Acquisition Prices and the Measurement of Intangible Capital *

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April 2019

Abstract

We estimate a capitalization model for intangible assets – knowledge and organizational capital – with over 1,500 purchase price allocations from 1996 to 2017. This method provides the first empirical estimates of the amount of organizational capital, which we find comprises over 75% of the average firm's intangible assets. Our total implied intangible capital stocks are 10% smaller, on average, than those implied by commonly used parameters while exhibiting dramatically more cross-sectional variation. Compared with these existing methods, our stocks have stronger explanatory power for market valuations and firm-level measures of personnel risk. Other validation exercises — of the stocks' trends, correlations with patent quality and valuations, and ability to improve the investment-q relationship — demonstrate that the new estimates replicate or improve upon current approaches.

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Corporate investment has changed dramatically in the last several decades as firms shift from investments in physical assets to investments in research and development (R&D) and other intangibles such as brand, customer lists, and human capital.[1] This change directly connects to a broader "investment puzzle" (e.g. Gutiérrez and Philippon, 2017) of declining private fixed investment and a weaker connection between firm valuation and investment. Accounting rules limit firms' ability to capitalize these investments, and measures of book assets, therefore, rarely capture these sources of value. Researchers in economics and finance respond to this limitation by estimating the value of intangible investments with accumulated flows of R&D and Selling, General and Administrative expenses (SG&A). For example, studies on the role of organizational capital in the cross-section of returns (Eisfeldt and Papanikolaou, 2013), firm valuation (Belo, Lin, and Vitorino, 2014; Eisfeldt and Papanikolaou, 2014) and firm's financing decisions (e.g. Sun and Zhang (2018)) each infer capital stocks from SG&A. Relatedly, knowledge capital stocks are estimated from R&D in studies of q-theory (Peters and Taylor, 2017) and firm cash balances (e.g. Falato, Kadyrzhanova, and Sim, 2013). Researchers who infer intangible capital stocks from capitalized intangible investments rely on parameters that have either unknown origin or cover a fraction of industries. We seek to fill this measurement gap.

A new solution for capitalized intangible assets is important for three reasons. First, any improvements to the depreciation rates of knowledge and organizational capital inform debates about the relative size of intangible assets in the economy, while the rates themselves are crucial inputs for estimates of returns to intangible investment (Hall, Mairesse, and Mohnen, 2010). For organizational capital in particular, we also require an estimation of how much of SG&A spending is investment. Second, existing depreciation rate estimates have gaps in industry coverage that rely on a large set of modeling assumptions or are simply ad hoc. The most commonly used parameters for knowledge capital originate from Li and Hall (2016), while Hulten and Hao (2008) provide the main parameter for organizational capital (hereafter, "BEA-HH"). The resulting estimates of intangible assets are thus difficult to compare, and it can be challenging to diagnose the key structural assumptions or data inputs. In contrast, our transparent, publicly-available data invites

[1] For example, see Corrado, Hulten, and Sichel (2009) and Kahle and Stulz (2017).

a methodology that rests on few structural assumptions. Third, both industry and time variation should matter in high-innovation settings; however, few studies (the exceptions are works such as Li and Hall 2016) can speak to either dimension. In fact, less than half of SIC codes have estimated depreciation rates. As described below, our data and estimation allow us to perform analyses by either industry or time in relatively flexible ways.

We achieve this by studying corporate investment activities that reveal the value of intangible assets: acquisitions. Acquisitions are an excellent setting to study intangible assets because they are a rare situation where both accounting rules and SEC guidelines allow recognition of intangible assets. When a U.S.-based public firm fully acquires another firm, SEC and GAAP rules require a comprehensive disclosure of the assets purchased. These assets are allocated into three major categories: physical assets, identifiable intangibles, and goodwill. Since 2004, over 85% of public-to-public acquisitions recognize the purchase of either identifiable intangibles or goodwill (Figure 1 (a)). These events thus provide a direct valuation of previously obscured intangible assets. For a publicly-traded acquired firm (i.e., target), one observes the history of their knowledge and organizational investments along with the value of previously uncapitalized intangibles. The valuation of the firm's intangible stock at the time of the acquisition combined with prior disclosures of the firm's intangible expenditures invite estimation parameters of the standard depreciation model.

The data comprise a large fraction of U.S. public firm acquisitions of U.S. public targets in SDC's M&A database. We consider deals closed between 1996 and 2017 so that we can view the financial statements filed after the acquisition. Those statements—typically SEC form 10 or 8—may reveal the purchase price allocation for material acquisitions completed using the purchase (not pooling) method. We hand-collect over 1,500 acquisition events and retrieve two key numbers from the filings: goodwill and identifiable intangible asset allocations.[2]

Although acquisitions provide a view of intangible asset values, they may be a non-representative and reflect both the public or market value of the assets and the private value to the acquirer. To

[2]We evaluated over 2,000 such acquisitions, but many lacked information for inclusion into the final sample. A few other papers use similar data. Li, Li, Wang, and Zhang (2018) study the acquisition of a target's organizational capital in acquisitions, using the existing depreciation parameters. Potepa and Welch (2018) use the acquired intangibles from M&A to revisit some of the questions about the informativeness of innovation proxies. To our knowledge, we are the first to use these market prices to estimate capitalization parameters.

address the issue of sample selection, we supplement the successful acquisitions with a set of over 450 bankruptcy events of publicly-traded companies over the sample period. For these events we assume a 70% debt recovery rate and allocate a fraction of this total to intangible assets using observed fractions from the acquisition sample. Next, rather than use the raw price of intangibles that likely include both private and public value, we attempt to remove two confounds: merger-specific values (i.e., synergies) and any under- or over-payment reflected in goodwill. Changes in the target and acquirer market valuations around deal announcement combined with observed merger failures probabilities inform these adjustments. The average final intangible asset valuations used in the estimation are 35% lower than those found in the filings data.

The estimated capitalization model closely follows the setup in existing work such as Corrado and Hulten (2014) and Peters and Taylor (2017), where the histories of R&D and SG&A are accumulated with separate depreciation rates to estimate the stock of knowledge and organizational capital, respectively. Our approach estimates these parameters using the acquisition price of intangibles, measured as the sum of goodwill and identifiable intangible assets. Effectively, we ask what depreciation rates of knowledge capital and rates of organizational capital investments best fit the valuations of intangible assets in acquisitions. The resulting parameter estimates imply an average 31% annual depreciation rate for R&D, which is significantly larger than the 15% benchmark rate commonly used in the empirical literature on R&D (Griliches and Mairesse, 1984; Bernstein and Mamuneas, 2006; Corrado, Hulten, and Sichel, 2009; Hall, 2007; Huang and Diewert, 2007). Our 29% estimate of the fraction of SG&A that represents investments in organizational capital is similar to that used in earlier work. However, the percentage of SG&A that represents an investment varies dramatically across industries, from 20% in the consumer industry to 50% in the healthcare industry.[3]

Reassuringly, the inclusion of the bankruptcies to the sample and the adjustment to goodwill for synergies have the expected impacts on the estimates. The bankruptcy outcomes lower the estimate of SG&A that is investment, while increasing the R&D depreciation rates. Similarly, the lowered goodwill values after adjustment result in a 48% larger R&D deprecation rate and 35%

[3]Note that these are average depreciation rates, including successful and failed projects.

lower fraction of investment in SG&A. The resulting directional changes to our parameter estimates suggest that our estimation strategy is effective in mitigating the aforementioned potential selection issues.

These new depreciation rates invite a straightforward capitalization of SG&A and R&D for the universe of Compustat firms and thus an estimate the total stock of intangible assets.[4] Once combined with traditional estimates of firm (tangible) assets, the new estimated intangible capital stocks are a significant percentage of total assets. This intangible intensity has increased from 37% of total (physical and intangible) capital in 1980 to 60% by 2016. The industry-specific parameter estimates result in relatively smaller intangible capital stocks for firms in the consumer and manufacturing industries and higher stocks in high tech and health firms. Over 80% of the average healthcare firms' assets are intangible in 2016, while the average manufacturing firm's intangible assets comprise about 40% of total capital.

Our estimation allows a straightforward decomposition of intangible capital into knowledge and organizational capital. Organizational capital comprises the majority (over 80%) of all intangible capital across firm-years. Although we assume time-invariant depreciation parameters, we document that the dynamics of these shares exhibit meaningful time-series variation due to changes in the relative use of R&D and SG&A over time.

The differences in our parameters and implied intangible capital stocks from those of existing approaches demand that we perform several validation exercises. We do so in four settings: market valuation regressions, human capital, patent valuation, and corporate finance tests of the neoclassical model of investment. Overall, our new estimates of intangible capital accumulation parameters perform at least as well and often significantly better as those commonly used in these various literatures.

Our first validation exercise asks whether the incorporation of our intangible capital stocks improves the explanatory power of firm book assets on enterprise values. We compare capital stocks that incorporate our measure of intangible assets with capital stocks implied by the BEA-HH parameters. Our measures improve the R^2 in the cross-section in all years from 1986 to 2016

[4] Parameter estimates and firm-year-level intangible stocks are available online: `https://github.com/michaelewens/intangible_capital`.

and are this additional power is statistically significant in all years after 1995. The additional explanatory power demonstrates that our estimated stocks are an improvement over existing methods.

Our second validation exercise verifies whether our new measure of organizational capital captures differences in human capital across firms and does so more effectively than current measures. We follow Eisfeldt and Papanikolaou (2013) in examining whether firms with high levels of organizational capital are relatively more likely to disclose risks of loss of key talent in their filings. To do so, we parse the management discussions of risk in over one hundred thousand 10-K filings from 2002–2017 and flag whether there is a mention of "personnel" or "key talent." Our measure of organizational capital stock outperforms the existing measures in all years: firms in the top quantile of organizational capital stock are significantly more likely to mention these human capital risks than those in the bottom quantile. In contrast, the current method of capitalizing SG&A only produces significant differences across firms in 35% of the sample years.

Our third validation exercise examines whether our new estimates of the intangible capital stock explain previous estimates of the the value of patents. Kogan, Papanikolaou, Seru, and Stoffman (2017) provide a measure of patent valuations from market reactions to patent grants. Regressions of these valuations on our new measures of knowledge and organizational capital stocks significantly increase within-firm R^2, while the estimates imply that an additional dollar of knowledge capital increases patent values 16%. To our knowledge, this is one of the first direct measurements of intangible investment returns.

The final validation exercise takes the implied capital stocks to the expansive literature that tests dynamic investment models through the lens of the investment-q relation (e.g. Fazzari, Hubbard, and Petersen (1988)). For example, Peters and Taylor (2017), using intangible capital accumulation parameters from Li and Hall (2016), show that incorporating measures of intangible capital investments and stocks strengthen this relation. The incorporation of our new measures of both stocks and investments improves explanatory power in the investment-q relation for R&D and broadly replicates previous results for SG&A or CAPEX.

Together, these findings contribute to three broad literatures. First, we contribute to a longstanding literature on growth economics that attempts to measure the value of knowledge in the economy by both re-estimating the knowledge capital accumulation process using market prices and by extending these estimates to organizational capital for the first time (Corrado, Hulten, and Sichel, 2009; Corrado and Hulten, 2010; Acemoglu, Akcigit, Alp, Bloom, and Kerr, 2013; Hall, 2007). Second, we contribute to an active debate surrounding intangible asset recognition. Lev (2018) suggests that standard-setters' resistance to recognizing intangible assets on firm balance sheets has substantial costs to both firms and the broader economy. In addition to confirming the value-relevance of currently included intangible assets such as goodwill, we provide evidence that estimating the value of additional intangibles is feasible and provides meaningful additional information to consumers of financial disclosures. Finally, we contribute to a growing literature in corporate finance that uses estimates of intangible capital as an input to examine real outcomes in firms (Eisfeldt and Papanikolaou, 2013; Gourio and Rudanko, 2014; Sun and Zhang, 2018; Falato, Kadyrzhanova, and Sim, 2013).

1 Accounting for intangibles

We exploit rich information on acquisitions by U.S. publicly-traded firms of other U.S. publicly-traded firms to explore intangible assets over the last 22 years. Such an exercise first requires a discussion of the regulatory and disclosure setting that surrounds these events. Appendix Section A1 provides a history of the accounting rules surrounding the acquisition of physical and intangible assets. Below we detail the accounting treatment of intangibles and the setting for our data collection.

1.1 Intangibles accounting

For nearly all internally generated intangible investments, such as intellectual and organizational capital, accounting methods differ significantly from that of long-lived physical assets.[5] While

[5]U.S. GAAP treats the development of computer software differently from other R&D costs. Following ASC 985 (formerly FAS 2), once a software developer has reached "technological feasibility," the developer must capitalize and amortize all development costs until the product is available for general release to consumers. https://asc.fasb.org/link&sourceid=SL2313776-111772&objid=6503587

a firm's capital expenditures on physical assets such as plant, property and equipment will be recorded on the balance sheet at its purchase price and depreciated over the estimated life of the investment, a firm's R&D, advertising or employee training expenditures will be fully expensed in the period in which the expenditure occurs.[6] Although these intangible expenditures may fulfill GAAP's primary criterion for asset recognition,[7] GAAP's justification for immediately expensing these expenditures stems from the high degree of uncertainty in measuring the value of these internally-generated intangibles.[8],[9]

In contrast to these methods, externally acquired intangibles via a business acquisition will be recorded as either identifiable intangible assets (IIA) or goodwill (GW) and be added to the acquirer's balance sheet, following guidance from ASC 350 (formerly FAS 142). If the target's internally funded intangible expenditures meet specified criteria they will be capitalized onto the balance sheet of the acquiring firm at fair market value.[10] The criteria for capitalization of intangibles documented in ASC 805 notes that an intangible asset is identifiable if it meets either the separability criterion, meaning it can be separated from the entity and sold, or the contractual-legal criterion, meaning that the control of the future economic benefits arising from the intangible is warranted by contractual or legal rights.[11] Some examples of these identifiable intangible assets include brand names, customer lists, trademarks, Internet domain names, royalty agreements, patented technologies and trade secrets. Any intangible assets, such as corporate

[6] For example, although The Coca-Cola Company spends several billion dollars each year to maintain the promote its products, and brand names such as Coca-Cola®and Dasani®are assets to the firm that create future benefits in the form of higher margins and increased sales volume, The Coca-Cola Company is not permitted to recognize these assets to the balance sheet.

[7] Asset recognition requires that the expenditure in the current period will provide economic benefits to the firm in future periods (Corrado, Hulten, and Sichel, 2009, 2005).

[8] https://asc.fasb.org/section&trid=2127268#topic-730-10-05-subsect-01-108369

[9] These accounting treatments will result in a downward bias to both assets and equity on balance sheet, since the intangible asset will be hidden from the books. Penman and Zhang (2002) note that this accounting conservatism does not appear to be immediately recognized by investors, resulting in temporary mispricing and predictable future stock returns.

[10] The approach by which intangibles are marked to fair value at the time of acquisition follows ASC 820 (formerly FAS 157). The firm's choice of method is disclosed in the appraisal notes for intangibles in the acquirer's financial statements. Firms have the option to appraise the value of intangibles by either: (1) estimating the replacement or reproduction cost of the asset, (2) comparing the asset to a similar or identical asset whose price trades on the open market, or (3) using discounted income or cash-flow valuation models were earnings or free cash flows are discounted by an appropriate discount rate. Because of the unique nature of intangibles, firms most often use the DCF approach when appraising these assets.

[11] https://asc.fasb.org/link&sourceid=SL4564427-128468&objid=99405171

culture, advertising effectiveness, management quality, with a non-zero market value that fail to meet these criteria for identification will be captured in the goodwill accounts of the acquirer's balance sheet.

In summary, the purchase and acquisition methods of accounting require that the target's net assets are marked to market at the time of the acquisition. During this process, any internally generated intangibles by the target firm that meet a set of specified criteria will be identified, appraised and brought onto the acquirer's balance sheet at fair value. Internally generated intangibles that do not meet such criteria but are still valued by the acquirer will not be separately identified, but will be recorded on the acquirer's balance sheet as goodwill.[12]

2 Literature

Given the importance of the book value of invested capital in measuring a firm's investment opportunity set, or assessing managerial performance, much research attempts to measure the value of intellectual and organizational capital that remains hidden from a firm's balance sheet due to accounting regulations. The most common method used in this stream of literature is based on the perpetual inventory method[13] (e.g. Corrado, Hulten, and Sichel, 2009; Corrado and Hulten, 2014; Cockburn and Griliches, 1988; Eisfeldt and Papanikolaou, 2013, 2014; Hall, 2007; Hulten and Hao, 2008; Zhang, 2014), which aggregates the accumulation of flows over the life of the firm to measure the total stock of intangible capital. These flows are then capitalized to the balance sheet.

The calculation of the year end off-balance sheet value of a firm's internally-generated intangible asset can be estimated by summing the estimated value of the intangible at the beginning of the period with the value of other expenditures used in the internal creation of intangibles in the given period, less any consumption of the asset over the given period. Thus, the value of the capitalized intangible asset at the end of year t, X_t, is as follows:

[12] Figures A2 and A3 in the Appendix provide basic examples of the differences between the purchase and pooling method. Section A4 provides several real-world examples found in our data.

[13] The OECD notes that this is also by far the most common method used in measuring the stock of physical assets (OECD Manual 2009, p. 38). https://www.oecd-ilibrary.org/docserver/9789264068476-en.pdf?expires=1533070661&id=id&accname=guest&checksum=7201974B80A2330318D1CA48385CDA2D

$$X_t = X_{t-1} + Z_t - D_t \tag{1}$$

where Z_t are real expenditures towards intangibles at the end of year t, and D_t represents the consumption or amortization of the intangible during period t. If we assume geometric amortization of the beginning of period intangible asset at the rate of δ, we have:

$$X_t = X_{t-1}(1 - \delta) + Z_t \tag{2}$$

Continuously substituting for the lag of X, the formula converges to:

$$X_t = \sum_{i=0}^{\infty}(1 - \delta)^i Z_{t-i} \tag{3}$$

In (3), the capitalized amount of the intangible asset is the sum of all unamortized off-balance sheet intangible expenditures. However, because the availability of high-quality accounting data on expenditures is generally scarce prior to the firm becoming publicly-traded, most papers use a modified version of (3):

$$X_t = (1 - \delta)^k X_{t-k} + \sum_{i=0}^{k}(1 - \delta)^{k-i} Z_{t-i} \tag{4}$$

Thus, in order to operationalize (4) and capitalize off-balance intangible assets, one must have suitable proxies over k periods for the intangible expenditures, Z, that give rise to the stock of knowledge and organizational capital, the value of the initial stock of the intangible, X_{t-k}, and parameters for the estimated depreciation rate, δ.

Following ASC 730's (formerly FAS 2) guidance and definition of research activities as development as "the translation of research findings or other knowledge into a plan or design for a new product or process,"[14] the consensus proxy for the flows of a firm's knowledge capital in the intangibles literature is its periodic disclosure of research and development expenditures. The proxy for the flows of a firm's organizational capital is more difficult to precisely measure. Perhaps part

[14] https://www.fasb.org/resources/ccurl/286/565/fas2.pdf, page 5.

of this measurement problem from an accounting perspective is due to the vagueness by which organizational capital is defined. For example, Evenson and Westphal (1995) first define organizational capital as the knowledge used to combine human skills and physical capital into systems for producing and delivering want-satisfying products. Eisfeldt and Papanikolaou (2013, 2014) define organizational capital as intangible capital that relies on essential human inputs, i.e. the firm's key employees. Lev and Radhakrishnan (2005) define organizational capital more broadly, as an agglomeration of technologies – such as business practices, processes and designs that gives a firm a competitive advantage and enables it to extract additional economic rents from its operating activities.

Current methods of estimating organizational capital rely on Sales, General and Administrative Expenses (SG&A) as a proxy for the firm's intangible investment flows. Contrary to the strict definition of R&D and its direct justification as a proxy for knowledge capital, the rationale for capitalizing SG&A stems from the lack of more direct measures and logical deduction. Selling, General and Administrative Expense is defined by GAAP as all commercial expenses of operation, i.e. expenses unrelated to cost of goods sold, that are incurred in the regular course of business pertaining to the securing of operating income. Some examples of expenses categorized as SG&A include advertising and marketing expenses, provisions for employee bonuses and stock options, bad debt expenses, and foreign currency adjustments. SG&A's inclusive categorization of items that should be classified as both expenses and assets create an additional parameter for capitalizing organizational capital.

Equation (5) modifies the perpetual inventory equation from (2) to include the fraction of SG&A, γ, that should be capitalized into the stock of organizational capital.[15]

$$X_t = X_{t-1}(1-\delta) + \gamma Z_t \tag{5}$$

[15]For example, Coca-Cola Company 2017 10-K disclose documents $12.5 billion in SG&A expenditures. Accompanying notes reveal that $4 billion of these costs are incurred to support the production costs of print, radio, television and other advertisements, while $1.1 billion of these SG&A costs are related to shipping and handling costs incurred to move finished goods from sales distribution centers to customer locations. Assuming that the advertising expenses incurred in 2017 will continue to enhance the firm's brand equity in future periods, these expenditures represent off-balance sheet intangible assets which should be capitalized. Conversely, the costs related to transporting finished goods to customers only support operations in the current period, and therefore should be immediately expensed.

To the best of our knowledge, there are no empirical estimates for the parameter estimates of γ. The only direct measurement, to the best of our knowledge, is from Hulten and Hao (2008) who estimate $\gamma = 0.3$ based on composite data of six companies in the pharmaceutical industry in 2006. Conversely, there have been a number of attempts to estimate δ for R&D investments. The main challenges, as stated by Griliches (1996) and Li and Hall (2016), stem from the fact that the majority of firms conduct R&D activities for their own use (and not to sell to third parties), and thus there does not exist a competitive marketplace for most R&D assets. Mead et al. (2007) argues that none of the current methods used to empirically estimate R&D depreciation rates are particularly satisfactory because the existing data at the firm-level has little variation over time, and nearly all of the existing models depend on strong identifying assumptions.

For example, Pakes and Schankerman (1984) develop a model by which they infer the depreciation rate of R&D by examining the decline in the renewal of patents as a function of age. This model assumes that productive R&D investments must yield benefits in the form of patents, and that the value of the R&D investment is directly inferable from the price of patent renewal.[16] Pakes and Shankerman obtain a point estimate on the depreciation parameter of 25%, with a 95% confidence interval between 18% and 36%. Lev and Sougiannis (1996) use an amortization model where the firm's current period operating income are regressed on lagged values of R&D expenditures. They interpret the size of each regression coefficient scaled by the sum of all coefficients as the estimated depreciation factor. Their model assumes that the amortization of R&D capital is responsible for generating earnings, which fully captures the benefits of R&D investments.[17] Their amortization model yields depreciation estimates of R&D that vary across industry between 11 and 20%.

Hall (2007) estimates R&D depreciation using a modified Cobb-Douglas production function and a market-based model. While these models do not suffer from the same issues as the patent models, they are forced to rely on other assumptions. The production model relies on one of two

[16]Hall, Helmers, Rogers, and Sena (2014) argue that patents are short-lived and applying for patent applications necessitate the disclosure of information and a reliance on trade law to protect the firm's economic rents from imitation, thereby making the use of secrecy a viable alternative for some firms.

[17]For example, some R&D investments may results in patent protection, which could add value to the firm by giving the firm the option to expand, or could provide competitive barriers to entry which could add value by reducing the riskiness of the firm.

assumptions to derive the implied depreciation rate. The first is that these firms operate in a perfectly competitive industry, which is likely inconsistent with the notion that R&D investment results in patents which provide the opportunity for monopolistic rents. The second assumes that the output elasticities of intangible and physical capital are exactly proportional to their shares, which she describes as a "heroic assumption (p. 26)." The market value approach makes two assumptions. First, the firm's valuation of physical and knowledge capital are identical and the depreciation of R&D capital will be one for one with ordinary capital. Second, the model assumes that firms earn returns that are equivalent to their expected returns, i.e. that no abnormal economic rents maybe accrued. Hall's production model estimated depreciation rates across industries as between -1 and -11%, while the market model estimated depreciation rates between 20 and 40%.

Li and Hall (2016) use a forward-looking profit model approach to estimate R&D depreciation with NSF-BEA data. Their model assumes a concave profit function for R&D investment, and that the firm will invest optimally in R&D capital to maximize the net present value of its investment. Unlike physical assets, the model assumes that R&D capital depreciates solely because its contribution to the firm's profit declines over time. Under these conditions, their model produces depreciation estimates between 12% and 38%. Their estimates cover 10.5% of 4-digit SIC codes and 28% of firm-year in Compustat, thus requiring ad-hoc assumptions for the vast majority of the firms.

Given the lack of parameter estimates for γ and the wide range of R&D depreciation estimates across varying model assumptions, it is not surprising that there is very little consensus among depreciation parameters used by empirical researchers across studies. The majority of studies tend to simply choose a set of parameter estimates for δ and γ when valuing the intangible stocks, then attempt to show that their results are robust to alternate parameter estimates. For example, Eisfeldt and Papanikolaou (2013) and Li, Qiu, and Shen (2018) estimate organizational capital, and assume γ to be 1 and 0.3, and δ to be 0.15 and 0.2, respectively. Corrado, Hulten, and Sichel (2009) allow δ on R&D investments to vary by industry and assume values between 0.2 and 0.6. Falato, Kadyrzhanova, and Sim (2013) assume δ on R&D equals 0.15, and both δ and γ on SG&A

to be 0.20.

3 Data

The main sample of acquisitions comes from Thomson's SDC Merger & Acquisition database. Sample construction starts with all U.S. public acquirer and public targets for deals that closed between 1996 and 2017 with a reported deal size. The constraints on years stems from our need to collect financial statements from the SEC's EDGAR website. We drop deals where the acquirer or target has a financial services, resources, real estate or utility SIC code.[18] Following the discussion in Section 1, we further exclude all deals that use the pooling method pre-2001.[19] What remains is a set of 2,109 acquisition events where we can search for the details on the purchase price allocation.

If available, purchase price allocations are provided in a footnote in the acquirer's subsequent 10-K, 10-Q, 8-K or S-4 filing. If the footnote was found, we collect all components of the deal. Our main analysis uses the reported goodwill and the "identifiable intangible assets" (IIA) valuations. Given these values may incorporate synergies, over-payment and strategic goals of the acquirer (e.g. Cunningham, Ederer, and Ma, 2018), we adjust them using changes in market valuations (discussed below). Some filings lack the footnote for the acquisition (e.g., the acquisition was immaterial) or we could not identify any filing for the acquiring firm (e.g. the firm has a unique registration type with the SEC). We found information on the purchase price allocation for 81% (1,719) of all candidate acquisitions. The last step requires merging the target and acquirer firms to Compustat and CRSP.[20] The final sample includes 1,521 events (70%). Below we describe how these deals differ from those lost in the data collection process.

[18]The excluded SICs are 6000 to 6399, 6700 to 6799, 4900 to 4999, 1000 to 1499.

[19]The results presented below for all deals from 1996–2017 are robust to exclusion of pre-2002 deals (see Appendix Table A3).

[20]We lose acquisitions because we either failed to find a Compustat identifier or the firm did not have stock price data in CRSP (e.g. it was traded on the OTC markets).

3.1 Sample selection

Acquisitions are non-random and often depend on the quality of both the acquirer and the target firm (e.g. Maksimovic and Phillips, 2001), the innovation needs of the acquirer (e.g. Phillips and Zhdanov, 2013; Bena and Li, 2014) and can be predicted by the relative market-to-books of acquirers and potential targets (e.g. Rhodes-Kropf, Robinson, and Viswanathan, 2005). Relatedly, the acquisitions in our sample naturally exclude another exit for target: failures. Our first attempt to address any sample selection from an acquisition-only estimation is to supplement them with other, presumably worse, exit events. We add to the sample 479 CRSP delistings from 1996–2017 which come from a combination of liquidations and bankruptcies.[21] Given the absence of a purchase price allocation disclosure, we make assumptions about the firm's exit value and the valuation of its intangible assets. Ma, Tong, and Wang (2017) shows that assuming a value of zero for intangibles is incorrect because innovation is a crucial asset class in asset allocation in bankruptcy. As an alternative for zero, we follow the literature on bankruptcies (e.g. Bris, Welch, and Zhu, 2006), who find that creditors receive about 70% of total debt value after liquidation.[22] This forms our "deal value" for failed firms. The intangible assets in this deal value are then assumed to match the ratio of IIA and goodwill to deal value observed in the same industry as our main acquisition sample. These resulting intangible valuations are on average 60% lower than those observed in the acquisition sample. Finally, including these requires a re-weighting to address the relatively large sample size compared to the acquisition sample (described in Section 4 below).

Any remaining selection issues after incorporating bankruptcies take one of two forms. If most acquisition targets are low productivity innovators (e.g. Bena and Li (2014)), then we may estimate too high a depreciation rate. Alternatively, acquired firms may on average represent firms with successful innovation projects or are purchased at the peak of their innovative productivity. In this case we would estimate too low a depreciation rate and/or too high a fraction of organizational capital investment (γ). It is not clear which source of selection issues dominate, so we use the

[21] CRSP delisting codes of 2 and 3.

[22] Bris, Welch, and Zhu (2006) report that secured and unsecured creditors combined mean (median) recovery is 69% (79%) in Chapter 11 reorganizations.

well identified parameter estimates from Li and Hall (2016) to help judge our estimates. As their estimation of depreciation parameters for R&D is from a representative set of firms, a lack of systematic differences with our estimates would indicate that our sample selection is not severe. Further, we will run all analyses with and without the bankrupt firms and evaluate whether the estimates change as predicted.

3.2 Private or public values: adjusting goodwill

Absent any sample selection, our estimation of population depreciation parameters still requires that the intangible asset valuations represent *public* or market value rather than private value. Mergers are often motivated by pair-specific value or synergies, which will bias the observed valuation. Further, managers may overpay for a target due to agency frictions or hubris (e.g. Roll (1986)). We follow the Bhagat, Dong, Hirshleifer, and Noah (2005) framework for estimation merger value creation. Specifically, we use their probability scaling method for announcement day returns to estimate the synergy and over-payment component of the acquisition value.[23] This estimate is removed from goodwill valuations from the purchase price allocation.[24] For each acquisition announcement, we first calculate the two day change cumulative abnormal return for both the target and acquirer.[25] Multiplied by the pre-deal (two days prior) market value of each gives the abnormal change in market valuation at deal announcement. Next, as the market's response incorporates expectations about merger failures, we weight them by the inverse of the probability of acquisition success observed in SDC over our sample period (78%). The sum of the target and acquirer's changes – the expected synergy – is subtracted from goodwill. Next, we remove the acquirer's change in valuation as it incorporates overpayment. Here, a decline in the acquirer's market value would signal over-payment and thus must be added back to goodwill. The final adjustment used are economically large. The average (median) deal sees a 35% (40%) decline in the goodwill.

[23]We cannot easily implement the second "intervention method" with our relatively small sample size.

[24]In cases where the adjustment exceeds goodwill (less than 15% of deals), the remainder is removed from the IIA valuation.

[25]The estimates below are robust to different event windows.

3.3 Main variables

The intangible components of acquisitions are identifiable intangible assets and goodwill. As discussed in Section 1, the latter captures the value of the transaction not directly attributable to either physical or intangible assets according to GAAP standards. For example, goodwill is often cited as the place-holder of estimated synergies from the merger of the two assets. The second component of interest is the aggregate "identifiable intangible assets," or IIA. Some items included in IIA are in-process R&D, patents, trademarks, trade names, brand, "technology", workforce, non-compete agreements, maintenance and support contracts, customer relationships (e.g., contracts or lists), intellectual property and royalty agreements. For each target firm merged to Compustat, we also gather up to 10 years of the firm's past R&D and SG&A expenditures along with any IIA and goodwill already existing on the balance sheet at the time of the acquisition.

Figure 1 (a) shows the prevalence of both goodwill and identified intangible assets for our sample of acquisitions. It reports the percentage of all deals that have some positive amount of either asset in the purchase price allocation. First, it demonstrates a meaningful increase in such deal components since the mid-1990s. Moreover, since 2004 over 85% of deals contain goodwill or some intangible assets. Figure 1 (b) repeats the analysis but weights by dollars in the acquisitions. The patterns remain. Next, Figure 2 asks how much of total enterprise value is comprised of goodwill and IIA. The latter represents some 25% of total transaction value over the sample period. On the other hand, goodwill accounts for approximately 35% of the typical deal size over the full sample period. Taken together, the data suggests that intangible assets play a major role in the U.S. acquisition market.

Recall that the goodwill valuations used in the estimation are adjusted following the methodology summarized in Section 3.2. Figure 3 reports the percentage of acquisition deal size allocated to goodwill and IIA after these adjustments. The prevalence of goodwill in deal size falls in all years (see the green arrows) and this has an impact on the total intangible value in acquisitions.

3.4 Summary statistics

Panel A of Table 2 presents summary statistics on deals and the parties. All dollar values are in 2012 dollars. The average deal year is 2005 with an average (median) deal size of \$2.3b (\$426). Deal size as measured by enterprise value (thus including assumed liabilities) averages \$2.5b. Consumer firms represent 18% of targets, while the average target has an EBITDA of \$142m. Over one quarter of the acquirers are headquartered in California, which is slightly above the rate for all public firms. This is likely a consequence of both our focus on acquisitions and our requirements for observability of the purchase price allocation for intangibles. We also see that goodwill is on average \$1.1b with a much lower median of \$159m.[26] IIA comprises 38% of total intangible assets (goodwill plus IIA). Finally, total intangibles represent 75% of enterprise deal size on average. In 281 acquisitions, the total intangible assets exceeded the enterprise value of the firm. We randomly checked 20 acquisitions in this subsample and verified that this was a result of the target's net tangible assets being less than zero. Correspondingly, we found that these targets tended to be high-tech or healthcare targets which happen to have very high levels of R&D and SG&A expenditures and very low levels PP&E on their balance sheets.

Panel B of Table 2 summarizes the failed firm sample. The average failure date in our sample is earlier than the acquisition date (2002 vs. 2004). In fact, over a quarter of the delistings in our sample occur in years 2000 and 2001, the burst of the e-commerce dot-com bubble. These failed firms are more likely than acquired firms to be in the consumer industry (34% vs. 18%). Not surprisingly, the average failed firm tends to be small and unprofitable with an average asset size of \$252m and net loss of \$80m. Total intangibles – which are estimated as a function of the "deal size" defined in the previous section – are small with an average of \$35m. Recall that we make no assumption about the breakdown of goodwill or identifiable intangibles, only the total.

[26] In a few of our observations, total intangibles (identifiable intangible assets and goodwill) is negative. These instances, while rare, occur because goodwill can take on negative values, and in our case takes on a negative value that is larger than the value of identifiable intangible assets. Since goodwill is the plug variable that equates the balance sheet, negative goodwill occurs when the acquirer is able to purchase the target at a price that is below the fair value of net assets that is measured during the due diligence appraisal. This negative goodwill is immediately recorded to the income statement as an extraordinary gain. We exclude deals with negative goodwill from the estimation (done in logs). See Figure A4 in the Appendix for an example.

3.5 Selection of acquisitions

Our final acquisition sample (excluding delistings from bankruptcies) excludes 588 deals where an extensive search failed to find the purchase price allocation information. Any inferences we make using our estimates of intangible capital depreciation may have to be qualified by sample selection issues. Fortunately, Table 3 shows that our sample of acquisitions is reasonably similar to those excluded. The right-most columns present the excluded acquisitions. These acquisitions occurred earlier in the sample, are less likely to be in manufacturing and have a smaller median deal size ($177 vs. $385m). The smaller size implies these acquisitions are more likely to be immaterial to the acquirer and, in turn, to not have a purchase price allocation in their filings. Reassuringly, the targets are not significantly smaller in the excluded group when measured by pre-acquisition assets or net sales. Overall, Table 3 shows that our acquisition sample likely tilts toward larger deals and more recent events. The inclusion of delisted firms – with low assumed "acquisition" values and no time period constraints – helps to balance many of these differences out.

4 Parameter Estimation

We measure the value of the target's intangible assets as the sum of externally acquired and internally generated intangible assets. The target's externally purchased intangible assets, I_{it}, are the intangible assets from the balance sheet (Compustat item *intan*). Building on a large empirical literature,[27] we measure the value of internally generated intangible assets as the sum of knowledge and organizational capital over the previous 10 years

$$K_{it}^{int} = G_{it} + S_{it}$$

where G_{it} is the value of knowledge capital and S_{it} is the value of organizational capital for firm i in year t.

We estimate these capital stocks by accumulating past spending in R&D and a fraction γ of

[27] Corrado and Hulten (2010, 2014), Corrado, Hulten, and Sichel (2009), Eisfeldt and Papanikolaou (2013, 2014), Falato, Kadyrzhanova, and Sim (2013), Lev and Radhakrishnan (2005), Zhang (2014) and Peters and Taylor (2017).

past spending on SG&A[28] using the perpetual inventory method:

$$G_{it} = (1 - \delta_{R\&D})G_{i,t-i} + R\&D_{it} \tag{6}$$

and

$$S_{it} = (1 - \delta_{SG\&A})S_{i,t-i} + \gamma SG\&A_{it}. \tag{7}$$

For each acquisition, we construct trailing 12-month measures for these two expenditures using the Compustat quarterly database.[29] Therefore, the fully specified capitalization model is:

$$K^{int}_{it} = (1 - \delta_{R\&D})G_{i,t-i} + R\&D_{it} + (1 - \delta_{SG\&A})S_{i,t-i} + \gamma SG\&A_{it} \tag{8}$$

Our ultimate goal is to estimate the structural parameters of the perpetual inventory equation (8), $\delta_{R\&D}$ and γ, by comparing the log of the capitalized intangible assets to the log of the allocated market price paid to acquire the firm's intangible assets, P^I_{it}.

The baseline specification estimates P^I_{it} as the sum of identified intangible assets (IIA) and goodwill (GW) reported in the acquirer's post-acquisition financial statements. To this we add the change in the acquirer's market capitalization around the acquisition event, which we define as $t - 2$ to $t + 2$ days around the acquisition announcement. A negative (positive) change in the acquirer's market capitalization represents the market's perception of whether the acquirer has overpaid (underpaid) for the target's net assets. Since goodwill acts as a plug variable between the target's marked-to-market identifiable assets and the fair value of the acquirer's offer, the market capitalization adjustment essentially acts as the market's correction for the inefficient pricing of goodwill in the deal.

We estimate an equation of the form

$$P^I_{it} = f(I_{it}, K^{int}_{it}; \theta_{it}) \tag{9}$$

[28] We measure SG&A net of R&D expense (*xrd*) and Research and Development in Process (*rdip*).

[29] This approach ensures that we have financial data on target firms in the quarter immediately before the acquisition. Using annual Compustat data often results in large gaps between financial report and the deal dates.

where θ_{it} is a parameter vector that includes γ, δ's and a general formulation of the market-to-book for intangibles. We start by assuming that the function f is linear and that the market-to-book enters as a multiplicative factor $\xi_{it} \in (0, \infty)$:

$$P_{it}^{I} = \xi_{it}(I_{it} + K_{it}^{int}) \tag{10}$$

Rearranging (10) shows that ξ_{it} is the intangible market-to-book ratio $\left(\xi = \frac{P}{I+K^{int}}\right)$. Our objective of estimating the book value of intangibles $I_{it} + K^{int}$ requires an assumption about ξ_{it}. Theories of firm dynamic investment such as Hayashi (1982) predict that ξ_{it} is one *on average*. Implementing this requires additional assumptions. In the extreme, we would let ξ_{it} be a firm fixed effect constrained to be one on average across all firms. Our cross-sectional data makes this infeasible. Instead we let ξ_{it} be a function of time through a year fixed effect (also assumed to be one on average):

$$\xi_{it} = \rho_t$$

where ρ_t is the year of the acquisition or delisting. Estimating (10) proceeds in several steps.

First, in order to avoid overweighting large firms in our sample, and without an obvious scaling variable, we first take the natural logarithm of each side of equation (10). This further necessitates adding one to the price and book value in order to avoid dropping acquisitions without any recognized intangibles:

$$log(1 + P_{it}^{I}) = log(\xi_{it}) + log(I_{it} + K_{it}^{int} + 1) \tag{11}$$

The nature of the perpetual inventory model necessitates that we put additional structure on the estimation, ensuring that depreciation rates are constant within capital types over time. We therefore estimate the structural parameters by minimizing the sum of squared errors of the non-linear equation:

$$log(1 + P_{it}) = log(\rho_t) + log(1 + I_{it} + G_{it} + S_{it}) + \varepsilon_{it}. \tag{12}$$

Next, due to the nature of SG&A spending, in particular the fact that it is very stable within firms over time, the parameters γ and $\delta_{SG\&A}$ in the K_{it}^{int} term are not separately identifiable.[30] We address this issue by estimating the parameter γ, and taking the depreciation of organizational capital δ_S as the standard 20% from the literature. We explore the implications of this assumption in Section 5 and the Appendix.

In order to avoid oversampling successful firms, as previously detailed in Section 3, we supplement the acquisition sample with a sample of delisted (failed) firms. When failed firms are included we estimate their market value of intangibles as the average debt recovery in bankruptcy (70%) multiplied by the average intangible intensity observed in the acquisition sample for firms in the same industry (See Figure 2 for the industry averages over time). Failed firm observations are weighted to match the unconditional relative frequency of acquisitions and non-acquisition delistings found in Compustat-CRSP. Since the model is in logs, model fit is assessed by comparing the exponent of the root mean standard error generated by the model to the exponentiated root mean squared error of a model that contains only a constant in the estimation. It should be noted that because our model does not contain a constant, a negative pseudo R^2 is possible.

Standard errors are estimated by bootstrap, re-drawing acquisition events and thus the full time series of target investments, with replacement (1000 replications). In the case of samples which include failed firms, we re-draw across all events before weighting to match the unconditional relative frequency of event types.

5 Results

We first estimate the capital accumulation process for intangible assets using the non-linear least squares estimation described above, then apply those estimates to a broader sample of CRSP-Compustat firms to investigate the validity and implications of our parameter estimates in a larger and more comparable sample of firms.

[30] To see this, consider the perpetual inventory equation for a firm i: $S_{it} = \sum_k \gamma SG\&A_{i,t-k}(1-\delta_S)^k$. If $SG\&A_{it}$ is constant for firm i, $SG\&A_{it} = SG\&A$, we have

$S_t = \sum_k \gamma SG\&A(1-\delta_S)^k = \gamma SG\&A\frac{1}{1-(1-\delta_S)} = \gamma SG\&A\left(\frac{1}{\delta_S}\right) = \frac{\gamma}{\delta_S} SG\&A$

In this case we can only identify the ratio $\frac{\gamma}{\delta_S}$. A similar result holds if SG&A has a constant growth rate.

5.1 Estimating the capital accumulation process

Results from the non-linear least squares estimation of equation (12) are found in Table 4. In all panels, the "All" row pools all firms while the other rows show separate estimates for the Fama French 5 industry breakdowns.[31] The column "$\bar{\delta}_G^{BEA}$" reports the average knowledge capital depreciation commonly used in the literature (Li and Hall, 2016), averaged within our industry categories. Panel A reports results using a sample that includes both acquisitions and failed firms while panel B reports results only from acquisitions. Recall that we assume that the organizational capital depreciation δ_S is .2. Reassuringly, Figure A1 in the Appendix shows no major changes in results presented here for parameter values in $[.1, .3]$. We thus maintain the assumption of .2 throughout.

The γ estimates in Panel A suggest that a significant portion of SG&A spending represents an investment in long-lived capital. Taking the organizational capital depreciation rates commonly used in the literature (Eisfeldt and Papanikolaou, 2014; Falato, Kadyrzhanova, and Sim, 2013; Peters and Taylor, 2017) of $\delta_{SG\&A} = 0.2$,[32] γ implies that the fraction of $SG\&A$ that represents an investment in the average firm is 29%. This is substantially larger than zero and nearly identical to the the 30% used in the literature. This is the first direct confirmation of the major assumption used in the literature. Although we match the estimate used in earlier work across all firms, our estimate of the fraction of SG&A to be capitalized varies across industries. The fraction of SG&A spending that represents an investment is lowest in the consumer industry at 20%. The lower estimate is consistent with selling expenses being a large fraction of SG&A for sectors such as retail, which tend to have lower levels of innovation. On the other extreme, the parameter estimate of 0.45 and 0.50 in the high tech and health sectors imply, along with the assumption on depreciation, that almost half of SG&A spending in these industries represents an investment. These relatively higher levels of investments in SG&A for high tech and health firms is consistent with their higher levels of employee training, database usage and branding.

The estimates also provide a new view on the rates of knowledge capital depreciation. Panel A

[31] We make one change to the FF5 industries, reclassifying SIC codes 8000-8099 (Health Services) as Consumer.

[32] Eisfeldt and Papanikolaou (2013) use a value of .15.

shows an average depreciation rate δ_G across all firms of 31% per year, which is significantly greater than the 15% benchmark rate commonly used in the empirical literature on R&D (Griliches and Mairesse, 1984; Bernstein and Mamuneas, 2006; Corrado, Hulten, and Sichel, 2009; Hall, 2007; Huang and Diewert, 2007; Warusawitharana, 2010). The cross-industry dispersion of δ_G in Panel A is also substantial, ranging from a low of 0.23 in the "other" industry to a high of 0.45 in high-tech firms. The last column in each panel reports the average knowledge capital depreciation used in the literature from the BEA estimates. The large standard errors for our estimates – likely due to small sample size – allow us to only say that the δ_G in high-tech differs statistically from existing estimates.

Panel B repeats the estimations on the sample without failed firms and shows similar patterns across industries. Excluding failed firms from the analysis raises the average fraction (γ) of SG&A that represents an investment in long-lived organizational capital from 29% to 44%, an increase of 49%. The point estimates for δ_G are lower in Panel B than Panel A, with the full sample implying an average depreciation rate of knowledge capital of 25% per year.[33] Next, Appendix Table A1 repeats the estimation without the adjustment to goodwill discussed in Section 3.2. As expected, the adjustments to goodwill have a large impacts on estimates. R&D depreciation rates are 35% higher and the percentage of SG&A that is investment are 48% lower with the adjusted goodwill. These changes demonstrate that our adjustments are controlling for a large part of the synergies and over-payment found in raw goodwill.[34]

Patterns in the industry-level estimates reassuringly match some expected features of intangible investments, while revealing whether certain selection concerns discussed earlier emerge. First, Table 4 shows that R&D depreciation is highest in the high tech industry (45%), which is also the largest in the BEA estimates (though a smaller 26%). These results confirm that the value of knowledge gained in this industry is short-lived, despite the fact that around 82% of high tech targets report R&D expenditures. The estimates of R&D depreciation rates in both specifications

[33] The negative depreciation for "Other" suggests that some firms in that industries were acquired for prices that dramatically exceeded even the raw sum of R&D. However, we cannot reject the null that the coefficient is zero.

[34] Additionally, and comfortingly, these estimates change relatively little between Table 4, which includes all targets and failures, and an estimation which includes only firms which report positive R&D (see Appendix Table A2 for these results).

exceed those those currently used in the literature. These differences suggest positive selection issues – e.g. acquisitions are more likely to be successful innovation projects – are not a first-order concern. We discuss any impacts of selection and non-representative pricing in the analysis of intangible capital stocks below.

As noted in Section 4, the estimation includes year fixed effects. These fixed effects act to connect our estimated book value of intangibles to the market values observed in the acquisition. A plot of the exponentiated estimated fixed effects ($\log(\rho_t)$) are shown in Figure 4, along with deviations from trend of the S&P 500 index. The fixed effects can be interpreted as the average market to book of intangibles in acquisitions, relative to the market to book in the average year. One should expect the market to book of acquisition targets to fluctuate with average market prices, which Figure 4 demonstrates. The correlation coefficient between these two series is 0.61.

5.2 From parameter estimates to intangible asset stocks

We next apply parameter estimates from our base specification in Panel A of Table 4 to the intangible capital accumulation process (Equation 8) of the broader CRSP-Compustat universe of firms.[35] The knowledge capital stock accumulates R&D spending following (6), while the organizational capital stock represents the accumulation of SG&A following (7). Each use the industry-level estimates of γ and δ_G. Total intangible stock is the sum of knowledge capital, organizational capital and externally acquired intangible assets on the balance sheet I_{it} (Compustat *intan*).

5.2.1 Comparison to existing methods

How do the differences between the current capitalization parameters and those in Table 4 manifest themselves in the stocks? To answer this, we first construct the intangible capital stocks – knowledge, organizational and existing intangibles on the balance sheet – using the BEA R&D depreciation estimates from Li and Hall (2016) and the literature's accepted parameters for organizational capital accumulation ($\gamma = 0.3$, $\delta_S = 0.2$). Recall that for organizational capital we only estimate γ (not δ_S) and thus have one mechanism for estimates of organizational capital to

[35]We follow Peters and Taylor (2017) in the details of the capital accumulation process such as capital stock initialization. For details see Appendix B2 their paper.

differ. Since we compare our estimates to the parameters commonly used in the literature, it is instructive to note that the BEA's numbers cover only 10.5% of 4-digit SIC codes and 28% of firm-years in Compustat. The literature commonly assumes a depreciation rate of 15% for non-covered firms, which are the vast majority. At the firm level, for firms covered by the BEA data, the correlation between our estimates and those of Li and Hall (2016) is 0.44.

Figure 5 presents the difference between our estimates ("EPW") and the current methods ("Current") and scaled by the latter. All the parameters are time-invariant, so any time-series variation in this percentage stems from changes in the relative use of R&D and SG&A. The differences in our estimated capital stocks relative to those from the literature vary dramatically across industries, as might be intuited from our parameter estimates. The "All" line in the figure shows that the new estimate is approximately 10% smaller across all firm-years. Our intangible capital stocks are lower than commonly assumed in both the consumer and manufacturing industries.

In contrast, estimated stocks are larger in all years for hi-tech firms and half the years for healthcare. In both cases, higher estimates of δ_G, which imply smaller knowledge capital stocks, are outweighed by larger implied organizational capital investments. Given the larger estimated depreciation of R&D for healthcare (33% vs. 17%), the relatively smaller stocks in healthcare in the 2000s reflects firms switching intangible investments to R&D from organizational capital investments.

5.2.2 Intangible assets by industry and time

The debate surrounding whether intangibles should be recognized as assets, and if so how to measure them, is based on the idea that such assets are increasingly becoming an important part of firms' balance sheets. Figure 6 presents one view on time series trends in intangible capital for the four industries. Each series plots the average ratio of intangible assets K^{int} $(S_{it} + G_{it} + I_{it})$ to total assets, e.g. intangibles and physical assets (Compustat *ppegt*). Reassuringly, intangible asset intensities are lowest in consumer and manufacturing firms. Firms in these industries have experienced an increase in the role of intangibles in their total assets since the late 1990s. In contrast, both healthcare and high-tech firms have high intensities that have each grown continually since the 1970s. Only since the mid-2000s have the growth rates slowed. The patterns in Figure 6 conform to basic predictions about differences across industries and over time and thus provide the first validation that our estimates measure real economic assets.

In a related analysis, we explore the relative importance of knowledge versus organizational capital by plotting the ratio of the former to total intangibles K^{int}. Figure 7 presents the results. Healthcare has the highest intensity of knowledge capital (and thus the lowest organizational capital intensity). Both healthcare and high-tech firms experienced increases in knowledge capital stocks from 1976 – 1996. Since 1996, the growth has either stalled (Healthcare) or the levels have fallen back to 1970's levels. One possible (though yet to be explored) explanation are changes in R&D tax credits. Many of these originated in 1981 (a period of increase in Figure 7) and expired in 1996 (Bloom, Schankerman, and Van Reenen (2013)). Given that the intensities for all industries has not fallen over this sample period, the decline in knowledge capital found here is connected to a shift to investment in organizational capital with SG&A spending.

5.3 Do these new intangible capital stocks perform better?

We now perform two cross-sectional analyses that can reveal whether the new stocks of intangible capital proposed here provide additional explanatory power over current methods. Note that the set of analyses where our estimates can improve in this way is limited by the our estimation of time-invariant, industry-level parameters. We also perform two other validation exercises, relating the estimated stocks of intangible assets to firms' patent values and demonstrating that the performance of our new measures is similar to those of the existing approach in the context of investment-q regressions. The results demonstrate that the new estimates behave as expected and in many situations out-perform current methods.

5.3.1 Explaining public firm valuations

Connections between between a firm's book value of capital stock and market valuations is closely tied to the large investment-q literature and asset pricing. One explanation for a separation between market and book values is measurement error in the latter, particularly missing intangibles.

Our intangible stocks provide an alternative adjustment to book values and an opportunity to directly compare the current capitalization approach to ours. Our first test for any improvements investigates the relative explanatory power of book value of capital stock for firm's market valuations. This regression typically uses the standard capital stock variable (total assets):

$$M_{it} = \beta_0 + \beta_1 K_{it}^{phy} + \rho_t + \epsilon_{it}$$

where M_{it} is end of fiscal year market capitalization of firm i,K_{it}^{phy} is the standard measure of physical capital stock and ρ_t are year fixed effects. Running this regression for the full 1986–2016 Compustat sample results in a R^2 of 84.4%. If intangibles are capitalized as proposed, then the asset side of the balance sheet should be adjusted, improving the explanatory power of these regression. Here we simply replace K_{it}^{phy} with our new $K_{it}^{phy} + K_{it}^{int}$. Using the existing BEA-HH estimates for K_{it}^{int} increases the R^2 to 85.6%. Reassuringly, the R^2 increases slightly more – to 86.1% – when we use our imputed intangible stocks.

Figure 8 presents a reinterpreted version of these results when the regressions are run on an annual basis. Here we estimate the model without capitalized intangibles ("None"), with the BEA-HH and our stock estimates ("EPW") each year, reporting the additional amount of explanatory power as the percent reduction in the residual sum of squares between the two models. The top panel reports the ratio $\frac{RSS* - RSS^{EPW}}{RSS*}$, where $RSS*$ is the residual sum of squares from either the BEA-HH approach or of ignoring off-balance sheet intangibles ("none"). A value greater than zero indicates improved fit. In every year of our sample period, the new measure outperforms the existing BEA-HH approach (red dashed line), and that the estimated capital stocks leave 1-3% less residual variance unexplained. When comparing our estimated capital stocks to firm capital without capitalized intangibles we find an upward trend in the relative explanatory power since 1994, consistent with the fact that the capitalization of intangibles has become increasingly important in explaining valuations as our economy has become more reliant on organizational and knowledge capital when generating economic value. For years after 2006 we find that including capitalized intangibles leaves 13-23% less unexplained variance in firm values.

The second panel of Figure 8 presents the formal test statistic for the null hypothesis that the R^2 from EPW and BEA-HH are identical, equivalent to the ratio above being zero, using influence functions. The solid blue line shows that incorporating our estimate has a statistically significant improvement in the R^2 since 1994 when compared to the baseline. When comparing the explanatory power of our estimated intangible capital stocks to those calculated using the BEA-HH approach (dashed red) the t-statistic in all years since 1992 excluding 1999 and 2016 is greater than two, suggesting that the improvements are statistically meaningful. In no years does the current capitalization method exhibit more explanatory power. Overall, these results demonstrate that the capitalized intangibles using the parameter estimates from Table 4 have the most predictive power for explaining enterprise value.

5.3.2 Organizational capital and personnel risk

Consider next the measure of organizational capital. Eisfeldt and Papanikolaou (2013) propose a similar capitalization of SG&A that is used in other earlier work and validate it using textual analysis on 100 10-K filings' "Managerial Discussion" (MD&A) sections. They seek out references for personnel risk in these filings and argue that any firm sorting by a measure of organizational capital should correlate with such mentions. We follow a similar approach, here using overs 120,000 10-K filings from 2002–2016.[36] We calculate the fraction of words in the MD&A statement that reference risk of personnel loss (keywords: "personnel" or "talented employee" or "key talent"). Firms are split into quintiles based on their organizational capital stock scaled by assets in each year using our measure and the current approach (i.e. $\gamma = .3$, $\delta_S = .2$).

A comparison by year of the existence of these words between these two quintiles reveals that our measure of organizational capital stock captures something real and new. First, the fraction in the top quintile versus the bottom with some reference of personnel risk is 68% and 51%, respectively across all years. This compares to 59% vs. 52% for the quintiles sorted using the current measures. Figure 9 demonstrates that our stock measures significantly outperform on this metric. It reports the t-statistic for the difference in means of personnel risk mentions between

[36] See `https://github.com/apodobytko/10K-MDA-Section` for the code to run this search.

the top and bottom quintile of organizational capital stock. In all years of the sample period, the difference between top and bottom quintile is significant. In contrast, in only six of fifteen years is the difference significant for the current stock measure (BEA-HH). We conclude that our new measure of organizational capital stock provides more predictive power for firm's assessment of the risks to their human capital.[37]

5.3.3 Patent valuations and the returns to knowledge capital

One of the more meaningful types of intangible assets built and owned by firms are patents. The production of patents requires investments in both knowledge and organizational capital. Thus, if our measures of S and G capture intangible investments, then they should correlate with patenting and patent valuations. Moreover, connecting capital stocks to patent valuations can reveal the private returns to investments in knowledge capital that has thus far been difficult to estimate. What has historically been missing is the same thing that was missing in our setting of intangible capital stocks: prices. Fortunately, Kogan, Papanikolaou, Seru, and Stoffman (2017) provide a new measure of patents valuation from market reactions to patent grants that can be connected to the knowledge and organizational capital stocks.

Table 5 presents a regression analysis relating two measures of patent values – market-based and citation-based – with our disaggregated intangible stocks G_{it} and S_{it}. For all Compustat-CRSP firms that pass the traditional filters, we calculate intangible capital stocks and merge on the Kogan, Papanikolaou, Seru, and Stoffman (2017) measures. Only firm-years with patents are available, and all right-hand side variables are lagged one year. Controls include firm and year fixed effects and all variables are scaled by lagged total assets (not including intangibles) and logged. We are thus asking whether changes in intangible capital stocks correlate with above average changes in firm's patent values. Interestingly, one can also interpret the coefficients as estimates of private returns to investments in knowledge or organizational capital.

Several patterns emerge that lead us to conclude that our intangible capital stocks are eco-

[37]Reassuringly, sorting firms by our organizational capital stocks (by year) results in similar patterns of firm productivity, size and executive characteristics as found in Eisfeldt and Papanikolaou (2013) (see Appendix Table A4).

nomically meaningful. Column (1) shows the baseline specification with a traditional size control of log sales. Column (2) adds in our knowledge capital stock. The positive and significant loading is consistent with R&D spending being an important part of patent production. We observe an almost doubling of the within-R^2 from (1) to (2), suggesting that knowledge capital stocks can explain changes in firm patent valuations. Column (3) considers organizational capital in isolation. The loading is smaller and R^2 is essentially unchanged. The full specification in column (4) demonstrates that the relationship between intangible stocks and patent value (in dollars) comes primarily through the stock of knowledge capital.

The coefficient estimates from column (4) suggest that a 1% increase in knowledge capital results in a .16% increase in patent valuations. To our knowledge, this is one of the first direct measurements of intangible investment returns and is an interesting area of future research.

The last four columns repeat this exercise with the more traditional citation-weighted patent value (e.g. Hall, Jaffe, and Trajtenberg (2005)). The measure of patent value is only weakly correlated with the market measure (.38) and represents value not completely owned by the firm. The results here are different. First, both stocks G and S have meaningful explanatory power as demonstrated in the increased R^2 in (2) and (3). Moreover, the last column shows that both intangible capital stocks load and explain variation in citation-weighted patent value. This result could be explained by the nature of organizational capital investments as modeled in Eisfeldt and Papanikolaou (2014), where such capital is only "partly firm specific" and tied to key employees.

5.3.4 Investment-q regressions

Having demonstrated that our measures of intangible capital stocks have the expected variation in both the cross-section and the time-series, improve explanatory power of capital stock to firm enterprise value, and exhibit expected correlations with output measures of knowledge and organizational capital, we perform one final validation test. Specifically, we test whether our capitalized intangible stocks can improve the explanatory power between a firm's "total Q" as in Peters and Taylor (2017) and its investment. We use our parameter estimates to construct a new total Q. This analysis allows us to address how our new measure of intangible assets stacks up against the prevailing approach to capitalizing knowledge and organizational capital. Here, Total Q is firm value divided by the replacement cost of physical capital (i.e., PPE), booked intangibles on the firm's balance sheet and our estimated intangible assets implied by the industry-level estimates in Table 4. The correlation between alternative measures is informative. The directly comparable measures of capitalized R&D and total intangible assets have a 90% and 83% correlations across approaches. The high correlations are a function of very similar inputs (e.g. past R&D), while indicating that different parameter estimates can still result in similar output. They also follow from the common assumption about time-invariant depreciation parameters.

The OLS regressions of interest relate our total-Q measure and that of Peters and Taylor (2017) to four measures of investment. Since we consider R&D and SG&A spending to be investment, they are objects suited for investment-q regressions. Our major goals are to confirm that the coefficient loads as expected (positive) and that we can match or exceed the R^2 found in earlier work. Table 6 presents the results for the four major industries.

The odd columns report the replication of Peters and Taylor (2017) using their specification of intangible assets. The even columns use our measure. First, the loadings across investment measures – e.g., column (2) shows R&D investment – are similar in both specifications and across industries. Second, our market-based model motivated by the structure of existing depreciation models explains a similar fraction of the variation measured by within-R^2 in investment when compared to Peters and Taylor (2017). Most striking is the improvement of explanatory power for R&D investment across all industries. These results reassuring because we have not added much modeling complexity, but have brought novel data – acquisition prices – to an old question.

6 What is goodwill?

Introducing a new microeconomic dataset and estimates of intangible capital stocks, we next attempt to shed some on the makeup of acquisition goodwill.

A unique feature of our setting is embedded in our estimate of acquired intangibles. Goodwill is often thought of as a "plug" associated with over-payment (Gu and Lev (2011)) in acquisitions (see the accounting for goodwill in Figure A4 in the Appendix). The adjustments made to the reported goodwill (discussed in Section 3.2) seeks to extract any overpayment or synergies in reported goodwill, leaving us with something closer to what is meant to capture: unidentifiable intangible assets. Even after our adjustments, goodwill plays an important role in acquisitions. To explore the inputs or investments that produce goodwill, we re-estimate the main model after setting all acquisition goodwill to zero. This change can reveal whether organizational and/or knowledge capital are important for predicting acquisition goodwill.

Estimation results for the specification without acquisition goodwill are in Table 7. The estimates of γ dramatically decrease for all industries. This result implies that very little SG&A spending represents investment in *identifiable* intangible assets, as the majority of SG&A is valued in the acquisition goodwill payment. In fact, the estimate for the full-sample results in both Panel A, which include both acquisitions and failures, and panel B, which include only acquisitions, are both statistically indistinguishable from zero, implying that essentially all of the long-lived capital generated with SG&A spending is accounted for in acquisition goodwill. It appears that investment in organizational capital produces relatively more unidentifiable assets than R&D.

Additionally, estimates of R&D depreciation rates increase. This suggests that at least some knowledge capital ends up as unidentifiable intangibles. Taken together, these results suggest that, rather than simply being the "plug" value which sets the purchase price equal to the total book assets, adjusted acquisition goodwill represents the accumulation of the target's past investments in unidentifiable intangible assets.

7 Conclusion

Over the past few decades, intangible assets have become a key component of economic productivity. Proper measurement of these intangible assets is required for accurate measurement of investment returns and firm value. Despite their importance, current accounting rules generally treat intangible investments such as R&D as expenses, thus leaving most of these generated assets off the balance sheet. However, the lack of an accepted capitalization approach has not impeded researchers in economics and finance from translating expenses as investments in intangible capital. This paper provides new estimates that both validate and improve these capitalization methods.

We hand-collect market valuations for intangible assets from over 1,500 acquisitions from 1996 to 2017, and use these prices to validate parameter estimates of (1) the depreciation parameters for knowledge capital based on prior R&D spending, and (2) the fraction of SG&A capital that represents long-lived organizational capital. The resulting parameter estimates confirm the conclusions of existing, more ad-hoc approaches for knowledge capital and providing new industry variation in organizational capital stocks. Our imputed values of knowledge capital across all public firms explains the value of patents, while our imputed values of organizational capital identify firms who disclose exposure to human capital risk in their financial statements. The new intangible-adjusted book values improve the explanatory power of the relation between a firm's capital stock and its enterprise value and in the canonical investment-q regression for R&D.

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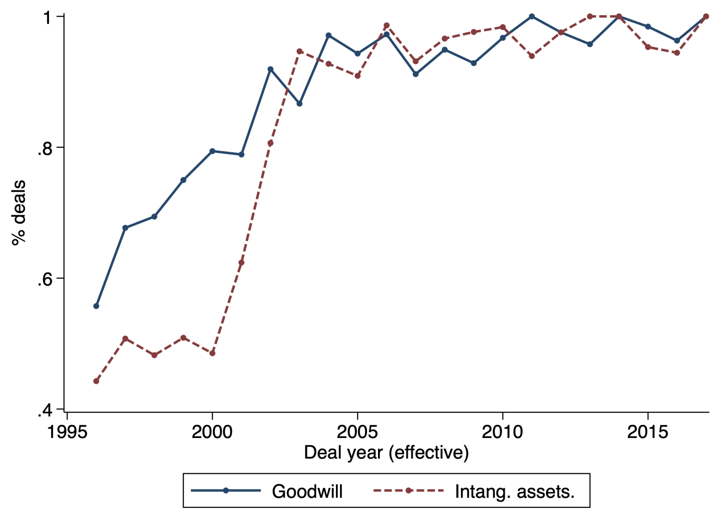
8 Figures and tables

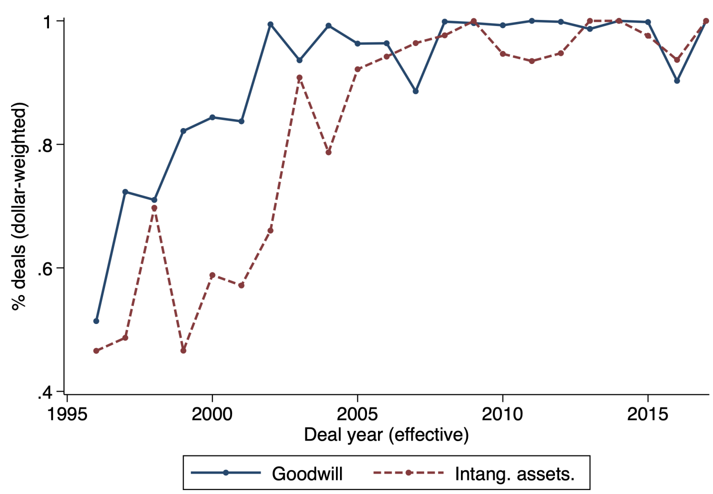
Figure 1: Percentage of acquisition deals with non-zero intangible assets or goodwill

The figure in Panel A reports the percentage of all acquisitions in the sample (see Section 3) that have non-zero intangible assets or goodwill acquired. The deals included are those where we could find a purchase price allocation in the target's 10-K, 10-Q, S-4 or 8-K. Panel B reports the percentage of all deal dollars in our sample of acquisitions (see Section 3) associated with deals that have non-zero goodwill or intangible assets acquired. So the "Goodwill" figure is the annual sum of transactions with some positive goodwill divided by the total amount of transaction dollars in that year.

(a) Prevalence of IIA and goodwill



(b) Deal-weighted



Acquisition deal size winsored at 95th percentile.

Figure 2: Percentage of acquisition deal size for intangible assets

The figure reports the average percentage of an acquisition deal size that is attributed to goodwill, intangible assets (IIA) and their sum. The sample is the subset of acquisitions (see Section 3) associated with deals that have non-zero goodwill or intangible assets acquired.

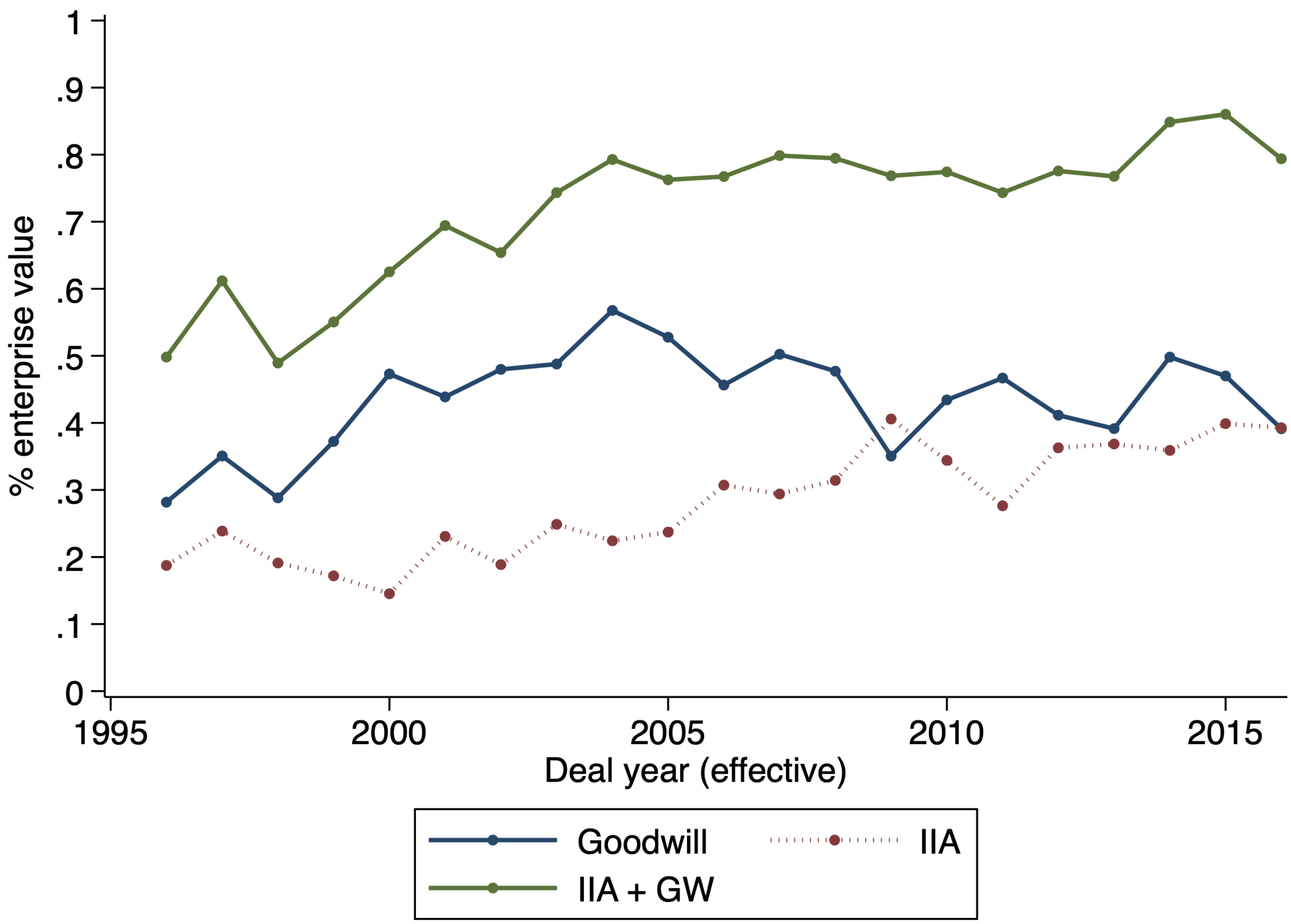


Figure 3: Percentage of acquisition deal size for intangible assets: post-goodwill adjustment

The figure reports the average percentage of an acquisition deal size that is attributed to goodwill after synergy or over-payment adjustment and its sum with IIA. The sample is the subset of acquisitions (see Section 3) associated with deals that have non-zero goodwill or intangible assets acquired.

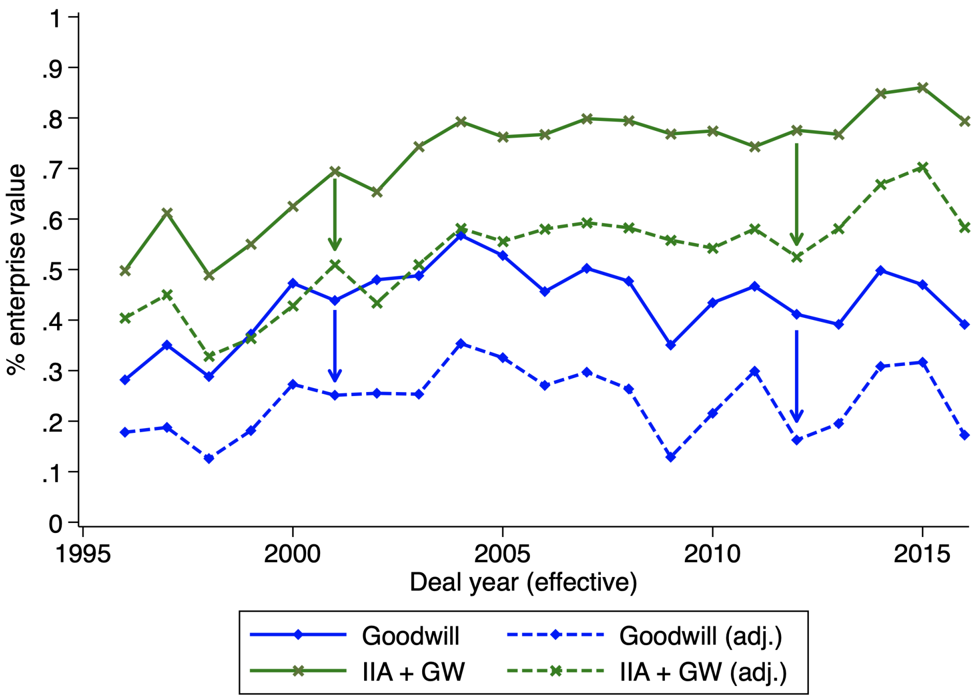


Figure 4: Estimated year fixed effects and S&P 500 index

The figure reports the estimated year fixed effects (exponentiated) from equation (12) and end of the 2nd quarter S&P 500 index (de-trended).

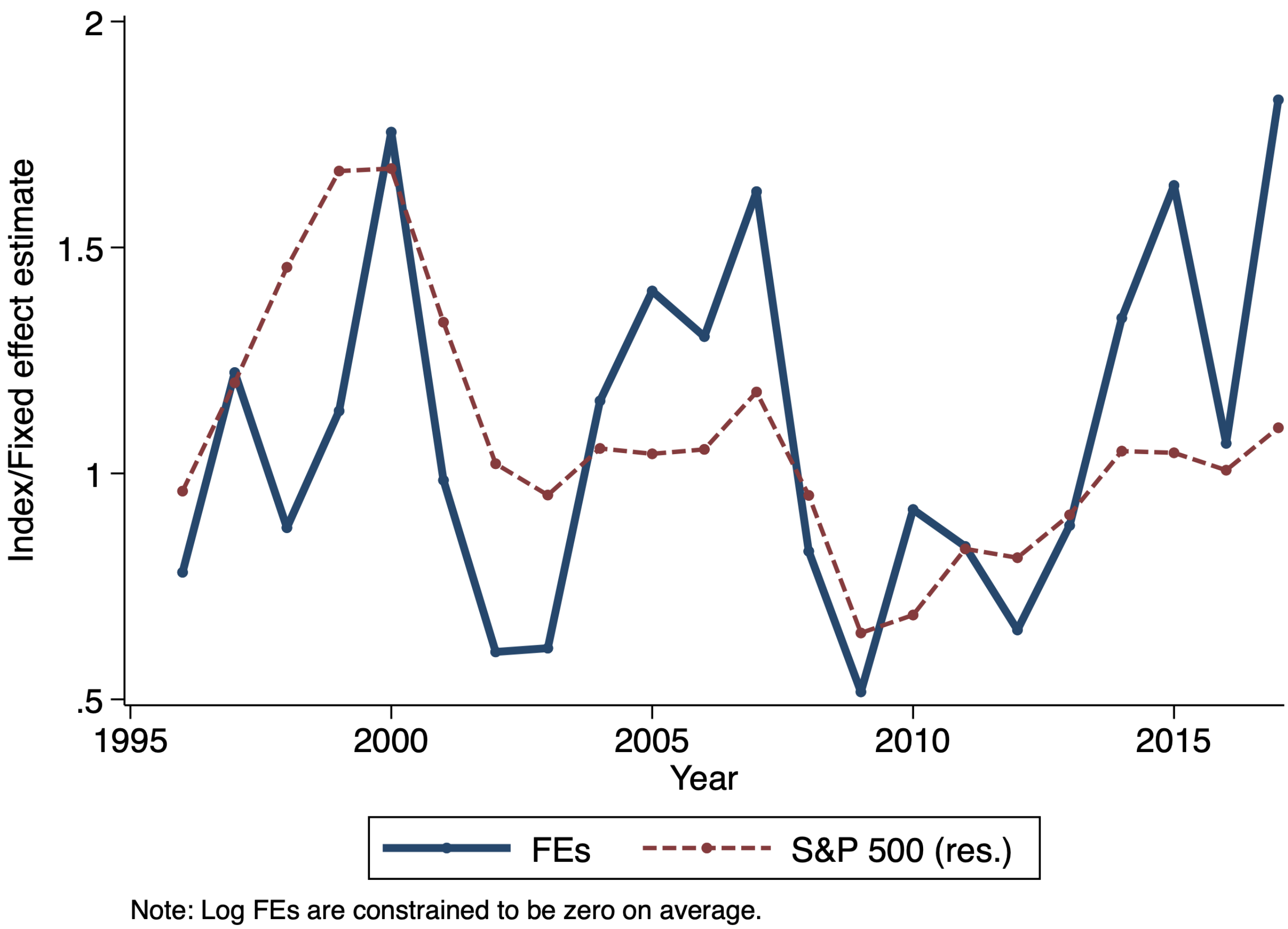


Figure 5: Comparing intangible stocks: new methods versus existing BEA-HH/Literature

The figure reports the percentage difference between the stocks constructed using the current capitalization method (i.e., BEA-HH and existing literature) and that proposed in this paper ("EPW"). A positive percentage difference implies that the proposed alternative implies a larger intangible capital stock than current methods. Averages by year and within-industry are reported.

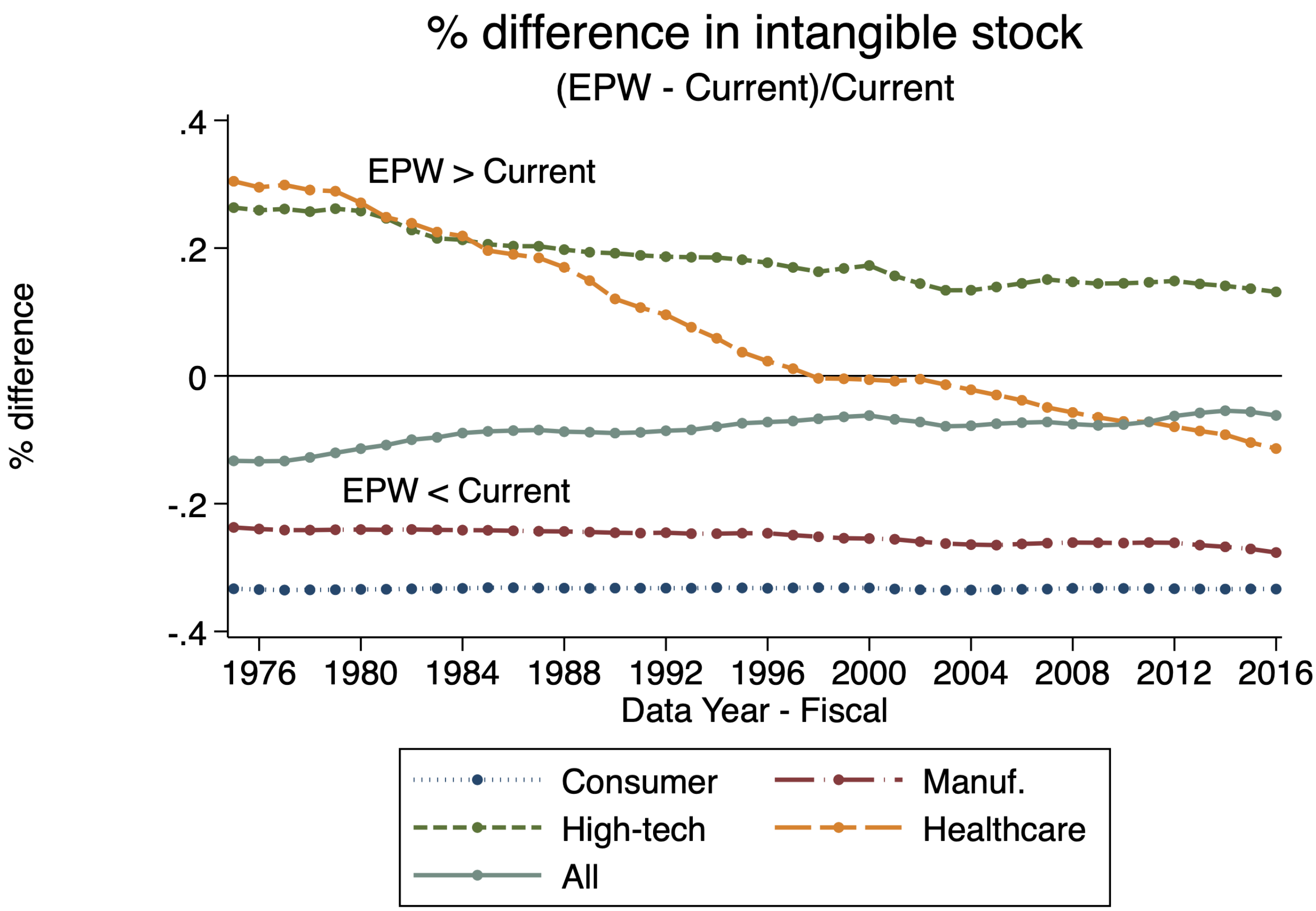


Figure 6: Intangible asset intensity

The figure reports of the ratio of total intangibles – capitalized using our method and those on the balance sheet – scaled by total capital stock (PPE + intangibles):

$$\frac{K^{int}}{K^{int} + K^{phy}}$$

across all (mean) firms within each industry-year. The "All" line reports the mean across all firms. The "Other" industry is not reported separated, but included in the "All" series.

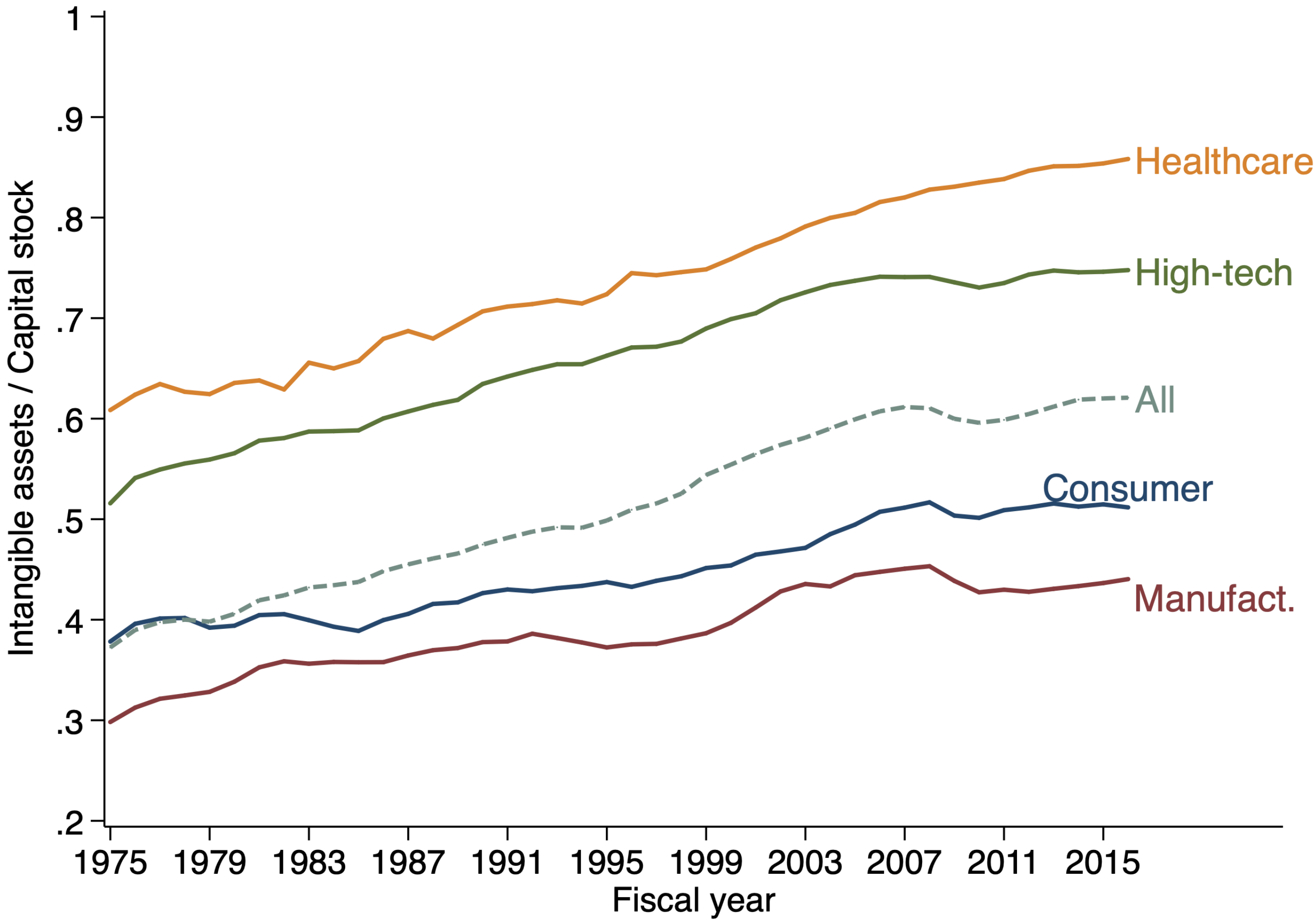


Figure 7: Knowledge capital as a fraction of total intangible capital

The figure reports of the ratio of knowledge capital – the accumulated R&D using the estimates from Panel A of Table 4 – to total intangibles (sum of knowledge and organizational capital) averaged across all firms in each industry-year.

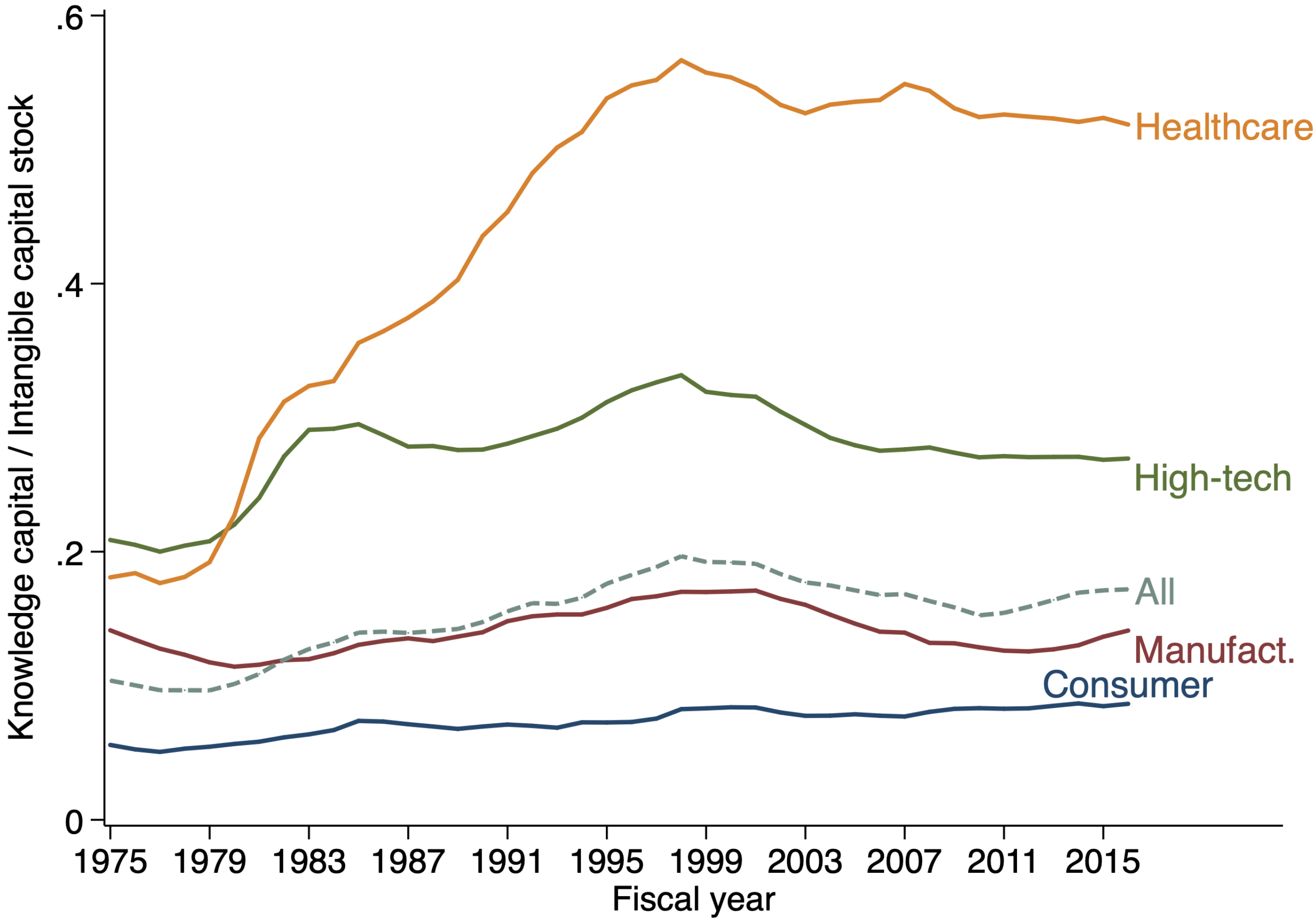


Figure 8: Comparing model fit of intangible capital stock measures

The figure reports the additional explanatory power of the estimated capital stock over other commonly used capital stocks in annual regressions of the log firm enterprise value (market capitalization plus debt) on the log of capital stock, calculated as

$$\frac{RSS* - RSS^{EPW}}{RSS*}$$

where RSS represents the residual sum of squares from the regression models. Capital stocks for "none" use the traditional total asset measure (Compustat 'at'). The "EPW" model adds to this asset the intangible stocks using our parameter estimates. The "BEA-HH" model instead uses the existing estimates of intangible stocks and the Hulten and Hao (2008) γ of 0.3. A number greater than zero indicates that estimated capital stocks have stronger explanatory power. The solid line compares the EPW model to the model without capitalized intangibles. The dashed line compares our method to that of using the existing BEA estimates. The second panel reports the t-statistics from the test of the hypothesis that the R^2 using EPW is the same as the R^2 from BEA-HH. The test statistic uses the influence function method to compare the two separate model statistics.

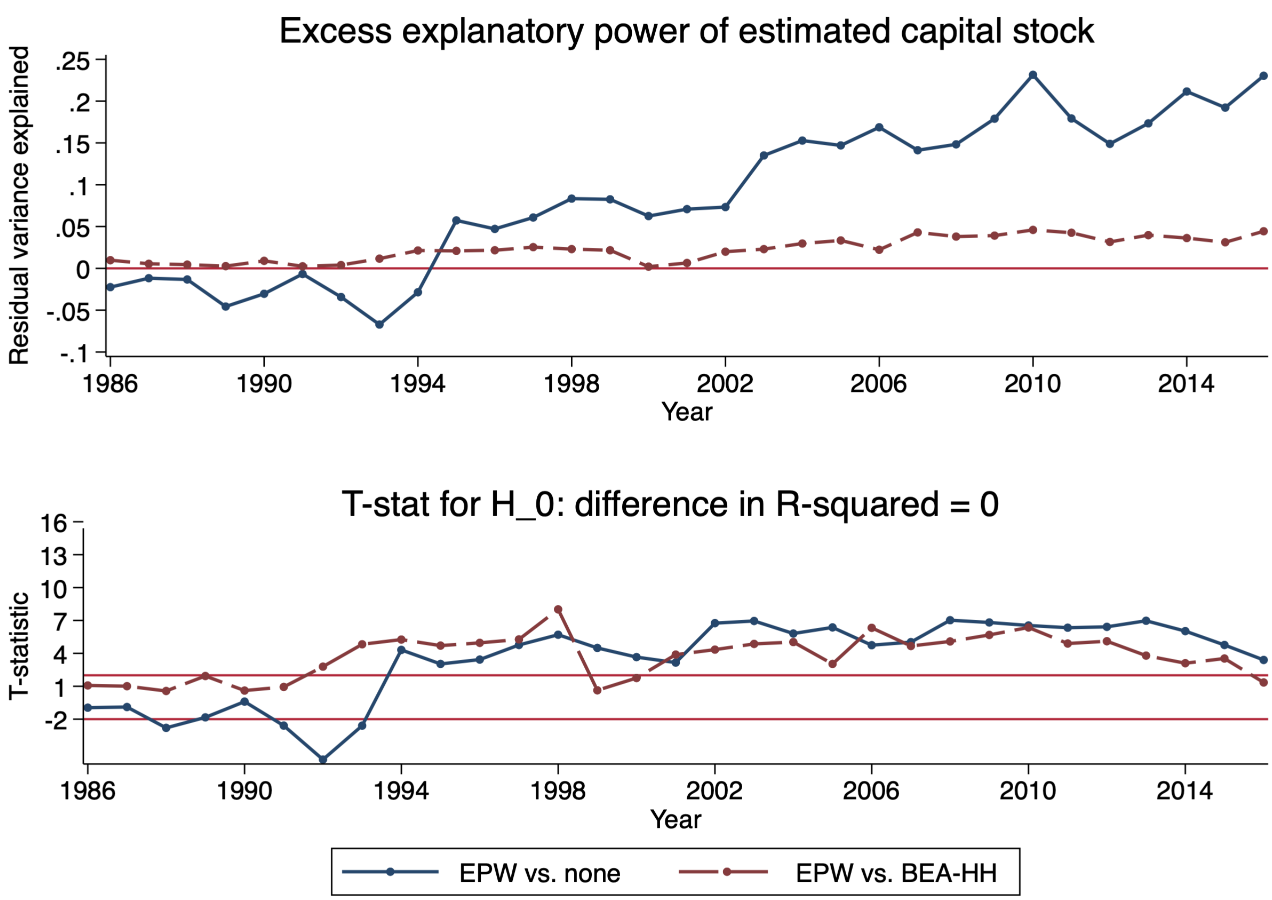


Figure 9: Testing differences in rates of 10-K mentions of "personnel" or "key talent"

In each fiscal year, we sort firms into quintiles based on their organizational capital stock using our depreciation rates (see Table 4) and those currently used in the literature ($\gamma = .3$ and $\delta_S = .2$). In each year, consider the firm-level variable that is one if the firm's 10-K mentions "personnel", "key talent" or "talented employee," zero otherwise. The figure report the t-statistics (each year) for the difference in mean test for the top vs. bottom quintiles. "EPW" are the t-statistics from our measure and "Current" are from the sorts using existing depreciation rates. The red horizontal line is at at $t = 1.96$.

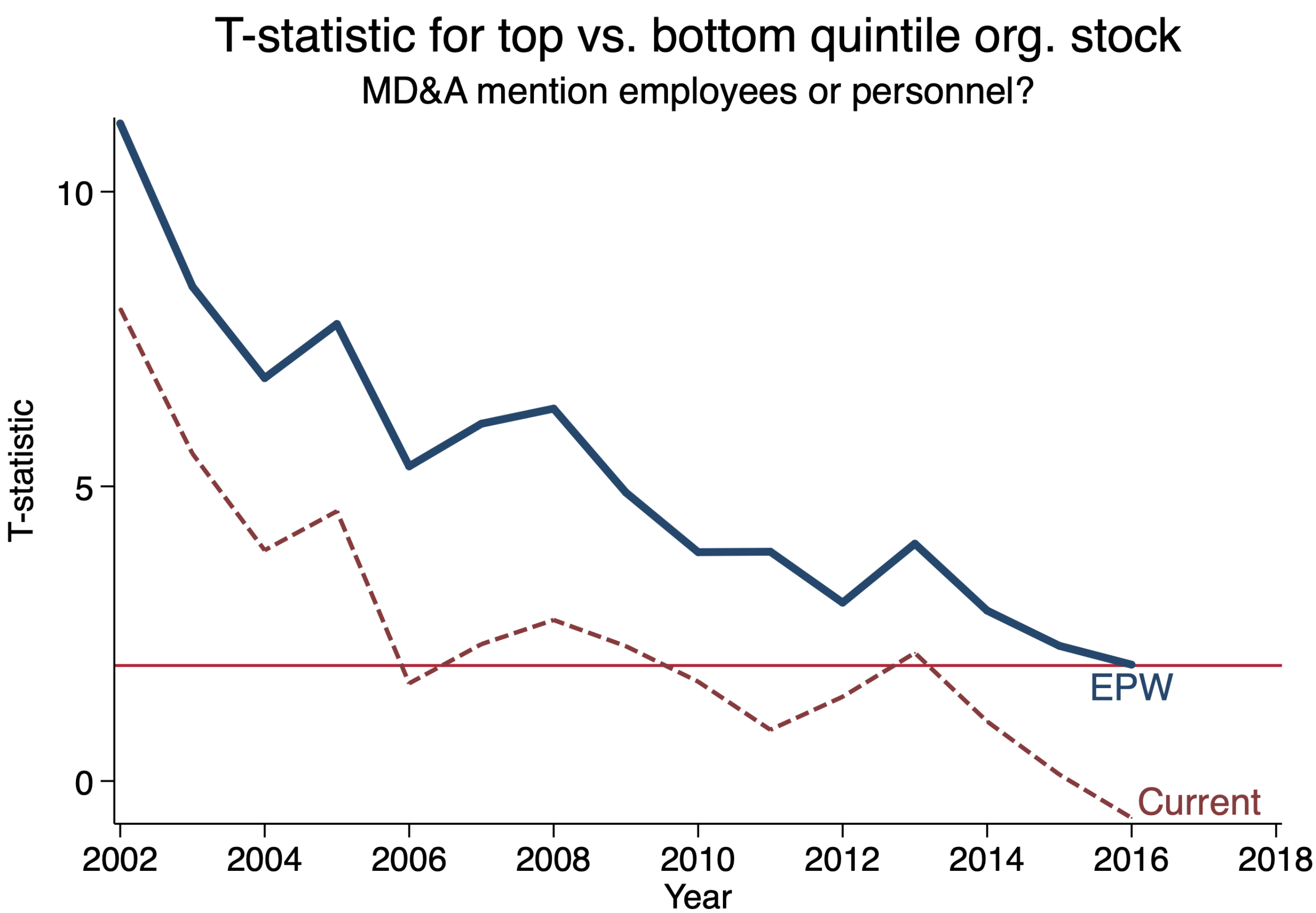


Table 1: Variables and definitions of terms

The table presents variable and term definitions used throughout the paper.

Variable/Term	**Definition**
Deal effective year	Year the acquisition was completed.
Year announced	The year that the acquisition was announced to the public.
Services firm (target)	An indicator equal to one if the acquisition target is in the services sector.
Value of transaction (mil)	The total value of the acquisitions (in 2012, USD millions) as reported in SDC.
Target Net Sales LTM (mil)	The last twelve month net sales for the target firm at the time of acquisition (2012 USD).
Target EBITDA LTM (mil)	The last twelve month EBITDA for the target firm at the time of acquisition (2012 USD).
Target total assets	Total assets of the acquired firm at the time of acquisition (2012 USD).
CA HQ (acq.)	An indicator variable that is equal to one if the firm is headquartered in California.
NY HQ	An indicator variable that is equal to one if the firm is headquartered in New York state.
Intangible assets (IIA)	The total identified intangible assets from the acquisition revealed through the purchase price allocation. Reported in millions (2012 USD).
Goodwill (mil)	The total goodwill allocated in the acquisition (2012 USD).
Goodwill (adj., mil)	The total goodwill net of an estimate of synergy and any over/under-payment of the target by the acquirer. The former is approximated by the sum of the product of 2-day window cumulative abnormal (CAR) and pre-deal market value for both target and acquirer, while the latter is the negative of the acquirer's CAR times the pre-deal market valuation.
All stock	An indicator variable equal to one if the acquisition was an all-stock deal.
All cash	An indicator variable equal to one if the acquisition was an all-cash deal.
Intangible M/B	The sum of the goodwill and value of identifiable intangible assets from an acquisition scaled by the book value of intangible assets from our proposed capitalization model.
Balance sheet intan.	The total intangible assets already on the balance sheet of the firm, typically from past acquisitions of intangibles and goodwill.

Table 2: Summary statistics for sample of found deals in model estimation.

Summary statistics for observable characteristics of deals, targets and acquirers for the sample of acquisitions in the main estimation. Panel A reports the characteristics of the acquisition sample and Panel B reports the characteristics of the failure sample. Variable definitions found in Table 1.

	Panel A: Deals in model sample (acquisitions)					
	Obs	Mean	Min.	Median	Max	Std dev
Deal effective year	1,521	2005.02	1996.00	2004.00	2017.00	6.02
Year announced	1,521	2004.72	1995.00	2004.00	2017.00	6.02
Manufacturing firm (target)	1,521	0.11	0.00	0.00	1.00	0.31
Consumer firm (target)	1,521	0.23	0.00	0.00	1.00	0.42
High-tech firm (target)	1,521	0.40	0.00	0.00	1.00	0.49
Enterprise value of transaction (mil)	1,521	2521.68	0.80	444.28	235456.36	9583.26
Value of Transaction (mil)	1,521	2145.85	0.59	385.22	213641.79	8329.79
Target EBITDA LTM (mil)	1,457	142.92	-7430.77	13.78	14080.53	718.85
Target Total Assets (mil)	1,503	1205.32	0.43	200.76	66446.13	4359.60
Target Net Sales LTM (mil)	1,489	1113.10	-35.17	193.75	67343.40	3763.57
CA HQ (target)	1,521	0.28	0.00	0.00	1.00	0.45
NY HQ (target)	1,521	0.06	0.00	0.00	1.00	0.24
CA HQ (acq.)	1,521	0.24	0.00	0.00	1.00	0.43
NY HQ (acq.)	1,521	0.10	0.00	0.00	1.00	0.29
Goodwill (mil)	1,521	1106.53	-5.54	159.10	52730.25	3475.09
Adjusted goodwill (mil)	1,521	781.26	-2099.53	67.26	37450.17	2863.58
Total intangibles (IIA + GW, mil)	1,521	2002.38	-5.54	266.84	170875.33	7981.41
Total intangibles (IIA + Adj. HW, mil)	1,521	1677.12	-2081.13	174.11	168775.80	7565.14
IIA / IIA + GW (if positive)	1,466	0.38	0.00	0.34	1.00	0.32
Total intangibles / Total deal size (all)	1,521	1.30	-0.11	0.84	411.69	11.09
Total intangibles / Total deal size (< 1)	1,056	0.63	-0.11	0.72	1.00	0.29
Total intangibles / Total ent. value (all)	1,521	0.75	-0.10	0.77	35.41	0.97
Total intangibles / Total ent. value (< 1)	1,248	0.63	-0.10	0.70	1.00	0.29

	Panel B: Deals in model sample (failures)					
	Obs	Mean	Min.	Median	Max	Std dev
Year failed	479	2002.99	1996.00	2001.00	2017.00	5.50
Manufacturing firm	479	0.10	0.00	0.00	1.00	0.30
Consumer firm	479	0.37	0.00	0.00	1.00	0.48
High-tech firm	479	0.22	0.00	0.00	1.00	0.41
Total assets (2012 USD)	469	253.29	0.31	67.28	6562.80	628.68
Net income (2012 USD)	444	-80.64	-9919.58	-10.49	95.52	537.74
Total intangibles	452	31.92	0.00	2.47	1566.04	117.12

Table 3: Summary statistics for sample of acquisitions in and out of sample.

Summary statistics of deal characteristics of deals in our main sample and those that were excluded. Excluded deals are described in Section 3 and are generally those acquisitions where we could not find the purchase price allocation in the acquirer's financial statements.

	Included acquisitions				Excluded acquisitions			
	Obs	Mean	Median	Std dev	Obs	Mean	Median	Std dev
Deal effective year	1,521	2005.02	2004.00	6.02	588	2002.63	2001.00	5.62
Year announced	1,521	2004.72	2004.00	6.02	588	2002.30	2001.00	5.66
Manufacturing firm (target)	1,521	0.11	0.00	0.31	588	0.12	0.00	0.33
Consumer firm (target)	1,521	0.23	0.00	0.42	588	0.28	0.00	0.45
High-tech firm (target)	1,521	0.40	0.00	0.49	588	0.33	0.00	0.47
Enterprise value of transaction (mil)	1,521	2521.68	444.28	9583.26	588	1941.54	226.19	6838.77
Value of Transaction (mil)	1,521	2145.85	385.22	8329.79	588	1586.12	177.82	6013.43
Target EBITDA LTM (mil)	1,457	142.92	13.78	718.85	526	207.39	10.12	1602.82
Target Total Assets (mil)	1,503	1205.32	200.76	4359.60	555	1246.84	148.93	4199.13
Target Net Sales LTM (mil)	1,489	1113.10	193.75	3763.57	542	1012.73	124.34	3513.33
CA HQ (target)	1,521	0.28	0.00	0.45	588	0.21	0.00	0.41
NY HQ (target)	1,521	0.06	0.00	0.24	588	0.09	0.00	0.28
CA HQ (acq.)	1,521	0.24	0.00	0.43	588	0.16	0.00	0.37
NY HQ (acq.)	1,521	0.10	0.00	0.29	588	0.13	0.00	0.33

Table 4: Parameter Estimates from Non-linear Least Squares Estimation

Statistics are based on non-linear least squares regressions of the price of non-physical target firm assets, as reported on acquiring firm financial disclosures, on cumulated intangible assets (see equation 12 in text). All estimations include year fixed effects constrained to an average of 0 (log of 1) across all years. In the case of firm failures, acquisition prices are the average debt-holder recovery from bankruptcy (70%) using the book value of debt prior to the failure. To get total intangibles in this pseudo-acquisition, we use the average fraction of acquired intangibles to total deal size in the same industry from the acquisition sample.

The first panel contains all firms, while panels B reports the estimates excluding failed firms. The first column reports the estimates of γ, the fraction of SG&A that is investment. The δ_S is assumed to be 0.2 (i.e., not estimated). The δ_G column reports the estimate of R&D depreciation rate. Pseudo R^2 estimates are calculated as the percent improvement in the exponentiated root mean squared error relative to a model which includes only a constant. As a comparison, the column with the header "$\bar{\delta}_G^{BEA}$" reports the average R&D depreciation rates from Li and Hall (2016) for SIC codes in each of the major industry groups (one obs. per SIC). Bootstrapped (1000 replications at the firm-level) standard errors reported in parentheses. N reports the number of unique acquired firms in the estimation. Firms can have up to ten years of financial data.

Panel A: All firms

	γ	δ_S	δ_G	N	$\bar{\delta}_G^{BEA}$
All	0.29	0.20	0.31	2000	0.164
	(0.026)		(0.038)		
Consumer	0.20	0.20	0.32	511	0.153
	(0.026)		(0.242)		
Manufacturing	0.24	0.20	0.34	233	0.156
	(0.059)		(0.130)		
High Tech	0.45	0.20	0.45	715	0.255
	(0.063)		(0.071)		
Health	0.50	0.20	0.33	245	0.172
	(0.142)		(0.063)		
Other	0.35	0.20	0.23	296	0.15
	(0.066)		(0.177)		
			Pseudo-R^2: .504		

Panel B: Excluding failed firms

	γ	δ_S	δ_G	N	$\bar{\delta}_G^{BEA}$
All	0.44	0.20	0.25	1521	0.164
	(0.042)		(0.040)		
Consumer	0.36	0.20	0.31	335	0.153
	(0.057)		(0.305)		
Manufacturing	0.24	0.20	0.15	186	0.156
	(0.077)		(0.129)		
High Tech	0.57	0.20	0.37	612	0.255
	(0.078)		(0.078)		
Health	0.62	0.20	0.23	218	0.172
	(0.193)		(0.062)		
Other	0.48	0.20	-0.23	170	0.15
	(0.120)		(0.112)		
			Pseudo-R^2: .404		

Table 5: Relationship between firm patent valuations and firm intangible assets

The table reports regressions of patent value from Kogan, Papanikolaou, Seru, and Stoffman (2017) using two alternative measures. A unit of observation is a firm-year where the patent valuation variables are available (i.e., the firm had a granted patent(s) to measure). The columns headed "Market-weighted" use the market valuation of granted patents in the firm-year, while the columns under the "Citation-weighted" present values of patents measured as the sum of citations received in that year scaled by citations received by patents in the same industry-year. The control "Log knowledge K" is the log (plus 1) of the estimated knowledge capital from the parameter estimates in Table 4 concerning R&D (e.g. δ_G). The control "Log org. K" presents the same measure, but using past SG&A and the parameters γ and .2 in Table 4. The variable "Balance sheet intan." is the total identifiable intangibles (including goodwill) on the firm's balance sheet. All measures are scaled by previous year total assets (Compustat "at") and all balance sheet items are lagged one year. All specifications include firm and year fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Market-weighted				Citation-weighted			
Log knowledge K		0.17***		0.16***		0.39***		0.34***
		(0.019)		(0.022)		(0.026)		(0.026)
Log org. K			0.060***	0.0096			0.29***	0.19***
			(0.022)	(0.024)			(0.031)	(0.028)
Balance sheet intan.	-0.0011	-0.0042	-0.0021	-0.0046	0.037***	0.030***	0.034***	0.029***
	(0.0074)	(0.0074)	(0.0074)	(0.0074)	(0.0071)	(0.0068)	(0.0072)	(0.0069)
Log sales	0.25***	0.19***	0.21***	0.19***	0.34***	0.20***	0.16***	0.10***
	(0.021)	(0.021)	(0.024)	(0.024)	(0.024)	(0.024)	(0.028)	(0.025)
Observations	39848	39848	39673	39673	39848	39848	39673	39673
R^2	0.76	0.76	0.76	0.76	0.82	0.84	0.83	0.84
Within-R^2	0.013	0.025	0.014	0.025	0.029	0.10	0.063	0.11
Firm FE?	Y	Y	Y	Y	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y	Y	Y	Y	Y

Table 6: OLS Results from an Investment-q Relation: By industry

Results are from OLS panel regressions of investment on lagged Tobin's q and firm and year fixed effects. A unit of observation is a firm-year for public firms from 1996–2016. We follow the Peters and Taylor (2017) method to construct both a new total capital that incorporates intangibles and a modified investment rate for *SG&A*. Each column uses a different investment measure noted in the top rows

$$I_{it} = Q_{it} + \mu_i + \eta_t + \varepsilon_{it}$$

"Total Q (PT)" is the Q_{it} from Peters and Taylor (2017) that uses the BEA-HH depreciation rates. The row "Total Q (EPW)" presents an alternative total Q that uses the depreciation and investment fractions from Table 4 to calculate total intangible stock. Because our main parameters in Table 4 are estimated by industry, each panel here is an industry sub-sample. The "Within-R2" are the within-firm and -year R^2. Standard errors clustered at the firm-year reported in parentheses. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	R&D		SG&A		CAPX		CAPX+R&D+SG&A	
	Consumer							
Total Q (PT)	0.0016***		0.0075***		0.0079***		0.017***	
	(0.00034)		(0.00078)		(0.00093)		(0.0014)	
Total Q (EPW)		0.0018***		0.0073***		0.0083***		0.017***
		(0.00035)		(0.00074)		(0.00089)		(0.0013)
Observations	29435	29435	29442	29442	29462	29462	29435	29435
R^2	0.57	0.58	0.64	0.63	0.38	0.38	0.50	0.49
Within-R^2	0.047	0.049	0.13	0.16	0.077	0.084	0.16	0.18
	Manufacturing							
Total Q (PT)	0.0026***		0.0057***		0.0059***		0.014***	
	(0.00055)		(0.00077)		(0.0011)		(0.0018)	
Total Q (EPW)		0.0029***		0.0054***		0.0060***		0.014***
		(0.00058)		(0.00074)		(0.0010)		(0.0017)
Observations	18467	18467	18469	18469	18476	18476	18467	18467
R^2	0.56	0.61	0.59	0.57	0.30	0.29	0.43	0.44
Within-R^2	0.057	0.059	0.11	0.11	0.050	0.053	0.13	0.13
	High Tech							
Total Q (PT)	0.0046***		0.0060***		0.0071***		0.018***	
	(0.00035)		(0.00037)		(0.00052)		(0.0010)	
Total Q (EPW)		0.0051***		0.0071***		0.0071***		0.019***
		(0.00039)		(0.00045)		(0.00051)		(0.0011)
Observations	28783	28783	28784	28784	28795	28795	28783	28783
R^2	0.61	0.62	0.53	0.51	0.42	0.42	0.56	0.55
Within-R^2	0.12	0.13	0.17	0.15	0.17	0.16	0.29	0.28
	Healthcare							
Total Q (PT)	0.0060***		0.0060***		0.0048***		0.017***	
	(0.00070)		(0.00049)		(0.00070)		(0.0014)	
Total Q (EPW)		0.0073***		0.0058***		0.0043***		0.017***
		(0.00074)		(0.00070)		(0.00067)		(0.0015)
Observations	13519	13519	13519	13519	13524	13524	13519	13519
R^2	0.54	0.61	0.56	0.48	0.28	0.26	0.47	0.44
Within-R^2	0.066	0.077	0.14	0.078	0.077	0.068	0.18	0.16
Year / Firm FE	Y	Y	Y	Y	Y	Y	Y	Y

Table 7: Parameter Estimates: Excluding Goodwill

The table reports the parameter estimates as found in Table 4 where we ignore goodwill for all acquisitions and failures as an intangible asset. See that table for details on estimation and variable construction. All estimations include year fixed effects constrained to an average of 1 (log of 0) across all years. Pseudo R^2 estimates are calculated as the percent improvement in the exponentiated root mean squared error relative to a model which includes only a constant. Bootstrapped (1000 replications at the firm-level) standard errors reported in parentheses. N reports the number of unique acquired firms in the estimation. Firms can have up to ten years of financial data.

Panel A: All firms

	γ	δ_S	δ_G	N
All	0.03	0.20	0.39	2000
	(0.004)		(0.024)	
Consumer	0.04	0.20	0.59	511
	(0.007)		(0.231)	
Manufacturing	0.00	0.20	0.80	233
	(0.004)		(0.109)	
High Tech	0.11	0.20	0.51	715
	(0.026)		(0.050)	
Health	0.17	0.20	0.27	245
	(0.090)		(0.062)	
Other	0.04	0.20	0.36	296
	(0.015)		(0.111)	
R^2	0.509			

Panel B: Excluding failed firms

	γ	δ_S	δ_G	N
All	0.03	0.20	0.32	1521
	(0.006)		(0.025)	
Consumer	0.03	0.20	0.48	335
	(0.009)		(0.268)	
Manufacturing	0.00	0.20	0.76	186
	(0.004)		(0.120)	
High Tech	0.12	0.20	0.43	612
	(0.031)		(0.051)	
Health	0.13	0.20	0.16	218
	(0.121)		(0.063)	
Other	0.05	0.20	0.13	170
	(0.018)		(0.132)	
R^2	0.494			

Appendix

A1 Acquisition accounting

The U.S. General Accepted Accounting Principles (GAAP) treatment for business acquisition has evolved significantly over time. This section constitutes a brief overview of the guidelines and principles provided by the FASB, and discusses their differential impact to the financial statements of the acquiring firm.

From 1970 until 2001, Accounting Principles Board (APB) Opinion No. 16 stated that "the purchase method and the pooling of interests method are both acceptable in accounting for business combinations, although not as alternatives for the same business combination." If the acquiring firm was in accordance with a list of specified conditions, it would account for the transaction as a pooling acquisition, otherwise it would use the purchase method.

In the purchase method, the acquirer restates all of the target's net assets to their fair value, and records the difference between the fair value of the acquirer's consideration and the fair value of the target's net assets as goodwill. The acquirer's goodwill asset would then be subjected to annual impairment tests if the carrying value of goodwill related to the reporting unit is suspected to be less than its fair value.[38] In the pooling method, the acquirer must finance the purchase entirely with stock. The assets and liabilities of the target firm are combined with the acquirer at book value, essentially implying that fair market values of the acquirer's consideration and the target's net assets are ignored for accounting purposes. The target firm's retained earnings are aggregated together with the acquirer's retained earnings. Equity shares issued by the acquirer for the purchase are recorded based upon book value of the target's net assets. Because of this, no excess of acquisition cost over the target's book value of net assets exists, and thus no new goodwill is recorded to the acquirer. Studies that have examined the firm's use of purchase vs pooling methods have generally found that the larger the difference between the book value of the target's asset and the price paid by the acquirer, the more likely that the acquirer will opt for the pooling method (Robinson and Shane (1990); Ayers, Lefanowicz, and Robinson (2000)). This is because the purchase method would result in the target's net assets being marked-to-market and any goodwill added to the acquirer's balance sheet being depreciated and amortized over time, resulting in an additional expense against the firm's reported profits in the subsequent years. As discussed below, any acquisitions using the pooling method cannot be used in our analysis.

On December 15, 2001 FASB enacted FAS 141[39], which eliminated the use of pooling-of-interest accounting in acquisitions.[40] At the same time, FAS 141 eliminated the amortization of purchased goodwill. Instead, goodwill would become considered an indefinite life asset, and amounts on the acquirer's books would be subject to "impairment" tests, which would be conducted when expectations for the reporting unit have been significantly reduced. At this time, the goodwill would be revalued and compared with its carrying book value, with any differences being expensed

[38] Prior to 2001, goodwill was amortized using a straight-line depreciation method over a period not to exceed forty years.

[39] `https://www.fasb.org/summary/stsum141.shtml`

[40] The FASB justified the elimination of the pooling method because "the purchase method, as modified by the board during deliberations, reflects the underlying economics of business combinations by requiring that the current values of the assets and liabilities exchanged be reported to investors. Without the information that the purchase method provides, investors are left in the dark as to the real cost of one company buying another and, as a result, are unable to track future returns on the investment." See `http://ww2.cfo.com/2001/01/fasb-reaffirms-plan-to-eliminate-pooling-updated-2/`

as a write-off for the acquiring firm.[41]

On December 15, 2007, FASB superseded FAS 141 with FAS 141R (now referred to as ASC 805 as of September 15, 2009).[42] ASC 805 stands as the current method of accounting for acquisitions. This method, known as the "acquisition method" is similar to the purchase method for acquisitions, with a few notable adjustments. (1) In FAS 141, there was no forced recognition of contingent assets or liabilities being acquired. Under FAS 141R, guidance for the recognition of contingent assets and liabilities depends on whether the contingencies are contractual, such as a warranty agreement, or non-contractual, such as the outcome of a lawsuit. Contractual contingencies are accounted for at fair value, while non-contractual contingencies are accounted for if the probability of realization of the contingent asset is greater than fifty percent. (2) In FAS 141, transaction costs such as legal fees, banking fees or other direct acquisition costs were included in the purchase price allocation, where as in FAS 141R they are recorded as expenses. (3) In FAS 141, in-process research and development (IPR&D) could be expensed immediately upon completion of the acquisition if the acquired IPR&D has no alternate use. In FAS 141R, IPR&D exists as an indefinite-lived intangible asset until the completion or abandonment of the associated R&D project.

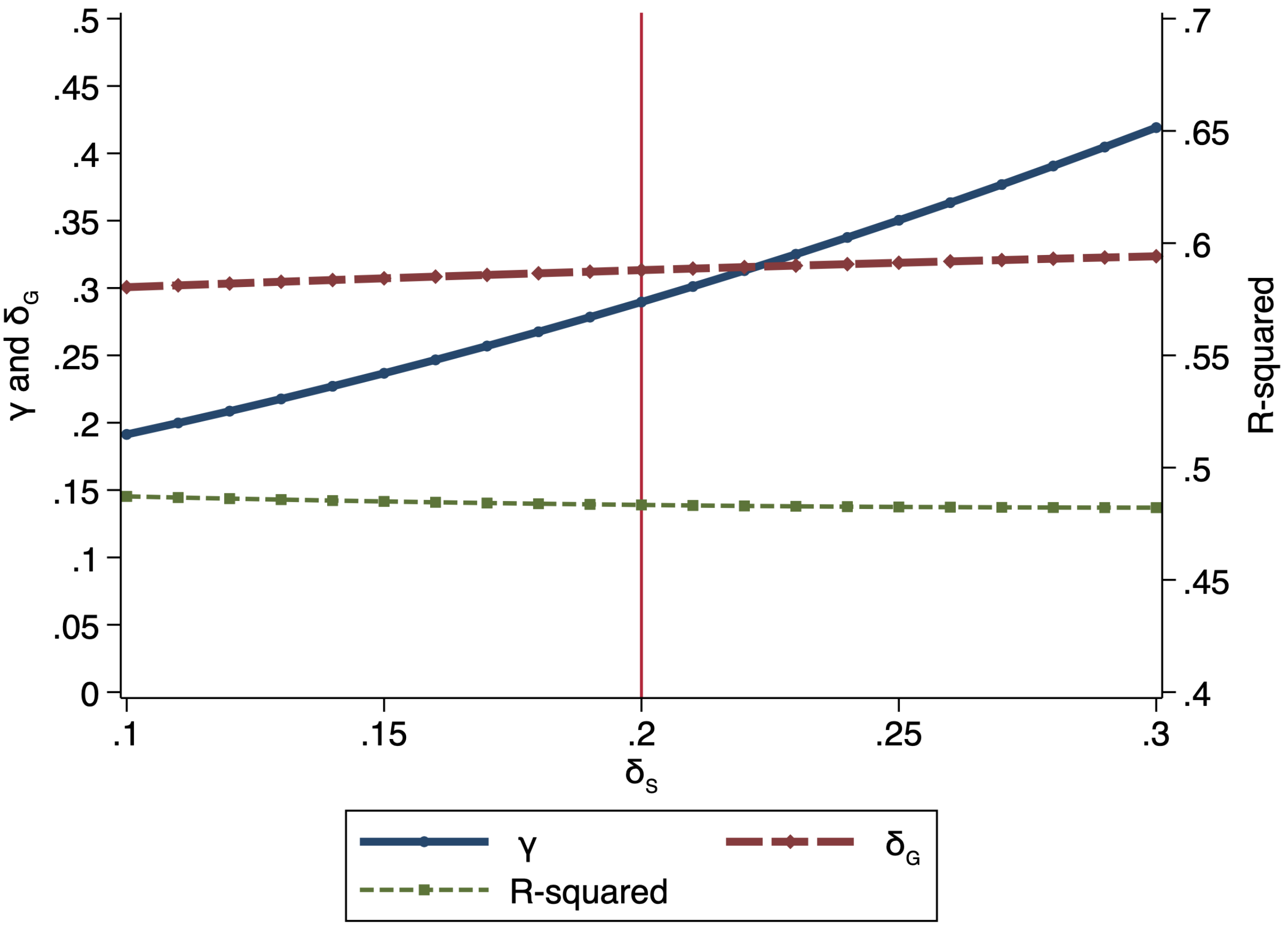
[41] For example, on April 25, 2014 Microsoft acquired the mobile hardware division of Nokia for $7.9 billion. In 2015, they announced a goodwill write-off of $7.5 billion related to the Nokia acquisition. In note 10 of the 10-K, they cite the following reason for the impairment: "Upon completion of the annual testing as of May 1, 2015, Phone Hardware goodwill was determined to be impaired. In the second half of fiscal year 2015, Phone Hardware did not meet its sales volume and revenue goals, and the mix of units sold had lower margins than planned. These results, along with changes in the competitive marketplace and an evaluation of business priorities, led to a shift in strategic direction and reduced future revenue and profitability expectations for the business. As a result of these changes in strategy and expectations, we have forecasted reductions in unit volume growth rates and lower future cash flows used to estimate the fair value of the Phone Hardware reporting unit, which resulted in the determination that an impairment adjustment was required." `https://www.sec.gov/Archives/edgar/data/789019/000119312515272806/d918813d10k.htm`

[42] `https://www.fasb.org/pdf/fas141r.pdf`

A2 Figures

Figure A1: Estimation sensitivity under different organizational stock depreciation assumptions

The figure reports the results of re-estimating the main model for different values of the organizational stock depreciation parameter δ_S. Recall that our main results assume that $\delta_S = .2$. Here we vary this parameter and present the estimated γ (fraction of SG&A that is investment), δ_G (the knowledge capital depreciation rate) and the R^2 from the estimation. The vertical red line indicates the main model assumption. The left y-axis reports the parameter estimates and the right y-axis reports the R^2.



A3 Tables

Table A1: Parameter estimates of depreciation rates and investment: raw goodwill without adjustments

The table reports the parameter estimates as found in Table 4 where we do not adjust the goodwill for synergies and over-payment (see Section 3.2).

Panel A: All firms				
	γ	δ_S	δ_G	N
All	0.43	0.20	0.22	2000
	(0.031)		(0.033)	
Consumer	0.27	0.20	0.09	511
	(0.034)		(0.136)	
Manufacturing	0.45	0.20	0.32	233
	(0.091)		(0.137)	
High Tech	0.71	0.20	0.38	715
	(0.073)		(0.067)	
Health	0.73	0.20	0.21	245
	(0.178)		(0.059)	
Other	0.54	0.20	0.23	296
	(0.087)		(0.200)	
			Pseudo-R^2:	.518

Panel B: Excluding failed firms				
	γ	δ_S	δ_G	N
All	0.69	0.20	0.14	1521
	(0.053)		(0.034)	
Consumer	0.52	0.20	0.06	335
	(0.076)		(0.114)	
Manufacturing	0.52	0.20	0.10	186
	(0.120)		(0.136)	
High Tech	0.93	0.20	0.29	612
	(0.104)		(0.060)	
Health	0.93	0.20	0.10	218
	(0.266)		(0.057)	
Other	0.81	0.20	-0.26	170
	(0.169)		(0.130)	
			Pseudo-R^2:	.403

Table A2: Parameter estimates of depreciation rates and investment: R&D-only sub-samples

The table reports the parameter estimates as found in Table 4 for the set of acquired companies that had at least some R&D expenditures in the 10 years prior to the acquisition event. See that table for details on estimation and variable construction. Pseudo R^2 estimates are calculated as the percent improvement in the exponentiated root mean squared error relative to a model which includes only a constant. Bootstrapped (1000 replications at the firm-level) standard errors reported in parentheses. N reports the number of unique acquired firms in the estimation. Firms can have up to ten years of financial data.

Panel A: All firms

	γ	δ_S	δ_G	N
All	0.34	0.20	0.36	1208
	(0.043)		(0.042)	
Consumer	0.26	0.20	0.42	96
	(0.092)		(0.271)	
Manufacturing	0.24	0.20	0.31	170
	(0.120)		(0.186)	
High Tech	0.42	0.20	0.43	641
	(0.060)		(0.069)	
Health	0.60	0.20	0.34	239
	(0.167)		(0.064)	
Other	0.46	0.20	0.31	62
	(0.142)		(0.204)	

Pseudo-R^2: .531

Panel B: Excluding failed firms

	γ	δ_S	δ_G	N
All	0.44	0.20	0.27	1016
	(0.061)		(0.042)	
Consumer	0.42	0.20	0.30	72
	(0.178)		(0.306)	
Manufacturing	0.18	0.20	0.06	136
	(0.187)		(0.209)	
High Tech	0.52	0.20	0.35	555
	(0.082)		(0.064)	
Health	0.73	0.20	0.24	214
	(0.243)		(0.066)	
Other	0.61	0.20	-0.22	39
	(0.348)		(0.251)	

Pseudo-R^2: .474

Table A3: Parameter estimates of depreciation rates and investment: post-2001 sample

The table reports the parameter estimates as found in Table 4 for the set of companies acquired after 2001. See that table for details on estimation and variable construction. Pseudo R^2 estimates are calculated as the percent improvement in the exponentiated root mean squared error relative to a model which includes only a constant. Bootstrapped (1000 replications at the firm-level) standard errors reported in parentheses. N reports the number of unique acquired firms in the estimation. Firms can have up to ten years of financial data.

Panel A: All firms

	γ	δ_S	δ_G	N
All	0.28	0.20	0.32	1152
	(0.035)		(0.045)	
Consumer	0.16	0.20	0.22	217
	(0.032)		(0.222)	
Manufacturing	0.20	0.20	0.32	122
	(0.096)		(0.128)	
High Tech	0.47	0.20	0.48	450
	(0.064)		(0.076)	
Health	0.82	0.20	0.37	181
	(0.187)		(0.082)	
Other	0.24	0.20	0.22	182
	(0.076)		(0.220)	
			Pseudo-R^2:	.618

Panel B: Excluding failed firms

	γ	δ_S	δ_G	N
All	0.48	0.20	0.25	939
	(0.056)		(0.050)	
Consumer	0.36	0.20	0.17	173
	(0.084)		(0.225)	
Manufacturing	0.22	0.20	0.03	102
	(0.157)		(0.169)	
High Tech	0.64	0.20	0.43	405
	(0.093)		(0.075)	
Health	1.00	0.20	0.25	162
	(0.254)		(0.093)	
Other	0.31	0.20	-0.23	97
	(0.109)		(0.144)	
			Pseudo-R^2:	.521

Table A4: Eisfeldt and Papanikolau (2013), Table IA.I: Using the Ewens, Peters and Wang (2018) organizational stocks

The table repeats the analysis of Table IA.I in Eisfeldt and Papanikolaou (2013)'s Internet Appendix. The table reports the statistics of various firm observables in an unconditional annual sort using our new measure of organizational stocks.

Ewens, Peters and Wang (2018)

	Lo	2	3	4	Hi
	mean	mean	mean	mean	mean
Organization capital to book assets	0.04	0.10	0.18	0.33	0.83
Market capitalization (log)	6.48	6.60	6.35	5.87	5.10
Tobin's Q	1.14	1.33	1.36	1.34	1.65
Tobin's Q (scaled by PPE)	4.83	8.20	8.87	7.79	7.45
Total Q (Ewens, Peters and Wang (2018)	3.05	2.37	2.22	1.64	1.05
Total Q (Peters and Taylor (2017)	2.99	2.32	2.14	1.62	1.10
Sales to book assets (%)	68.19	84.24	104.82	121.75	145.38
Earnings to book assets (%)	7.19	7.82	7.90	6.38	-0.43
Advertising expenditures to book assets	1.10	1.61	2.52	3.60	6.42
Investment to capital (organization, %)	181.88	141.96	125.10	108.82	82.66
Investment to capital (physical, %)	17.95	15.92	15.31	14.87	14.19
Physical capital to book assets	64.56	61.19	50.22	41.16	42.88
Debt to book assets	33.42	29.15	25.22	20.77	16.60
Capital to labor (log)	4.82	4.57	4.21	3.96	3.74
Firm Solow Residual	-37.34	-9.63	9.01	19.76	14.19

	Lo	2	3	4	Hi
	mean	mean	mean	mean	mean
Executive compensation to book assets (%)	0.17	0.28	0.36	0.47	0.65
CEO turnover	0.18	0.16	0.17	0.18	0.20

Figure A2: Example of Purchase Accounting

Acquiring firm (A) acquires target firm (T) in an acquisition which closes on March 31, 2018. Book value of T's net assets ex-acquisition is 55. In the due diligence process, T's net assets are marked to market to a value of 95 following ASC 805. Identifiable intangible assets of 35 are revealed on A's balance sheet post-acquisition date. A agrees to purchase T by issuing stock with a fair market value of 150. Goodwill of 55 is recorded to A's balance sheet to represent the additional value paid by the acquirer over and above the fair value of all of T's identifiable net assets.

Target (T's) Balance Sheet as of December 31, 2017 (Pre-Acquisition)

Assets		Liabilities & Equity	
Cash	10	Current Liabilities	15
Receivables	10	Long-Term Debt	30
Inventories	20	Capital Stock	10
PP&E, net	60	Retained Earnings	45
T's Total Assets	100	T's Total Liabilities & Equity	100

Acquiror (A's) Balance Sheet as of December 31, 2017 (Pre-Acquisition)

Assets		Liabilities & Equity	
Cash	80	Current Liabilities	120
Receivables	120	Long-Term Debt	230
Inventories	100	Capital Stock	500
PP&E, net	700	Retained Earnings	150
A's Total Assets	1000	A's Total Liabilities & Equity	1000

On March 30, 2018, Acquiror Purchases Target for Fair Value Consideration in exchange for 10 shares of common stock

Target's Fair Market Value of Net Assets as of March 31, 2018 (Acquisition Date)

Cash	10
Receivables	10
Inventories	15
PP&E Net	70
Tangible Assets	105
IPR&D	20
Patents	10
Trademarks	5
Intangible Assets	35
Total Assets	140
Current Liabilities	15
Long-Term Debt	30
Total Liabilities	45
FV of Net Assets	95

Note that the purchase method results in identifiable intangible assets (IIA) of 35, and goodwill (GW) of 55.

Acquiror's entry to record transaction using purchase method on March 31, 2018

Cash	10	
Receivables	10	
Inventories	15	
PP&E Net	70	
IPR&D	20	
Patents	10	
Trademarks	5	
Goodwill	55	
Current Liabilities		15
Long-Term Debt		30
Capital Stock		150

Value assigned to goodwill is the difference between the fair value consideration of the acquiring firm and the target's fair value of net assets.

Goodwill = 150 - 95 = 55

Acquiror (A's) Balance Sheet as of April 1, 2018 (Post-Acquisition)

Assets		Liabilities & Equity	
Cash	90	Current Liabilities	135
Receivables	130	Long-Term Debt	260
Inventories	115	Capital Stock	650
PP&E, net	770	Retained Earnings	150
IPR&D	*20*		
Patents	*10*		
Trademarks	*5*		
Goodwill	*55*		
A's Total Assets	1195	A's Total Liabilities & Equity	1195

Figure A3: Example of Pooling Accounting

Acquiring firm (A) acquires target firm (T) in an acquisition which closes on March 31, 2018. Book value of T's net assets ex-acquisition is 55. A agrees to purchase T by issuing shares of common stock. Contrary to the purchase method, fair market values of both A's net assets and T's common stock offering are ignored for accounting purposes. No goodwill or intangible assets are identified and brought to A's balance sheet. A's post-acquisition balance sheet represents only the net assets of T at book value.

Target (T's) Balance Sheet as of December 31, 2017 (Pre-Acquisition)

Assets		Liabilities & Equity	
Cash	10	Current Liabilities	15
Receivables	10	Long-Term Debt	30
Inventories	20	T's Capital Stock	10
PP&E, net	60	Retained Earnings	45
T's Total Assets	100	T's Total Liabilities & Equity	100

Acquiror (A's) Balance Sheet as of December 31, 2017 (Pre-Acquisition)

Assets		Liabilities & Equity	
Cash	80	Current Liabilities	120
Receivables	120	Long-Term Debt	230
Inventories	100	Capital Stock	500
PP&E, net	700	Retained Earnings	150
A's Total Assets	1000	A's Total Liabilities & Equity	1000

On March 30, 2018, Acquiror Purchases Target's Net Assets in exchange for 10 shares of A's common stock

Target's Book Value of Net Assets as of March 31, 2018 (Acquisition Date)

Cash	10
Receivables	10
Inventories	20
PP&E Net	60
T's Total Assets	100
Current Liabilities	15
Long-Term Debt	30
T's Total Liabilities	45
Net Assets	55

Note that in the pooling method, no mark-to-market occurs at the time of acquisition.

No goodwill is recognized, and intangible assets are not identified in the pooling method.

Acquiror's Entry to record transaction using pooling method on March 31, 2018

	Debit	Credit
Cash	10	
Receivables	10	
Inventories	20	
PP&E Net	60	
Current Liabilities		15
Long-Term Debt		30
A's Capital Stock		10
Retained Earnings		45

Acquiror (A's) Balance Sheet as of April 1, 2018 (Post Acquisition)

Assets		Liabilities & Equity	
Cash	90	Current Liabilities	135
Receivables	130	Long-Term Debt	260
Inventories	120	Capital Stock	510
PP&E, net	760	Retained Earnings	195
A's Total Assets	1100	A's Total Liabilities & Equity	1100

Note that in the pooling method, the balance sheet of acquiror and target are simply combined at book values.

Figure A4: Example of goodwill accounting and negative goodwill

A credits-and-debits analysis of goodwill and negative goodwill.

Standard Case: **Goodwill** contains synergies, mark-to-market of assets is too conservative, or overpayment.

Fair Value of Assets of Acquirer (+A)	100		
Fair Value of Liabilities of Acquirer (-L)		50	
Cash (-A)		130	
*Goodwill (+A)	80		← (Goodwill to balance)

*Goodwill asset impaired over subsequent years, until is depleted.

Amortization of Goodwill (-E)	XX	
Goodwill (-A)		XX

Rare Case: Negative goodwill. May arise due to bargain purchase of target (e.g., distressed fire-sale), too conservative in mark-to-market of liabilities (or off-balance sheet liabilities exist),

Fair Value of Assets of Acquirer (+A)	100		
Fair Value of Liabilities of Acquirer (-L)		50	
Cash (-A)		30	
**Neg Goodwill-plug (-A)		20	← (Neg goodwill to balance)

**Immediate write-off of negative goodwill as extraordinary gain.

**Neg Goodwill-plug (-A)	20		
Extraordinary Gain		20	← (Recorded to I/S as one-time gain)

A4 Real-world purchase price allocation examples

Matrix Pharmaceutical, February 20, 2002

Note 4 – Acquisition of Matrix Pharmaceutical, Inc.

On February 20, 2002, Chiron acquired Matrix Pharmaceutical, Inc. a company that was developing tezacitabine, a drug to treat cancer. As of March 31, 2002, Chiron acquired substantially all of the outstanding shares of common stock of Matrix Pharmaceutical at $2.21 per share, which, including estimated acquisition costs, resulted in a total preliminary purchase price of approximately $67.1 million. Matrix Pharmaceutical is part of Chiron's biopharmaceuticals segment. Tezacitabine expanded Chiron's portfolio of cancer therapeutics.

Chiron accounted for the acquisition as an asset purchase and included Matrix Pharmaceutical's operating results, including the seven business days in February 2002, in its consolidated operating results beginning on March 1, 2002. The components and allocation of the preliminary purchase price, based on their fair values, consisted of the following (in thousands):

Consideration and acquisition costs:		
Cash paid for common stock	$	49,986
Cash paid for options on common stock		1,971
Common stock tendered, not yet paid		8,751
Options on common stock, not yet paid		260
Acquisition costs paid as of March 31, 2002		3,323
Acquisition costs not yet paid as of March 31, 2002		2,796
Total purchase price	$	67,087
Allocation of preliminary purchase price:		
Cash and cash equivalents	$	17,337
Assets held for sale		2,300
Deferred tax asset		10,000
Other assets		1,469
Write-off of purchased in-process technologies		54,781
Accounts payable		(2,898)
Accrued liabilities		(15,902)
Total purchase price	$	67,087

Electronic Data Services, August 26, 2008

On August 26, 2008, HP completed its acquisition of EDS, a leading global technology services company, delivering a broad portfolio of information technology, applications and business process outsourcing services to clients in the manufacturing, financial services, healthcare, communications, energy, transportation, and consumer and retail industries and to governments around the world. The acquisition of EDS will strengthen HP's service offerings for information technology outsourcing, including data center services, workplace services, networking services and managed security; business process outsourcing, including health claims, financial processing, CRM and HR outsourcing; and applications, including development, modernization and management.

The total preliminary estimated purchase price for EDS was approximately $13.0 billion and was comprised of:

Acquisition of approximately 507 million shares of outstanding common stock of EDS at $25 per share in cash	$12,670
Estimated fair value of outstanding stock options and restricted stock units assumed	328
Estimated direct transaction costs	34
Total preliminary estimated purchase price	$13,032

In connection with the acquisition, HP assumed options to purchase approximately 8 million shares of HP's common stock at a weighted-average exercise price of approximately $50 per share. HP also assumed approximately 11 million restricted stock units with a weighted-average grant date fair value of $45. [...]

Direct transaction costs include investment banking, legal and accounting fees and other external costs directly related to the acquisition.

The purchase price allocations as of the date of the acquisition in the table below reflect various preliminary estimates and analyses, including preliminary work performed by third-party valuation specialists, and are subject to change during the purchase price allocation period (generally one year from the acquisition date) as valuations are finalized.

In millions	
Cash and short-term investments	$ 3,034
Accounts receivable	2,549
Property, plant and equipment	3,203
Other tangible assets	3,126
Notes payable and debt	(3,298)
Pension liability (Note 15)	(2,243)
Restructuring liability (Note 8)	(1,515)
Net deferred tax liabilities	(1,427)
Other liabilities assumed	(5,370)
Total net tangible liabilities	$ (1,941)
Amortizable intangible assets:	
Customer contracts and related relationships	3,199
Developed technology and trade name	1,349
Goodwill	10,395
IPR&D	30
Total preliminary estimated purchase price	$13,032

J. Jill, May 3, 2006

4. ACQUISITION OF J. JILL

On May 3, 2006, the Company acquired J. Jill, a multi-channel specialty retailer of women's apparel. J. Jill markets its products through retail stores, catalogs, and online. As of May 3, 2006, J. Jill operated 205 stores in the United States. J. Jill circulated approximately 56 million catalogs during 2005. The Company believes that the acquisition of J. Jill will provide the Company with a long-term growth vehicle and an opportunity to maximize the cost synergies of J. Jill and Talbots similar business models, particularly in back office functions. Both J. Jill and Talbots serve the 35 plus customer population; J. Jill focusing on apparel for a sophisticated casual lifestyle, with artistically inspired styles, providing a counterpoint to Talbots offering of updated modern classics.

Talbots acquired all of the outstanding shares of J. Jill for $24.05 per share for total consideration of $518,320 in cash. The Company used the proceeds from its $400,000 loan facility (see Note 9), as well as cash on hand to fund the acquisition. The Company also incurred acquisition-related fees and expenses of $5,967. The acquisition has been accounted for as a purchase in accordance with Statement of Financial Accounting Standards ("SFAS") No. 141, *Business Combinations* ("SFAS No. 141"), and accordingly, the results of operations of J. Jill have been included in the accompanying condensed consolidated statements of operations for the thirteen and twenty-six weeks ended July 29, 2006 from the date of the acquisition. In accordance with SFAS No. 141, the total purchase price has been preliminarily allocated to the tangible and intangible assets and liabilities acquired based on management's estimates of current fair values and may change as appraisals are finalized and as additional information becomes available. The resulting goodwill and other intangible assets will be accounted for under SFAS No. 142, *Goodwill and Other Intangible Assets* ("SFAS No. 142"). The following table summarizes the preliminary estimated fair values of the assets acquired and liabilities assumed, at the date of the acquisition, for an aggregate purchase price of $524,287, including acquisition costs.

	As of May 3, 2006
Cash	$ 30,445
Other current assets	109,842
Property and equipment	154,553
Goodwill	221,171
Trademarks	80,000
Other intangible assets	93,152
Current liabilities	(55,266)
Deferred income taxes	(98,224)
Other long-term liabilities	(11,386)
Total	$ 524,287

As part of the purchase price allocation, all intangible assets were preliminarily identified and valued. Of the total purchase price, $80,000 was assigned to trademarks, and $93,152 was assigned to other intangible assets, which consist of customer relationships of $77,700, non-compete agreements of $4,500, and favorable leasehold interests of $10,952. Management is in the process of finalizing the valuation of the acquired J. Jill intangibles. The amortization of the intangible assets that are subject to amortization is expected to be recognized over a weighted average life of approximately 11 years.

The acquired trademarks have been assigned an indefinite life and will not be amortized. Trademarks will be reviewed for impairment or for indicators of a limited useful life on an annual basis or when events indicate that the asset may be impaired.

The amount assigned to customer relationships, $77,700, is being amortized using a method that reflects the pattern in which the economic benefits of the intangible asset are expected to be consumed over a weighted average life of approximately twelve years. The amount assigned to non-compete agreements, $4,500, is being amortized on a straight-line basis over the period that the agreements are enforceable, approximately twenty months. The amount assigned to favorable leasehold interests, $10,952, is being amortized on a straight-line basis over the remaining lease period, or a weighted average of approximately eight years.

The excess of the purchase price over the fair value of tangible and identifiable intangible net assets was allocated to goodwill, which is non-deductible for tax purposes and preliminarily is estimated to be $221,171. In accordance with SFAS No. 142, this amount will not be amortized. Goodwill will be reviewed for impairment on an annual basis or when events indicate that the asset may be impaired.

R.R. Donnelley & Sons acquires Edgar Online, May 3, 2006[43]

On August 14, 2012, the Company acquired EDGAR Online, a leading provider of disclosure management services, financial data and enterprise risk analytics software and solutions. The acquisition of EDGAR Online will expand and enhance the range of services that the Company offers to its customers. The purchase price for EDGAR Online was $71.5 million, including debt assumed of $1.4 million and net of cash acquired of $2.1 million. Immediately following the acquisition, the Company repaid the $1.4 million of debt assumed. EDGAR Online's operations are included in the U.S. Print and Related Services segment.

[. . .]

The XPO and EDGAR Online acquisitions were recorded by allocating the cost of the acquisitions to the assets acquired, including intangible assets, based on their estimated fair values at the acquisition date. The excess of the cost of the acquisitions and the fair value of the contingent consideration over the net amounts assigned to the fair value of the assets acquired was recorded as goodwill. The preliminary tax deductible goodwill related to these acquisitions was $12.3 million. [. . .] Based on the current valuations, the purchase price allocations for these acquisitions were as follows:

Accounts receivable	$ 15.4
Prepaid expenses and other current assets	0.8
Property, plant and equipment	2.2
Amortizable other intangible assets	24.2
Other noncurrent assets	14.0
Goodwill	44.4
Accounts payable and accrued liabilities	(16.3)
Other noncurrent liabilities	(0.1)
Deferred taxes-net	10.4
Total purchase price-net of cash acquired	95.0
Less: debt assumed	1.4
Less: fair value of contingent consideration	3.5
Net cash paid	$ 90.1

The fair values of technology, amortizable intangible assets, contingent consideration and goodwill associated with the acquisitions of XPO and EDGAR Online were determined to be Level 3 under the fair value hierarchy. The following table presents the fair value, valuation techniques and related unobservable inputs for these Level 3 measurements:

	Fair Value	Valuation Technique	Unobservable Input	Range
Customer relationships	$ 20.2	Excess earnings, with and without method	Discount rate Attrition rate	16.0% - 17.5% 7.0% - 20.0%
Technology	13.4	Excess earnings, relief-from-royalty method, cost approach	Discount rate Obsolescence factor Royalty rate (after-tax)	16.0% - 17.0% 10.0% - 20.0% 4.5%
Trade names	3.1	Relief-from-royalty method	Discount rate Royalty rate (after-tax)	15.5% - 17.5% 0.5% - 1.2%
Non-compete agreements	0.9	With and without method	Discount rate	17.5%
Contingent consideration	3.5	Probability weighted discounted future cash flows	Discount rate	4.5%

[43] https://www.sec.gov/Archives/edgar/data/29669/000119312512446613/d416826d10q.htm