Measuring Intangible Capital with Market Prices

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This Paper

- Despite the importance of intangibles in today's economy, researchers lack consensus on the size and distribution of these key assets in and across firms. Previous approaches:
  - Leave gaps in coverage
  - Rely on outcomes to proxy for value
  - Require strong assumptions on production and the nature of the firm

- We propose a new approach to estimating intangible capital in firms using prices. Key benefits:
  - Prices incorporate the present discounted value of *all* future benefits
    - E.g. complementarities and real option value
  - Weaker assumptions on production function and lag structures
  - Flexible framework

Examples of Intangible Assets in Firms

Knowledge is our most powerful engine of production.
Alfred Marshall, 1890

- Process and procedures
  - Anything that increases productivity or reduces costs
- Patents and trademarks (IP)
  - Monopoly rights for certain products or brands
- Human capital
  - High-quality inventors or productive employees/management

Internally Generated vs Externally Acquired Intangibles

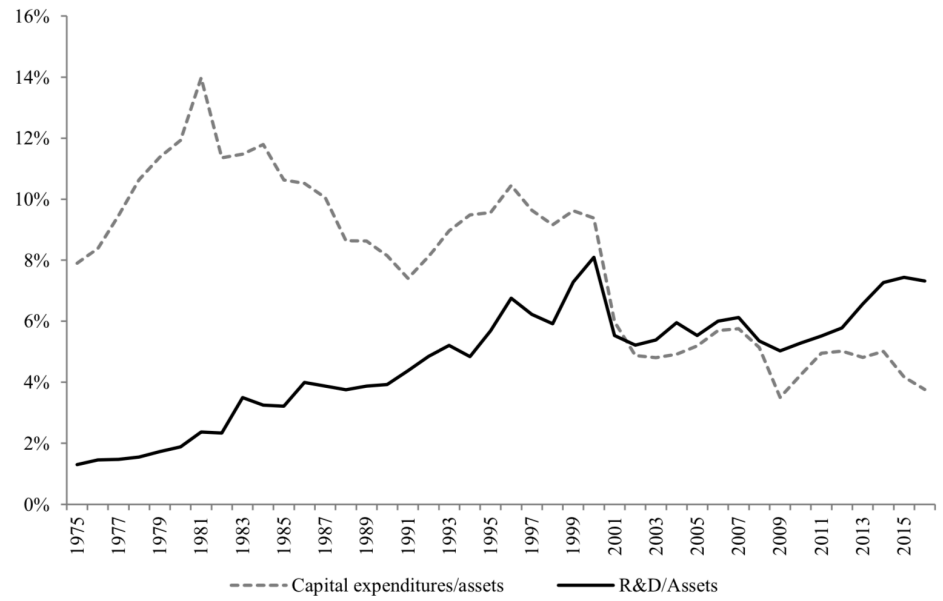
- GAAP: R&D and SG&A *expenses* rather than *investments,* since
  - High uncertainty measuring value of internally-generated intangibles
  - Tough to match outlays to earnings
  - Difficult to verify and low reliability

- They therefore skip the balance sheet entirely, with consequences for e.g.
  - Book Assets
  - Book Equity
  - Net Income

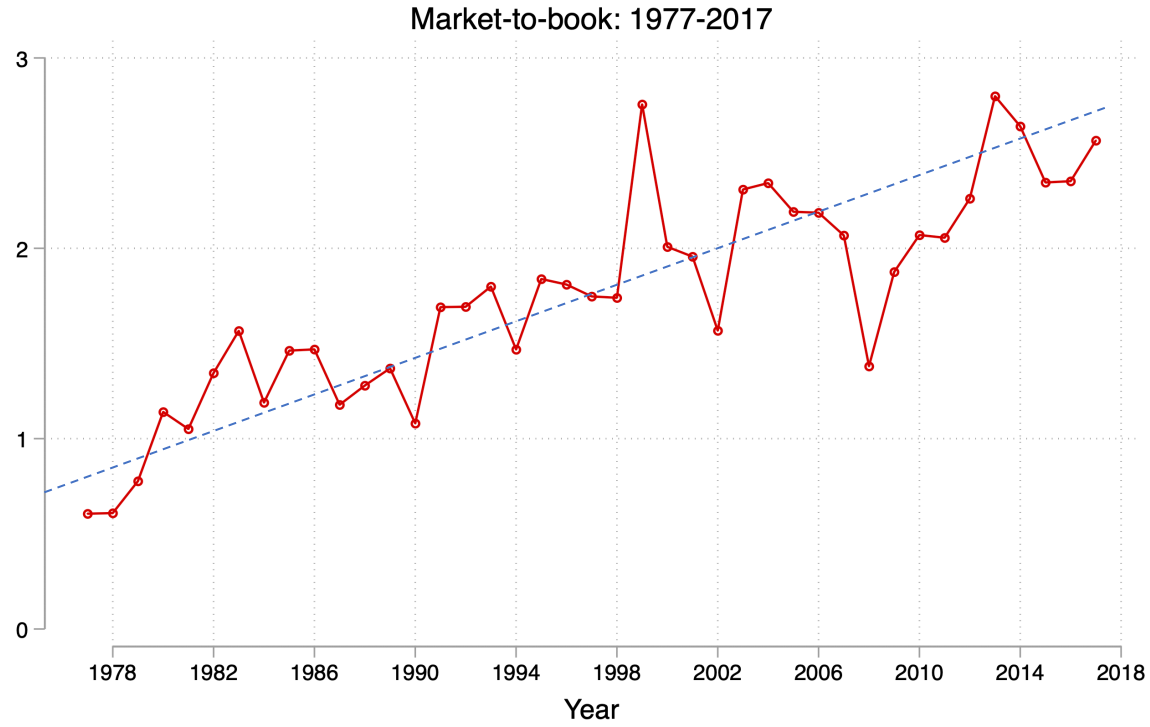
- Externally-acquired intangibles enter balance sheet at market value

Consequences of unrecorded intangibles

Figure 5. Capital expenditures versus research and development expenditures.



Doidge, Kahle, Karolyi and Stulz (2018)



Intangible assets skip book,
implies upward bias in M/B ratio

Measuring intangible capital

$$\text{Total Intangible Capital} = \mathrm{I}_{i,t}^{EXT} + \mathrm{K}_{i,t}^{INT} = \underbrace{IIA_{i,t} + GW_{i,t}}_{\text{Externally Acquired Intangibles}} + \underbrace{G_{i,t} + S_{i,t}}_{\text{Internally Generated Intangibles}}$$

Internally created Intangibles

- Intangible Capital = Knowledge Capital + Organizational Capital
  - Knowledge capital is accumulated R&D

$$G_{i,t} = G_{i,t-1}(1-\delta_G) + RD_{i,t}$$

  - Organizational capital: fraction of accumulated SG&A (Selling, General and Administrative Expenses)
  - Brand building, distribution systems, employee training.

$$S_{i,t} = S_{i,t-1}(1-\delta_S) + \gamma_S SGA_{i,t}$$

Externally purchased intangibles

- Balance Sheet Intangibles $\left(IIA_{i,t}, GW_{i,t}\right)$

Baseline Capitalization Parameters

Knowledge Capital (via R&D):

- Li and Hall (2020):

  BEA-NSF data, by industry
  - Covers < 11 % of SIC codes, and 28% of Compustat firms

Organizational Capital (via SG&A):

- Hulten and Hao (2008):

  30% of SG&A spending represents long-term investment
  - From aggregate data of **6** pharmaceutical firms in 2006

- Status quo $\delta_S = 20\%$

- Current measurements do not allow for any industry variation.

Hereafter, the "current method" will be called "BEA-HH".

E.g.) Capitalize R&D using Li and Hall (2020) data if available, and HH assumptions for org cap.

Fitting intangibles prices to capitalization model

$$\mathrm{P}_{it}^{I} = f(I_{it} + G_{it} + S_{it})$$

Assumptions:

- Functional form $\mathrm{P}_{it}^{I} = f(I_{it} + G_{it} + S_{it}) = \xi_{it}(I_{it} + G_{it} + S_{it})$
- ξ_{it} is a year fixed effect ρ_t constrained to be 1 across years
  - Allows the ratio of $\mathrm{MV}_{\text{intangibles}}/\mathrm{BV}_{\text{intangibles}}$ to vary over time

Substitute in perpetual inventory models for G and S,

$$\log(\mathrm{P}_{it}^{I}) = \log(\rho_t) + \log\left(I_{it} + \sum_{k=0}^{9}(1-\delta_G)^k RD_{i,t-k} + \gamma_S \sum_{k=0}^{9}(1-0.2)^k SGA_{i,t-k} \right) + \varepsilon_{it}$$

Solve for γ_S and δ_G to minimize sum of squared residuals (NLLS)

Two Settings, and Some Tradeoffs

Ideal setting:

- Choose a random set of publicly-traded firms and “price” their intangibles:
- Assess the standalone value of the assets, e.g.) benefits that would accrue to any owner (no synergy)

Setting 1 (Compustat):

- Use stock prices and accounting values to back out intangibles

  Pro: No selection issues

  Con: Can’t price physical and intangible assets separately

Setting 2 (Acquisitions):

- Use acquisition/exit valuation of intangibles

  Pro: Directly observe intangible prices, eliminating the need to back them out

  Con: Potential selection issues (exits are not random), synergies and/or overpayments

Which Capital Stocks Perform Best?

Comparisons of different measures

- BEA-HH, the current standard
- Market prices (Compustat)
- Acquisition/exit prices

Propose tests where “performance” of intangibles can be assessed:

- Total capital – physical and intangible – to explain market valuations
- Organizational capital (SG&A) alone to explain human capital risk, brand value, and employee satisfaction
- Intangible capital value to explain patent values and trademarks

Setting 1: Financial Market Prices

Publicly-traded firm valuations reveal intangibles:

$$P_{it}^{Total} = P_{it}^{Tangible} + P_{it}^{I}$$

…but, tangible assets on balance sheet recorded at historical cost.

- Hence, $\mathrm{MV}_{\text{intangibles}}$ measured with error.

$$P_{it}^{I} = P_{it}^{Equity} + P_{it}^{Liabilities} + P_{it}^{Preferred} - P_{it}^{Tangible}$$

Compustat has $\mathrm{BV}_{\text{Tangible}}$ → must make markup assumption

We try 2 assumptions for physical markup:

- No markup (Net tangibles)
- Use historical cost (Gross tangibles) <- This works much better

- One (randomly chosen) observation per firm in Compustat (14,876 firms)

Setting 2: Acquisitions

Strategy: Use intangibles' market prices in exits to estimate capitalization parameters

- 1521 acquisitions from SDC M&As 1996–2017; public acquiror/target
  - purchase price allocation (PPA) for (i) identifiable intangibles and (ii) goodwill
  - Search 10-Ks, 10-Q and 8-Ks
- 479 acquisitions in bankruptcy using recovery rates from Moody's DRD
- Adjust allocations for announcement return of acquirer to avoid capturing overpayment or synergies following Bhagat, Dong, Hirshleifer, and Noah (2005)

Parameter Estimates

$$\log(\mathrm{P}_{it}^{I}) = \log(\rho_t) + \log\left(I_{it} + \sum_{k=0}^{9}(1-\delta_G)^k RD_{i,t-k} + \gamma_S \sum_{k=0}^{9}(1-0.2)^k SGA_{i,t-k} \right) + \varepsilon_{it}$$

	BEA-HH		Compustat		Acquisitions	
	(1)	(2)	(3)	(4)	(5)	(6)
	γ_S	δ_G	γ_S	δ_G	γ_S	δ_G
All	0.30	0.28	0.39	0.28	0.27	0.33
			(0.012)	(0.012)	(0.026)	(0.038)
Consumer	0.30	0.31	0.31	0.20	0.19	0.33
			(0.013)	(0.064)	(0.027)	(0.317)
Manufacturing	0.30	0.25	0.33	0.32	0.22	0.42
			(0.016)	(0.043)	(0.055)	(0.163)
High Tech	0.30	0.31	0.47	0.34	0.44	0.46
			(0.026)	(0.051)	(0.060)	(0.072)
Health	0.30	0.18	0.49	0.26	0.49	0.34
			(0.039)	(0.020)	(0.138)	(0.065)
Other	0.30	N/A	0.63	0.15	0.34	0.30
			(0.031)	(0.093)	(0.062)	(0.184)
Pseudo-R^2			0.425		0.515	
N			14,876		2,000	

γ = Fraction of SG&A that is organizational capital.

Literature assumes $\gamma = 0.3$

δ_G = Depreciation rate of R&D knowledge capital

An Example: Apple's Balance Sheet

$$K^{\text{int}}_{AAPL,t} = \underbrace{I_{it}}_{\substack{\text{Book intan} \\ \text{from prior M\&A}}} + \left(\sum_{k=0}^{\infty} (1-\underbrace{0.46}_{\delta_G})^k RD_{i,t-k} + \underbrace{0.44}_{\gamma_S} \sum_{k=0}^{\infty} (1-0.2)^k SGA_{i,t-k} \right)$$

Non-current, non-financial assets:	Sep. 2017	Sep. 2016
Property, plant and equipment, net	33,783	27,010
Goodwill	5,717	5,414
Acquired intangible assets, net	2,298	3,206
Other non-current assets	10,162	8,757
Total assets	51,960	44,387
Knowledge capital (net)	12,515	9,640
Organizational capital (net)	13,672	12,515
Total assets (incl. off-bs intan)	78,157	66,542
increase (%)	50%	50%

Explaining Firm Value with Total Capital

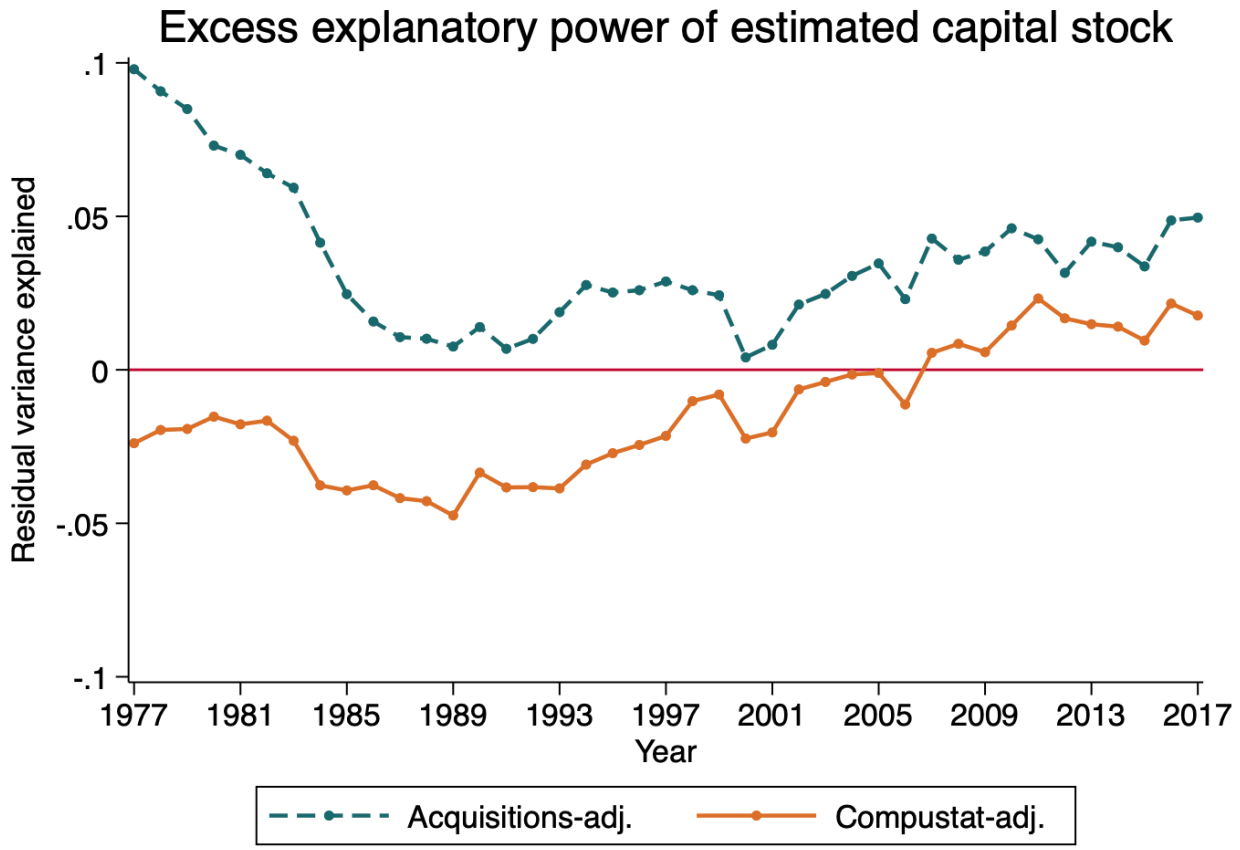
Higher quality accounting statements should better inform market values.

We run cross-sectional regressions of market valuations on book assets.

$$\log(E_{it}) = \alpha + \beta \log(K_{it}^{tot}) + \varepsilon_{it}$$

E_{it} is market enterprise value, and K_{it}^{tot} is book value of assets adjusted for intangible stocks via:

- BEA-HH-implied Parameters (reference values)
- Equity-price Parameters (Compustat-adj.)
- Exit-price Parameters (Acquitions-adj.)



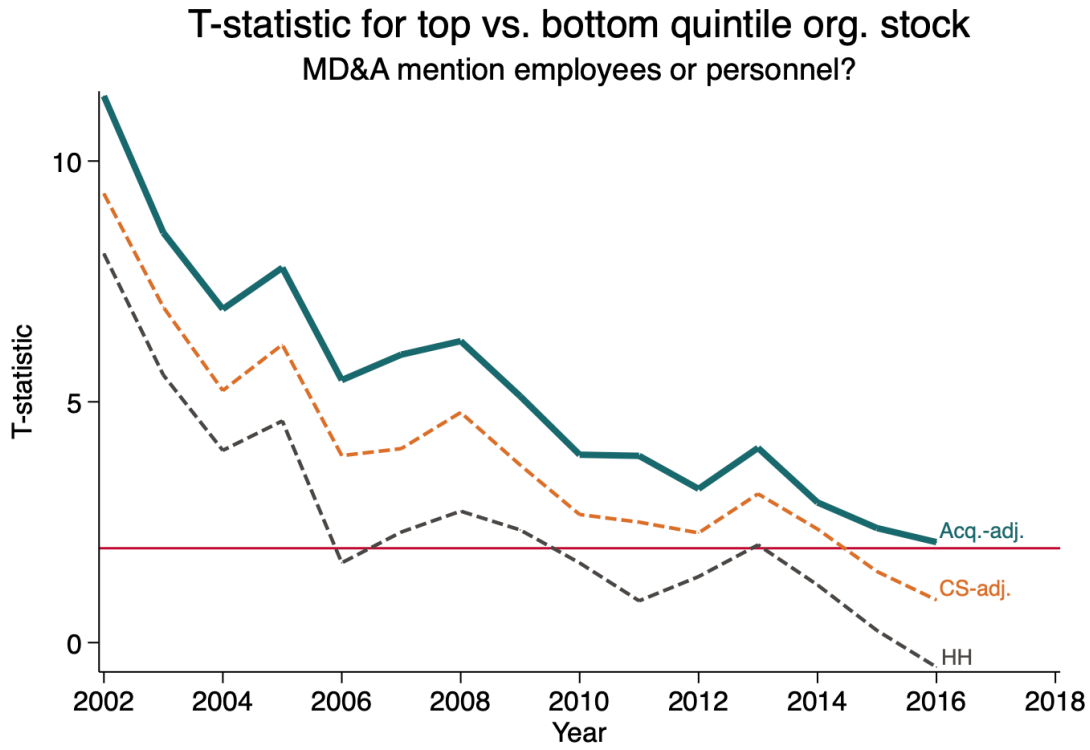
Organizational capital and human capital risk

Can firm sorts by the new Org-Cap capture human capital risk?

- Follow Eisfeldt and Papanikolaou (2013)

Approach:

- Text crawl all 10-K filings since 2002
- Search for personnel = [“key personnel”, “talented employee”]
- Sort firms into annual quintiles by:
  - HH-implied org cap (HH)
  - Equity-price Parameters (Compustat-adj.)
  - Exit-price Parameters (Acquitions-adj.)
- Compare quintiles in terms of
  Prob(mention one of those words)



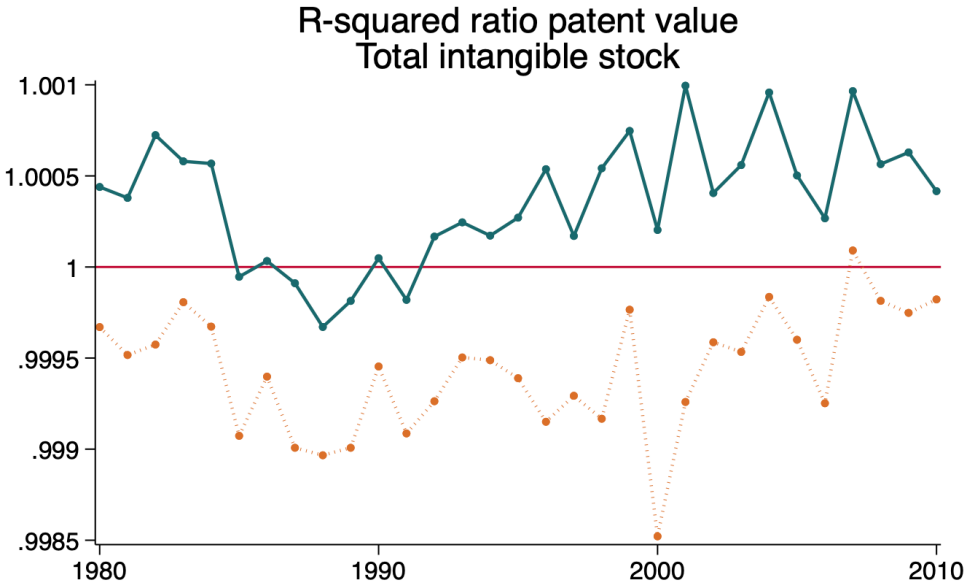
Intangible capital, patents, and trademarks

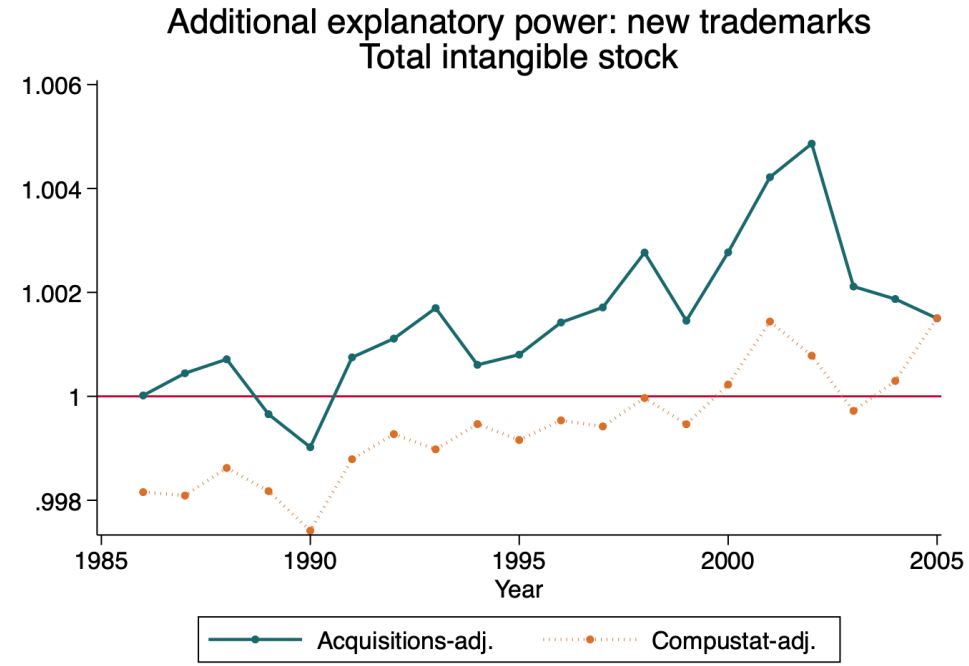
Which estimates better capture patent values and trademarks?

- Follow Kogan, Papanikolaou, Seru, and Stoman (2017) for patents
- Heath and Mace (2020) for trademarks

Approach:

- Regress patent values & trademark counts on own lagged values and intangibles





Characterizing the Stock of Intangible Capital

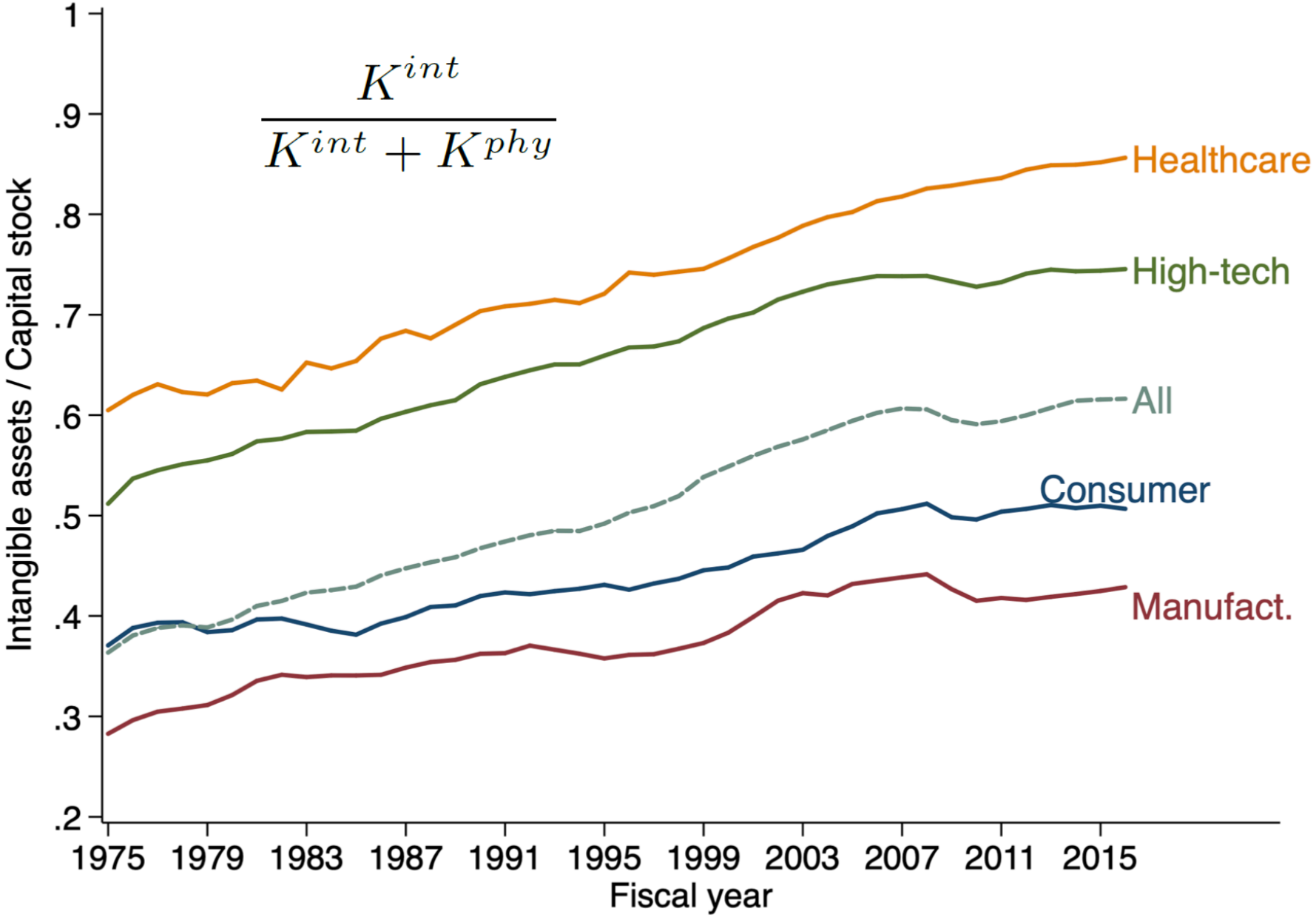
This is the first paper to attempt to estimate firms' stock of intangible capital

- Acquisitions measure outperforms the alternatives in every category
  - market valuations,
  - return predictability,
  - personnel risk,
  - patent values and trademarks,
  - brand value,
  - employee satisfaction

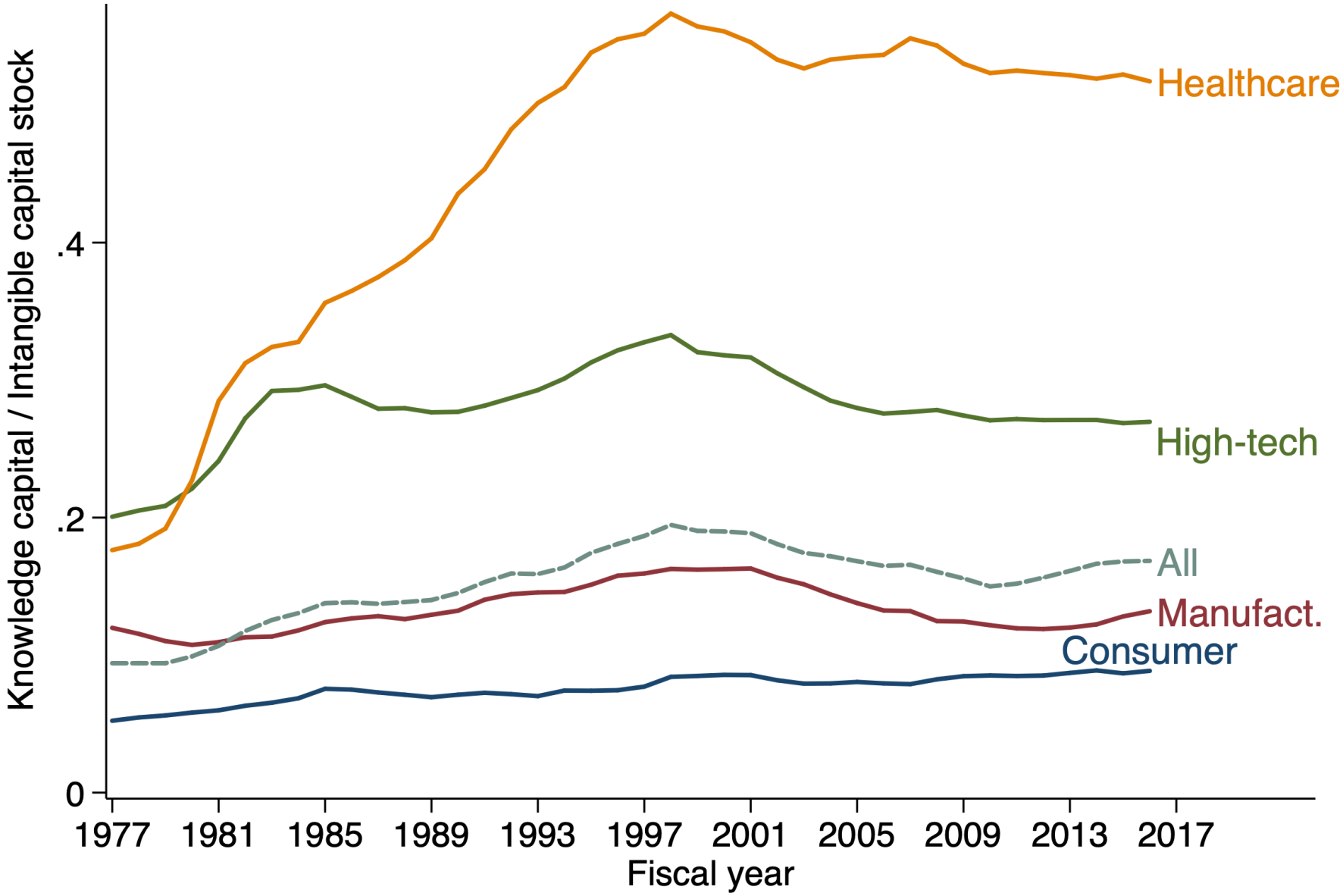
We believe this is the best existing measure of intangible assets in firms

So how big are intangible assets?

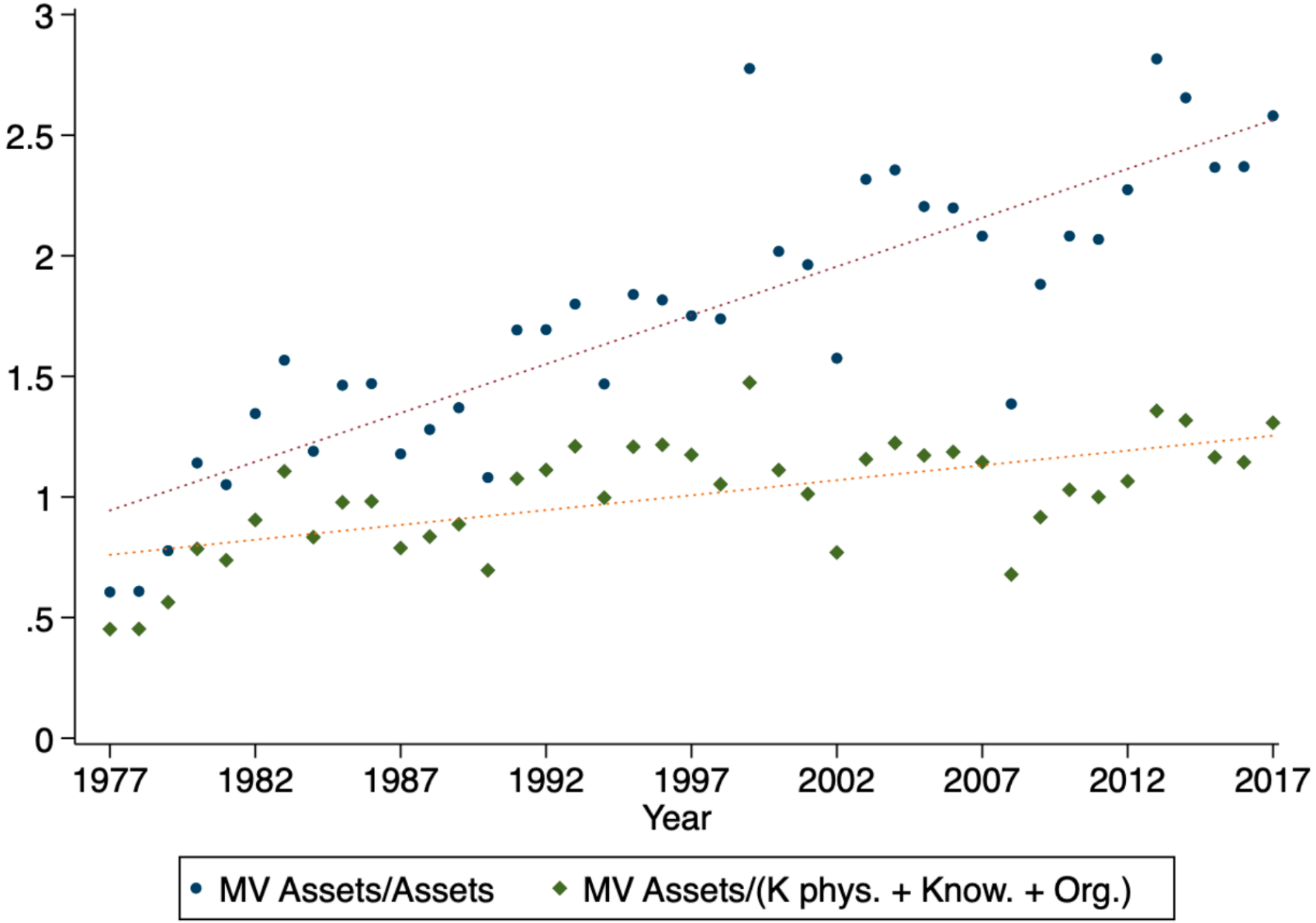
Intangible asset intensity over time



Knowledge Capital as a Share of Total Intangibles



Market-to-book using EPW intangibles: smaller trend



Conclusion

We propose a new method to estimate intangible assets in firms using prices and are the first to estimate the total intangible capital stock in firms

Comparing two potential sources of prices and an array of diagnostic tests, we find that the benefits of price allocations in the acquisition setting outweighs whatever weaknesses exist

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