Measuring Intangible Capital with Market Prices

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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

Doidge, Kahle, Karolyi and Stulz (2018)

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

\[
\text{Total Intangible Capital} = \left( I_{i,t}^{\text{EXT}} + K_{i,t}^{\text{INT}} \right) = IIA_{i,t} + GW_{i,t} + G_{i,t} + S_{i,t}
\]

**Externally Acquired Intangibles**

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

**Externally purchased intangibles**

- Balance Sheet Intangibles \((IIA_{i,t}, GW_{i,t})\)
## 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

\[ P_{it}^I = f(I_{it} + G_{it} + S_{it}) \]

Assumptions:
- Functional form \( P_{it}^I = f(I_{it} + G_{it} + S_{it}) = \xi_{it} (I_{it} + G_{it} + S_{it}) \)
- \( \xi_{it} \) is a year fixed effect \( \rho_t \) constrained to be 1 across years
- Allows the ratio of \( MV_{intangibles} / BV_{intangibles} \) to vary over time

Substitute in perpetual inventory models for \( G \) and \( S \),

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

Solve for \( \gamma_S \) and \( \delta_G \) 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, \( MV_{intangibles} \) measured with error.

\[ P_{it}^{I} = P_{it}^{Equity} + P_{it}^{Liabilities} + P_{it}^{Preferred} - P_{it}^{Tangible} \]

Compustat has \( BV_{Tangible} \) → 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

\[ \log(P_{\text{it}}^I) = \log(\rho_i) + \log \left( I_{\text{it}} + \sum_{k=0}^{9} (1 - \delta_G)^k RD_{i,t-k} + \gamma_S \sum_{k=0}^{9} (1 - 0.2)^k SGA_{i,t-k} \right) + \epsilon_{\text{it}} \]

<table>
<thead>
<tr>
<th>Parameter Estimates</th>
<th>BEA-HH (1)</th>
<th>Compustat (3)</th>
<th>Acquisitions (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_S )</td>
<td>0.30</td>
<td>0.39</td>
<td>0.27</td>
</tr>
<tr>
<td>( \delta_G )</td>
<td>0.28</td>
<td>0.28</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.012)</td>
<td>(0.026)</td>
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<tr>
<td></td>
<td>(0.013)</td>
<td>(0.064)</td>
<td>(0.317)</td>
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<tr>
<td></td>
<td>(0.016)</td>
<td>(0.043)</td>
<td>(0.055)</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.051)</td>
<td>(0.060)</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.020)</td>
<td>(0.138)</td>
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<tr>
<td></td>
<td>(0.031)</td>
<td>(0.093)</td>
<td>(0.062)</td>
</tr>
<tr>
<td>Pseudo-( R^2 )</td>
<td>0.425</td>
<td>0.515</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>14,876</td>
<td>2,000</td>
<td></td>
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\( \gamma = \) Fraction of SG&A that is organizational capital.

\( \delta_G = \) Depreciation rate of R&D knowledge capital.

Literature assumes \( \gamma = 0.3 \).
An Example: Apple’s Balance Sheet

\[ K^\text{int}_{AAPL,t} = I_{it} + \left( \sum_{k=0}^{\infty} (1-0.46)^k RD_{i,t-k} + 0.44 \sum_{k=0}^{\infty} (1-0.2)^k SGA_{i,t-k} \right) \]

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<tr>
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<tbody>
<tr>
<td>Property, plant and equipment, net</td>
<td>33,783</td>
<td>27,010</td>
</tr>
<tr>
<td>Goodwill</td>
<td>5,717</td>
<td>5,414</td>
</tr>
<tr>
<td>Acquired intangible assets, net</td>
<td>2,298</td>
<td>3,206</td>
</tr>
<tr>
<td>Other non-current assets</td>
<td>10,162</td>
<td>8,757</td>
</tr>
<tr>
<td><strong>Total assets</strong></td>
<td>51,960</td>
<td>44,387</td>
</tr>
<tr>
<td><strong>Knowledge capital (net)</strong></td>
<td>12,515</td>
<td>9,640</td>
</tr>
<tr>
<td><strong>Organizational capital (net)</strong></td>
<td>13,672</td>
<td>12,515</td>
</tr>
<tr>
<td><strong>Total assets (incl. off-bs intan)</strong></td>
<td>78,157</td>
<td>66,542</td>
</tr>
<tr>
<td>increase (%)</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
</table>
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 (Acquisitions-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 \(\text{Compustat-adj.}\)
  - Exit-price Parameters \(\text{Acquisitions-adj.}\)
- Compare quintiles in terms of 
  \(\text{Prob(mention one of those words)}\)
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

\[
\frac{K^{int}}{K^{int} + K^{phy}}
\]

- Healthcare
- High-tech
- All
- Consumer
- Manufact.
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 outweigh whatever weaknesses exist.

You can use this data now: http://bit.ly/intan_cap