sectoral input shares not distorted
- Measure $1 - \alpha_{T,s} - \alpha_{I,s}$ as $\frac{\text{COGS}}{\text{SALE}}$ for each sector-year
- Pin down $\frac{\alpha_{T,s}}{\alpha_{I,s}}$ from $\frac{K_{T,s} r_T}{K_{I,s} r_I}$
  - rental rates
- Alternatively, use $\alpha_{T,s}$ and $\alpha_{I,s}$ from BEA
- Reallocation gains not sensitive to alternative α_x and r_x

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HK+I vs HK

- Defined HK+I, how to compare to HK?
- Estimate HK from same data, need to define capital stock and factor share
- Capital stock is tangible capital: $k_{s,f} = k_{T,s,f}$
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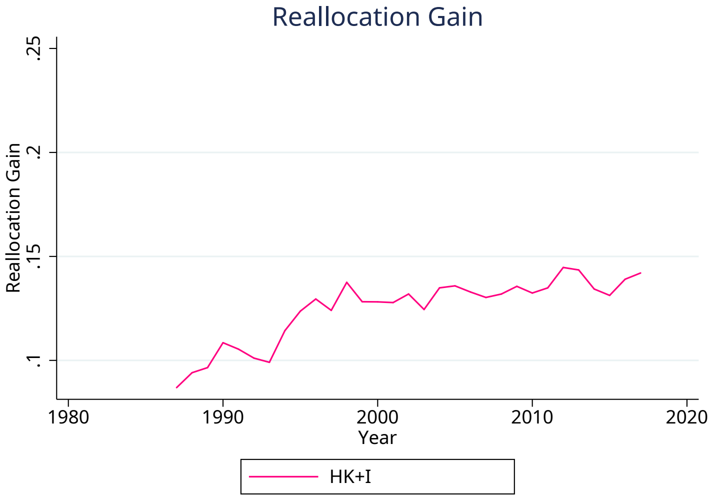

- HK+I: 8.7% $\rightarrow$ 14.2% of Y, HK: 9.0% $\rightarrow$ 21.9%
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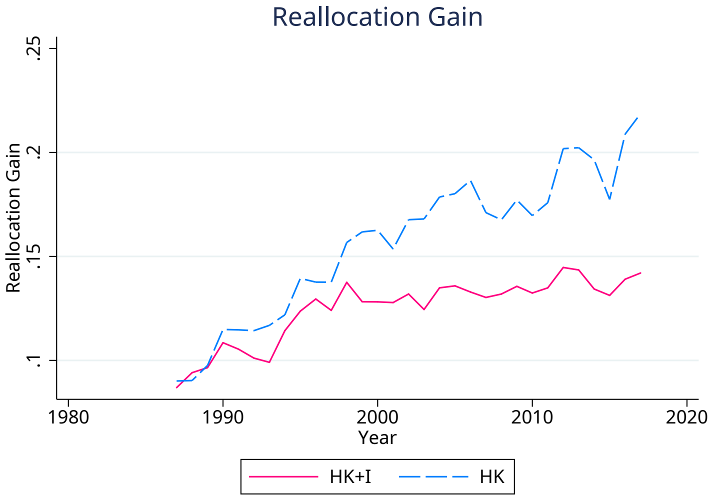

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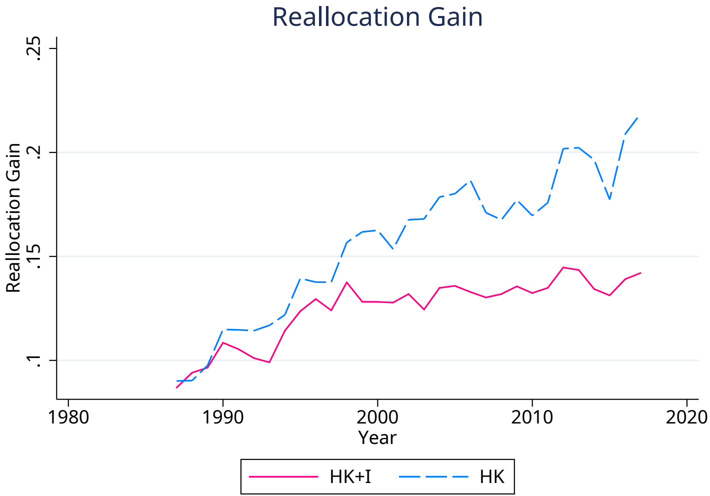

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- Over/underestimation of Gain driven by HK's over/underestimation of $a_{s,f}$

$$a_{s,f} = \frac{y_{s,f}}{\underbrace{k_T^{\alpha_{T,s}+\alpha_{I,s}}}_{a^{HK}\downarrow}\underbrace{k_I^{\alpha_{I,s}}}_{a^{HK}\uparrow} v^{1-\alpha_{T,s}-\alpha_{I,s}}}$$

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Misallocation and Intangible Share

- Are intangible-intensive sectors more distorted or less?
- Split sectors into high/low-intangible groups by their $\frac{K_{I,s}}{K_{T,s}}$ in 2017
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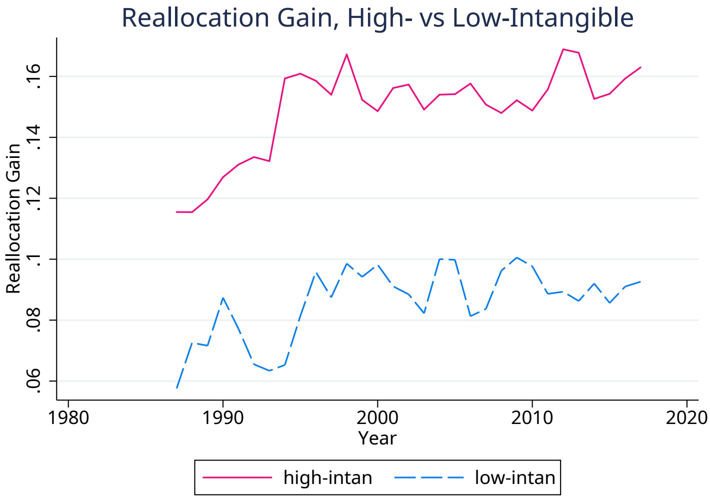
Misallocation by Intan Intensity



- High-intan: 11.5% → 16.3%, low-intan: 5.8% → 9.3%

HK | tfpr dispersion | Reallocation of Sales

Potential Mechanisms

The Most and the Least Intan-Intensive Sectors

$\frac{K_I}{K_T}$ Rank	Sector	$\frac{K_I}{K_T}$
1	Motion picture and sound recording	4.85
2	Computer systems design	4.81
3	Publishing industries	4.47
⋮		
26	Transportation equipment	1.14
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High- vs Low-Intan Sectors

	high-intan	low-intan	mechanism
K_T factor share	0.083	0.230	
K_I factor share	0.260	0.124	
V factor share	0.657	0.646	
SD of demeaned log sales	2.53	1.95	winner-take-most
Median firm growth rate SD	0.24	0.17	uncertainty
Median leverage ratio	0.20	0.32	fin. frictions
Sales-weighted markup	1.178	1.048	market power

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Variable Markup Model

Model Overview

- Uncertain productivity of intan investment + markup heterogeneity
- Add intangibles to PE version of Edmond, Midrigan and Xu (2018)
- Small sector: sectoral variables do not affect prices
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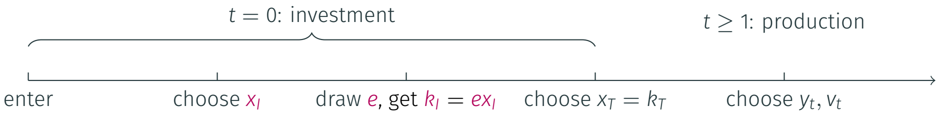
Timeline

- All firms enter, make one-time investment x_I, draw e to get $k_I = ex_I$, choose k_T, then produce



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- Sectoral composite good produced from varieties ω using the Kimball aggregator

$$\int_0^{F_t} \Upsilon\left(\frac{y_t(\omega)}{Y_t}\right) d\omega = 1$$

- Use the functional form for Υ from Klenow and Willis (2016)

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- Produce with

$$y_t = \underbrace{k_T^{\alpha_T} k_I^{\alpha_I}}_{\equiv z} v_t^{1-\alpha_T-\alpha_I}$$

- Static production problem in $t \geq 1$:

$$\pi(z) = \max_{y_t, v_t} p(z)y(z) - wv(z)$$

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- Given k_I draw, choose tangible capital to max discounted profits less cost of investment

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Intangible Investment

- Choose intangible investment to max expected profits less cost of investment

$$\max_{x_I} \int \left(\beta \sum_{t=1}^{\infty} (\beta(1-\delta))^{t-1} \pi_t \left(k_T^{\alpha_T}(ex_I)(ex_I)^{\alpha_I} \right) - k_T(ex_I) \right) dG(e) - x_I{}^{\phi}$$

- $\phi > 1$ needed to close the model
- Then draw $e \sim G(e)$ and obtain $k_I = ex_I$

Calibration

- Calibrate to the low-intangible group of sectors
- $e \sim lognormal(0, \iota^2)$

Parameter	Symbol	Value	Rationale
discount rate	β	0.96	standard
death rate	δ	0.10	standard
intan inv convexity	ϕ	1.1	ad hoc
Low-Intan Sector			
tangible share	$\alpha_{T,l}$	0.230	compensation share
intangible share	$\alpha_{I,l}$	0.124	compensation share
average elasticity	$\tilde{\sigma}$	29	aggregate markup
superelasticity	ε	6	sales-COGS relationship
productivity dispersion	ι	2.25	sales distribution
High-Intan Sector			
tangible share	$\alpha_{T,h}$	0.083	compensation share
intangible share	$\alpha_{I,h}$	0.260	compensation share

Targeted moments

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- Intan investment productivity dispersion $\rightarrow$ size dispersion $\rightarrow$ markup dispersion $\rightarrow$ measured misallocation

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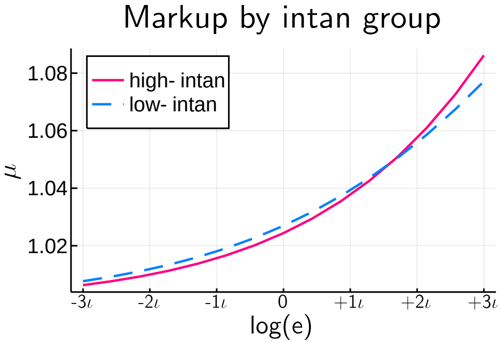
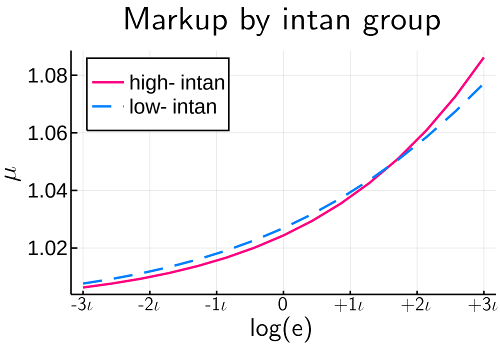
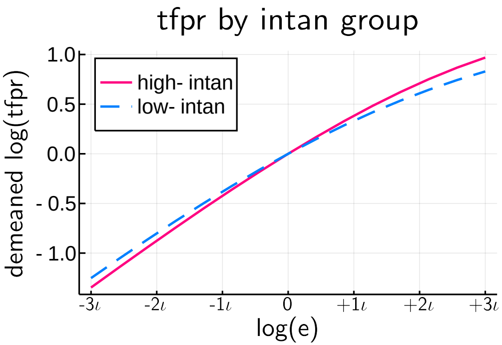


Mechanism

- Intan investment productivity dispersion → size dispersion → markup dispersion → measured misallocation





Measured Misallocation

- Apply HK+I to model-generated data

	low-intan		high-intan	
	data	model	data	model
HK+I TFP Gain	9.3%	17.0%	16.3%	19.7%
TFPR Dispersion	0.300	0.353	0.545	0.397

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  - Ignoring intangibles **overestimates misallocation** by 50%
    - and its growth by 130%, **explaining ~all measured deterioration** in last 20 years
  - High and deteriorating misallocation driven by **intangible-intensive** sectors
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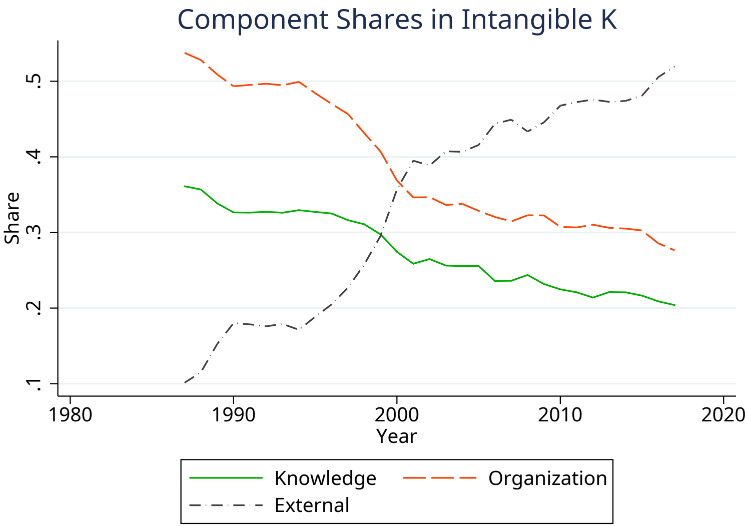
Intangible K Components



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Productivities

$$\text{tfpr}_{s,f} = \frac{\sigma}{\sigma-1}\left(\frac{(1+\tau_{T,s,f})r_T}{(1-\tau_{Y,s,f})\alpha_{T,s}}\right)^{\alpha_{T,s}}\left(\frac{(1+\tau_{I,s,f})r_I}{(1-\tau_{Y,s,f})\alpha_{I,s}}\right)^{\alpha_{I,s}}\times$$

$$\left(\frac{w}{(1-\tau_{Y,s,f})(1-\alpha_{T,s}-\alpha_{I,s})}\right)^{1-\alpha_{T,s}-\alpha_{I,s}}$$

$$a_{s,f} = \left(P_s Y_s^{\frac{1}{\sigma}}\right)^{\frac{\sigma}{1-\sigma}} \frac{\left(p_{s,f}y_{s,f}\right)^{\frac{\sigma}{\sigma-1}}}{k_{T,s,f}^{\alpha_{T,s}} k_{I,s,f}^{\alpha_{I,s}} v_{s,f}^{1-\alpha_{T,s}-\alpha_{I,s}}}$$

$$\text{TFPR}_s = \left(\frac{\text{MRPK}_{T,s}}{\alpha_{T,s}}\right)^{\alpha_{T,s}}\left(\frac{\text{MRPK}_{I,s}}{\alpha_{I,s}}\right)^{\alpha_{I,s}}\left(\frac{\text{MRPV}_s}{1-\alpha_{T,s}-\alpha_{I,s}}\right)^{1-\alpha_{T,s}-\alpha_{I,s}}$$

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Rental Rates

- Assume $r = 0.05 + \delta$
- $r_T = 0.12$, $r_I = 0.22$
- Rates matter for factor shares, but not (directly) for reallocation gains

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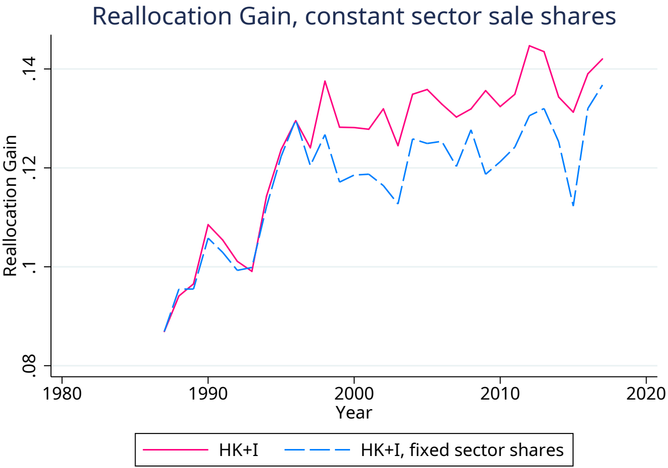
Reallocation of Sales Across Sectors



- $\frac{1}{10}$ of increase due to reallocation of revenue to more distorted sectors

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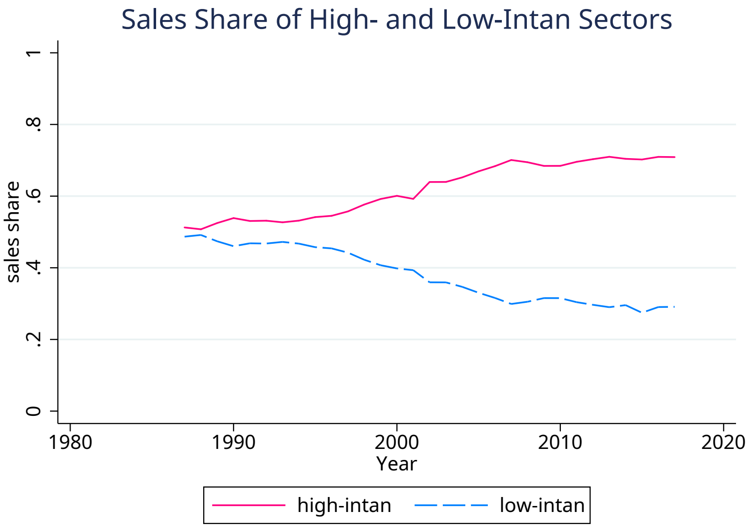
Sales Shares by Group



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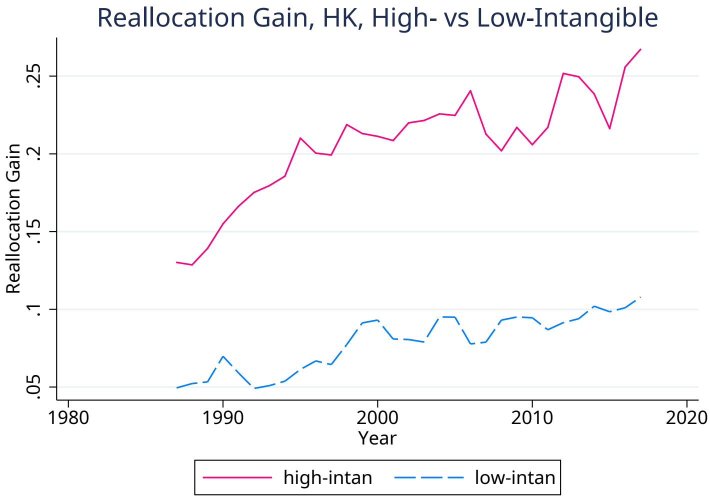
Misallocation by Intan Intensity, HK



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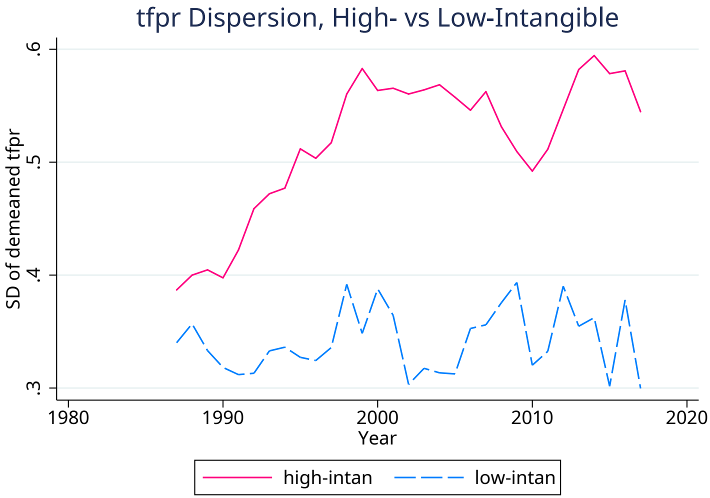
Dispersion by Intan Intensity



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Targeted Moments

	low-intan (targeted)		high-intan (non-targeted)	
	data	model	data	model
Aggr. Markup				
M	1.048	1.048	1.178	1.053
Relative COGS				
decile				
1st	-4.20	-2.47	-5.17	-3.70
2nd	-3.01	-1.64	-4.14	-2.77
3rd	-2.06	-1.07	-3.52	-2.16
4th	-1.62	-0.77	-2.79	-1.67
5th	-1.22	-0.50	-2.32	-1.24
6th	-0.85	-0.21	-1.57	-0.78
7th	-0.34	0.11	-1.20	-0.39
8th	0.06	0.35	-0.47	0.05
9th	0.75	0.79	0.27	0.54
10th	1.64	1.31	2.00	1.66
Relative Sales				
percentile				
20th	-3.22	-2.83	-4.23	-3.47
40th	-1.72	-1.73	-2.70	-2.25
60th	-0.77	-0.82	-1.54	-1.22
80th	0.24	0.18	-0.23	-0.06
90th	0.98	0.89	0.74	0.79
95th	1.43	1.46	1.49	1.47
99th	2.28	2.46	2.77	2.69

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