Scalable Intangibles: To Buy or to Build?*

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Preliminary, do not circulate; Here for the latest version.

Abstract

This paper studies firms' investments in intangibles and how the investment patterns vary with firm size. We show that among US public firms, larger firms tend to acquire intangibles more through merger and acquisition (M&A) rather than in-house investments (R&D and Organizational capital). We propose that the scalability of intangibles, is a potential explanation for these investment patterns. The firm production technology in our model features scalability of intangibles and the substitutability between production inputs. We derive testable hypotheses regarding firms' spending shares over acquiring and building intangibles, and physical capital, as well as how the unit price of intangibles varies with the size of an M&A transaction. We test these hypotheses using data on US public firms from Compustat and M&A deal information from Refinitiv's M&A Standard.

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1 Introduction

Investments in *intangibles* match the scale of investments in tangibles in the United States today (Corrado et al. 2022).[1] Intangibles are vital to the modern economy not just because of their investment share, but also due to their critical role in innovation and growth. This paper studies how firms invest in intangibles and explore the variations in investment patterns among firms of different size. We show that among US public firms, larger firms are more inclined to acquire intangibles through merger and acquisition (M&A) as opposed to in-house research and development (R&D) or Organizational capital investment. We propose that scalability, a defining characteristic of intangibles, is one potential factor that shapes this pattern.

Our analysis proceeds in three steps. First, we document the differing spending patterns on buying and building intangibles as the size of a given US public firm increases. Second, we introduce a stylized model that highlights two key aspects of firm production: the scalability of intangibles and the substitution between production inputs. This model forms the basis for our testable hypotheses. Third, we use data on US public firms from Compustat as well as information on M&A deals from Refinitiv's M&A Standard to test our hypotheses.

A firm's investments and assets can be categorized into tangibles like total property costs, equipment costs or other tangible assets (PPE) and intangibles. Intangible assets acquired through M&A are recorded on the firm's balance sheet (On-BS), whereas R&D and organizational costs are recorded immediately as expenses, not appearing on the balance sheet. We follow the state-of-the-art methodology (Ewens et

[1]Intangibles and tangibles are measured and defined in national accounts. According to Corrado et al. (2022) intangible and tangible investments accounted for roughly 3% and 12% of private GDP in 1985, respectively, and 7% and 8% in 2021. These figures for intangibles include only those categories present in current national accounts. Including a broader range of intangibles increases their share to over 16% of private GDP in 2021.

al. 2020) to estimate the capitalized R&D and Organizational intangible assets, and label them as Off-BS intangibles. With these adjusted asset measures and corresponding spending shares, we find that the proportion of spending on On-BS intangibles significantly increases, while that on Off-BS intangibles decreases strongly, as the firm size (measured by sales) grows. When examining the combined spending on On- and Off-BS — the total intangible investment — we observe a negative correlation with the size of the firm.

We show that the divergence in spending shares between On-BS and Off-BS intangibles over firm sizes persists and strengthens over time. We segment our firms into different size categories and analyze the time series of their average spending and asset shares in On-BS, Off-BS, and total intangibles. For example, the difference in M&A asset shares between large and small firms is positive and expands from less than 5% to more than 20%, while the gap in Off-BS asset shares between large and small firms also enlarges.

There is larger differences across sectors. The Transportation and Agriculture, Mining, and Oil & Gas sectors have almost no differece between small and large firms on the On-BS and Off-BS intangible spending shares. On the other hand, sectors that are likely to depend more on intangibles, such as Healthcare, IT & software, and Telecoms & Broadcasting, as well as the Manufacturing sector exhibit strong differences for small and large firms.

The increasingly important role of M&A in intangible investments, especially for large firms, and the proportionally less investments in Off-BS intangibles, especially R&D, have raised many concerns. These include large firms potentially "stifling" innovation (e.g., Seru 2014; Cunningham et al. 2021), M&A being associated with weakened competition and increasing market concentration (e.g., Grullon et al. 2019), and financial constraints making smaller firms less competitive in innovation. Our analysis of M&A, R&D, and Organizational intangible investment shares over firm size takes these issues into account by controlling for leverage ratios, cash flows, firm ages, and Tobin's Q. While not discounting the concerns raised in existing literature, we introduce an alternative explanation for the divergent spending patterns, focusing on the distinctive characteristics of intangibles compared to tangibles. Our model and empirical tests explicitly look at cross-sector and over-time variation in firm scalability and how it correlates with firm spending patterns.

We present a stylized model in a static and partial equilibrium environment with two types of firms. The first type of firm only conducts in-house intangible investments and uses tangible assets. The second type of firms, in addition, have the option to make M&A. We consider the first type as potential targets and the second type as acquirers, and discuss potential extensions to this simplifying assumption.

The firms in our model departs from standard production technology in two main aspects. First, intangibles are scalable, whereas tangibles are not. In our model, firms can endogenously choose the number of product lines they operate, with each product line combining tangible and intangible assets to produce output. Tangible assets are limited to use in a single product line, but intangibles assets can be used across all product lines, displaying a degree of non-rivalry. This distinction aligns with existing macroeconomic literature on intangibles, which identifies several unique properties of intangibles, including scalability, e.g., Crouzet et al. (2022b); Argente et al. (2021).

Consider a group of firms that invest in tangibles and intangibles only through in-house building. We show that more productive firms, under realistic parameters, will select a larger scope, and have larger within-product-line spending shares on intangibles. However, when tangibles and intangibles are complements, the total spending share of intangibles is decreasing in firm productivity and size (consistent with empirical facts), as each unit of intangibles is scalable and more tangibles are needed.

We next derive the per unit intangible price for a firm described above when it is sold in an M&A market as a target. We show that when having larger scopes is not too costly and each product's demand curve is steep enough, the complementary tangible spending increases faster than the firm value, and the spending on intangibles increases fast enough such that the unit of intangibles becomes cheaper. This is the key driving force that affects an acquirer's M&A spending patterns when both M&A and R&D options are available to it.

When firms in our model have two ways to acquire intangibles: through in-house investments and M&A on the market, we treat the intangibles acquired from both R&D and M&A as substitutable. In contrast to firms that are restricted to in-house investments and are seen as potential targets, those with access to both options are thought of as acquirers.

Larger acquirers naturally buy targets with more intangibles. When intangibles through in-house investment and M&A are sufficiently substitutable, we would expect a growing spending share on M&A within the intangibles budget, thanks to the decreasing unit price of M&A intangibles. Correspondingly, it also makes larger firms decrease their spending on in-house investments like R&D faster than they would without the M&A option.

We choose parameters that are qualitatively consistent with the motivating facts on Compustat firms' spending shares over firm size distributions, and vary the key parameter of interest, the intangible scalability, to develop testable hypotheses for empirical analysis. Our model predicts that the divergent spending patterns on On-BS and Off-BS over firm size distribution are more pronounced when the acquirer firms' potential targets have higher intangible scalability, and for target firms whose intangibles are more scalable, the unit price of their intangibles decreases faster over the quantity of intangibles.

To test these two hypothesis, we construct a measure of the scalability of an acquirer's potential set of targets. We utilize detailed M&A deal data from Refinitiv's M&A Standard to understand that for an acquirer in a given sector, what sector are its targets likely to be in. We measure an SIC 2-digit sector's average scope, which is used as a proxy for this sector's scalability, using our Compustat sample and the scope measures from Hoberg and Phillips (2023). Together with these measures, we construct the potential target scalability that are used as interaction variables with the firm sales.

We show that for acquirers in sector-years whose targets' have on average higher scopes and thus likely have more scalable intangibles, the positive effect of firm size on M&A spending is stronger, whereas its negative impact on R&D and Organizational intangible spending is also more pronounced. Again, there are large difference across sectors on how much the potential targets' scalability affect the effect of firm size on acquirers' spending shares. For example, the IT & software sector stands out where we see the strongest effect among all sectors.

To measure the per unit intangible price for targets, we again use detailed M&A deal data from Refinitiv's M&A Standard, merged with firm-level information from Compustat. We show that there is a negative correlation between the unit price of intangibles and the log of Target Intangible Size, and more importantly, targets from sectors where intangibles are more scalable have faster decrease in the unit intangible price as the size of intangible increases.

The remainder of the paper proceeds as follows. We discuss how our paper relates to and contributes to the existing literature. In Section 2, we introduce some of our data and document the patterns of intangible spending among US public firms. Section 3 presents a stylized model that highlights the role of intangibles and how their scalability can lead to counterintuitive findings regarding a firm's spending shares that are consistent with empirical facts. We test our model hypotheses from the model in Section 4.

Related Literature

First, we contribute to the literature on intangibles primarily within the field of macroeconomics. One strand of this literature measures the importance of intangibles in the modern economy. It argues that intangibles significantly alter growth accounting and our understanding of aggregate productivity slowdowns (Basu et al. 2004; Corrado et al. 2009, 2022), contribute to the secular decline in the labor share (Koh et al. (2020)), and affect factors like inequality, rent shares, capital-skill complementarity, and weak investment in physical capital, etc.[2] Another stand of literature highlights the unique properties of intangibles compared to traditional capital. Crouzet et al. (2022a) highlights the non-rivalry and the need for storage of intangibles, along with the implications of these characteristics. Similar to our focus on scalability of intangibles, Argente et al. (2021) present a theory of firm size, incorporating the endogenous choice of scope and two different types of expertise, one scalable and one local. A key contribution of our paper is that we explore the distinct implications of intangible scalability on both M&A and R&D, two important yet different methods of acquiring intangibles.[3]

Second, our paper relates to the extensive literature on mergers and acquisitions in corporate finance and industrial organization. A major part of this literature studies various motivations behind firm's M&A decisions, such as traditional Q-theory (Jovanovic and Rousseau 2002), behavioral motives (Shleifer and Vishny 2003), and

[2]See Crouzet et al. (2022a) for literature review about these issues.

[3]We emphasize the cross-firm-size implications measured by firm sales. There are other dimensions where intangible scalability could be influential, such as firm scopes explicitly measured, as in Hoberg and Phillips (2023).

complementarities (Rhodeskropf and Robinson 2008; Hsu et al. 2022). Some papers study firms' decisions on both M&A and R&D at the same time. Phillips and Zhdanov (2013) argue that an active acquisition market affects firm incentives to innovate and conduct R&D, leading smaller firms to prioritize innovation and larger firms to access innovation through acquisitions. Our approach, focusing on intangible scalability, provides a different perspective from theirs. Additionally, while their work centers on the innovation decisions of target firms, our study documents patterns and explores the implications for acquirers. Other research has explored the varying choices between M&A and R&D, considering factors like the human capital gap between a firm and its entry sector (Beaumont et al. 2023) and potential synergies from M&A (Bena and Li 2014).

Third, our paper contributes to the longstanding discussion on the determinants of firms' innovative activities (see a survey by Cohen (2010)) and to the recent debates concerning the declining productivity growth and increasing market concentration, which often emphasize the role of large firms (e.g., Akcigit and Ates 2021, 2023). Elicited by Schumpeter's controversial claims about the key role of large monopolistic firms in advancing technology, a large literature studies the relationship between market concentration or firm size and innovative effort. A segment of this literature, including Acs and Audretsch (1988), posits that smaller firms often contribute more innovations relative to their size and that R&D productivity decreases as firms grow larger. Recent studies like Seru (2014); Grullon et al. (2019); Cunningham et al. (2021) also suggest that large firms may engage less in innovation, potentially to the detriment of the overall economy. While not dismissing these mechanisms, our paper offers an alternative perspective on the R&D behavior of large firms. We focus on how the technological property of scalability in intangibles can lead to empirical patterns aligning with some of these concerns.

2 Patterns of Intangible Spending

We document strong and robust patterns of firm spendings and assets on different categories over the firm size distribution. We argue that intangible scalability can help to explain these patterns.

2.1 Data Sources & Sample Selection

We construct our empirical variables using Compustat North America Annual. We keep only firm-year observations between 1989 and 2020. We exclude financial firms (SIC 6000 - 6999), regulated utilities (SIC 4900 - 4949), and public administration entities (SIC 9211 - 9281) from our sample. We require firms to have non-missing sales, total assets, employment, cost of goods sold, and capital stock. Our analysis is limited to firms located and incorporated in the United States, resulting in a final dataset of 125,346 firm-year observations.

2.2 Intangible Assets: On- and Off-Balance Sheet

We first categorize firm assets into two types: intangibles and tangibles. Tangibles include total property costs, equipment costs or other tangible assets (PPE). Intangibles consist of two categories: on-balance sheet intangibles and off-balance sheet intangibles. On-balance sheet (On-BS) intangible assets are acquired through M&A and are recorded on firms' balance sheets.[4] The sum of the tangible assets and M&A assets would be the total assets on a firm's balance sheet.

Off-balance sheet (Off-BS) intangible assets can be further broken down into R&D and organizational assets, which, under accounting standards, are expensed in

[4]The M&A intangibles can be further broken down into estimated fair value (INTAN) and goodwill (GDWL). Our measure for M&A intangibles is the sum of these two components. If INTAN is missing, we replace it with GDWL.

the year they occur and do not add to the firm's balance sheet capital. We construct capitalized R&D and organizational assets following the methodology of Ewens et al. 2020).[5] We replace missing and negative R&D or organizational asset values with zeros. (1) summarizes the above decomposition of assets. For the rest of the paper, we use On-BS and M&A, and Off-BS and R&D + Organizational interchangeably.

$$\text{Total Asset} = \underbrace{\overbrace{\text{M\&A}}^{\text{On-BS}} + \overbrace{\text{R\&D + Organizational}}^{\text{Off-BS}}}_{\text{Intangibles}} + \underbrace{\text{PPE}}_{\text{Tangibles}} . \tag{1}$$

To construct our variables of interest, we calculate annual spending on each asset type by taking one-year differences in their values, which takes the depreciation rates of different types of assets into account.[6] We then compute the spending share of each asset by dividing its spending by the total spending sum.

We also compute the adjusted total assets by adding capitalized R&D and Organizational capital to the firm's total assets and averaging this over the current year and previous year. The asset shares are calculated accordingly. We winsorize these spending and asset share variables at the 2.5% and 97.5% percentiles, and drop observations with negative total spending for spending shares.

Firm size is measured using the standardized log of sales. We include several control variables both in this section and in our more detailed regression analysis later. We use the log of the leverage ratio (total liabilities divided by total assets) and Cash flow[7] divided by the adjusted asset to control for the impacts of financial constraints

[5]They estimate capitalization parameters using market prices from firm exits and use them to capitalize intangibles for a comprehensive panel of firms from 1978-2017.

[6]Compared to some existing literature that uses gross investment, our spending shares are net, and are the correct ones to use from an economic perspective in a dynamic world.

[7]Cash flow is calculated by summing Income Before Extraordinary Items (IB), Depreciation and Amortization (DP), R&D expenditure (XRD), and adjusted Selling, General, and Administrative Expenses (XSGA).

on firm spending behavior. We standardize all these variables by subtracting the variable's (yearly) mean and dividing by the yearly standard deviation. We include firm age to control for firm's life cycle behavior, calculated as the number of years since IPO, or if missing, since the firm's first appearance in CRSP/Compustat, capped at 50. We also calculate a firm's Tobin's Q to control for its overall investment incentives. Finally, we control for a firm's scope using measures from Hoberg and Phillips (2023).

2.3 Intangible Spending Shares

Figure 1 plots the cross-sectional spending share on On-BS intangibles, Off-BS intangibles, and their combined total. We control for sector-year fixed effects and control variables mentioned above. As the firm size, measured by sales, increases, the spending share on On-BS intangibles rises from less than 5% to almost 20%, while spending on Off-BS intangibles correspondingly decreases, from around 80% to less than 50%. Figure A1 further breaks down the Off-BS intangibles into R&D and Organizational intangibles.

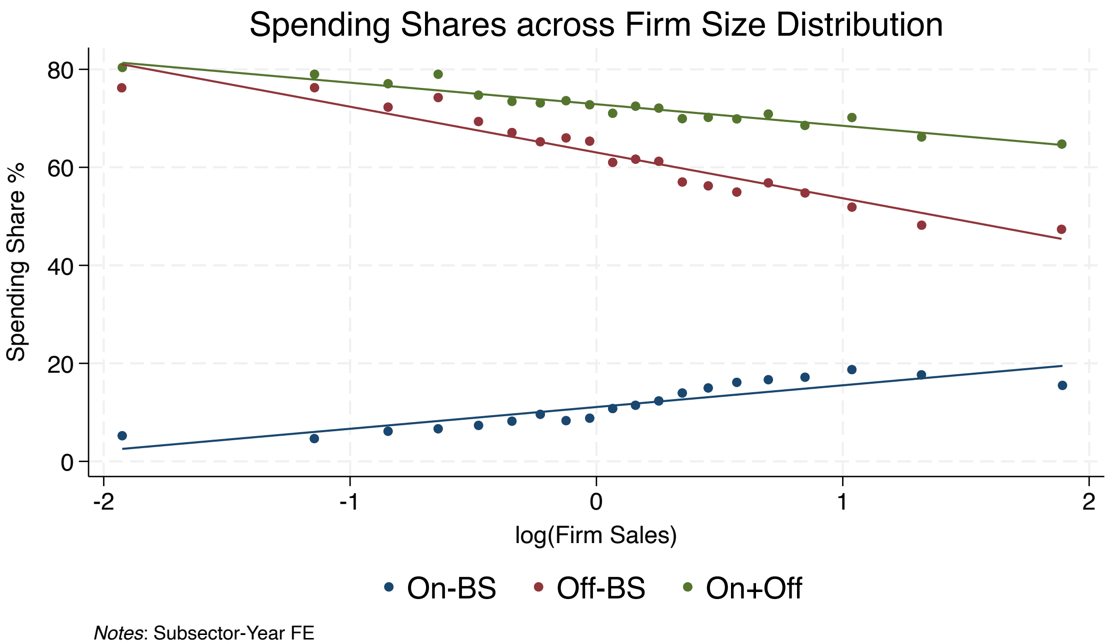


Figure 1: Cross-sectional Intangible Spending Shares

Table 1 reports the regression coefficients on standardized Log firm sales for the three spending shares, with the following regression equation

$$\text{Spending Share}_{i,t} = \beta_1 \cdot \log(\text{Size}_{i,t}) + \beta_2 \cdot \text{Scope}_{i,t} + \beta_3 \cdot \text{Age}_{i,t} + \cdots . \tag{2}$$

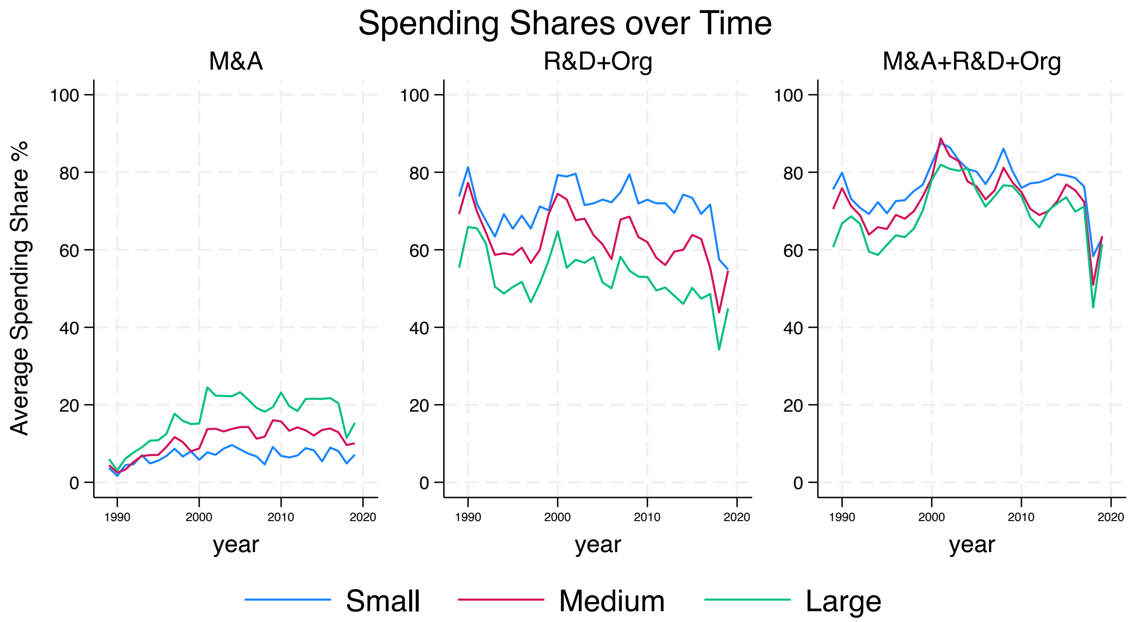
Table A1 in Appendix B shows the expanded regression table including coefficients for control variables and on the spending shares of subcategories of assets.

	M&A	R&D+Org	Intangible
	(1)	(2)	(3)
Log Sale (STD)	8.702**	-12.64**	-3.572**
	(0.651)	(0.908)	(0.565)
Controls	✓	✓	✓
Subsector-Year FE	✓	✓	✓
Within R^2	.021	.031	.012
# Years	31	31	31
Dep. Var. Mean	10.48	62.18	72.66
Observations	27403	28355	28317

Notes: Controls include scope, log leverage ratio, cash flow to asset, firm age, log adjusted asset, and Tobin's Q. Samples are constraint to those whose ratio of On-BS intangibles to total adjusted asset is larger than 0.05. Dependent variables winsorized at 2.5th and 97.5th percentiles. SE doubly clustered at firm and year level. Subsector-Year FE included. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Table 1: Regression: Cross-sectional Intangible Spending Shares

Figure 2 add the time dimension to these spending shares. We categorize firms into small, medium, and large based on their annual sales, and calculate the mean spending share for On-BS, Off-BS and the total. Large firms increasingly spend more than medium and small firms on M&A intangibles during 1980s and 1990s, and the gaps stay quite stable after 2000. Conversely, small firms consistently spend more on R&D and Organizational intangibles than medium and large firms. The total intangible spendings are quite similar across the three broad size groups over time.



Notes: Subsector-Year FE

Figure 2: Over-time Intangible Spending Shares across Firm Size Groups

To better illustrate the cumulative effects, Figure 3 plots the asset shares rather than spending shares. The disparity in M&A assets between large and small firms expands from less than 5% to about 20%, and the gap in R&D plus Organizational assets between large and small firms enlarges. The total intangible assets versus tangible assets account for an increasingly larger share of assets over time.

Significant shifts during the economic crises around 2000 and 2008 suggest that broader economic conditions likely influence firms' investment and asset strategies. For example, the declines in M&A spendings and assets are notable across all firm sizes during 2008. However, the impact of the aggregate business environment appears to be similar across different firm groups, suggesting that the observed trend is influenced by factors beyond these, such as financial constraint and liquidity. Through our model and subsequent empirical analysis, we argue that this trend of widening spending shares on different types of intangibles across firm sizes is closely linked to the nature of intangibles, specifically their scalability.

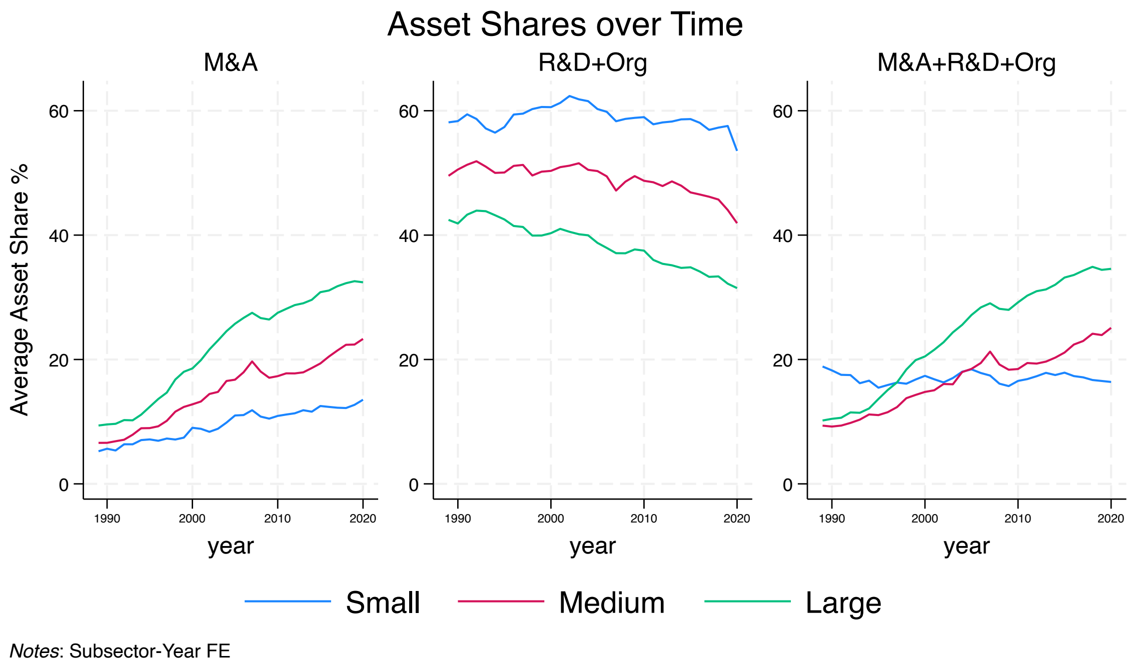


Figure 3: Over-time Intangible Asset Shares across Firm Size Groups

Figure 4 shows the standardized log firm sales coefficients on On-BS and Off-BS spending shares using Equation (2) separately for each year in our sample, while Figure 4 shows the corresponding coefficients separately for 9 broad sectors. The divergence between On-BS and Off-BS spending shares for larger firms becomes more salient since later 1990s and further increases after the global financial crisis in 2008. But in general, this is a pattern consistently existing over time. On the other hand, there is larger differences across sectors. The Transportation and Agriculture, Mining, and Oil & Gas sectors have almost no difference between small and large firms on the two spending shares. Sectors that are believed to depend more on intangibles, such as Healthcare, IT & software, and Telecoms & Broadcasting, as well as the Manufacturing sector exhibit large differences.

Figure A2 in Appendix B further breaks down the Off-BS spending share into

R&D and Organizational intangibles. A notable outlier is the Healthcare sector, where there is a significantly negative correlation between firm size and R&D spending share. Existing research papers that focus on the Healthcare sector suggest that M&A as a means for larger firms to potentially stifle innovations from smaller competitors (Cunningham et al. 2021). Our analysis, however, points to a broader and more generalized pattern across various sectors.

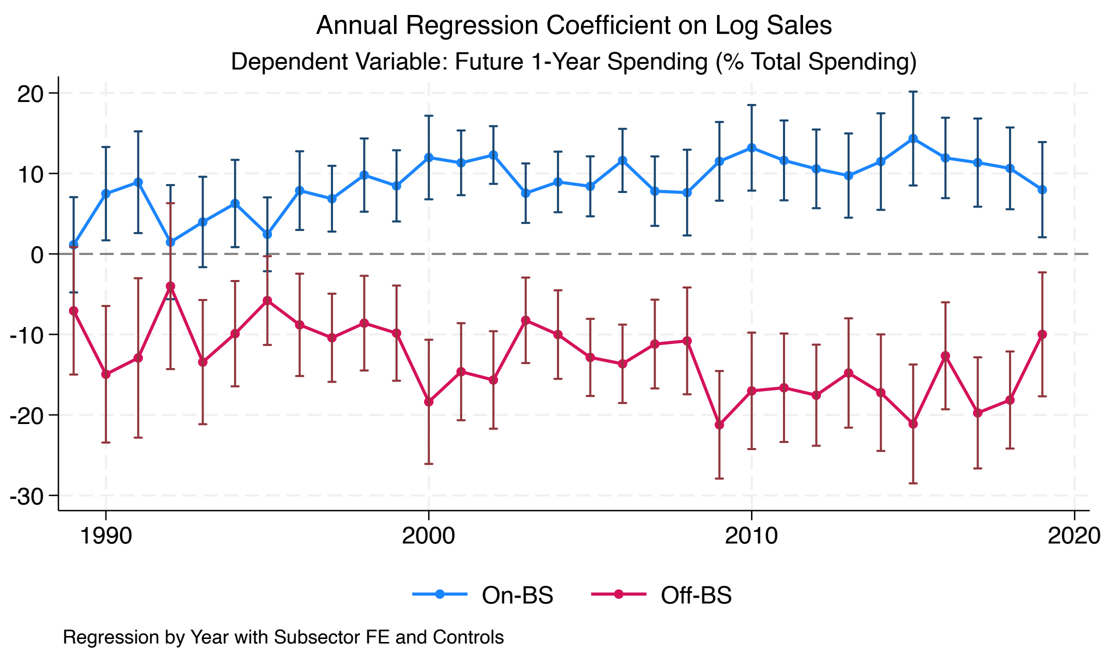


Figure 4: Over-time Intangible Spending Shares on Firm Sales: Regression Coefficient

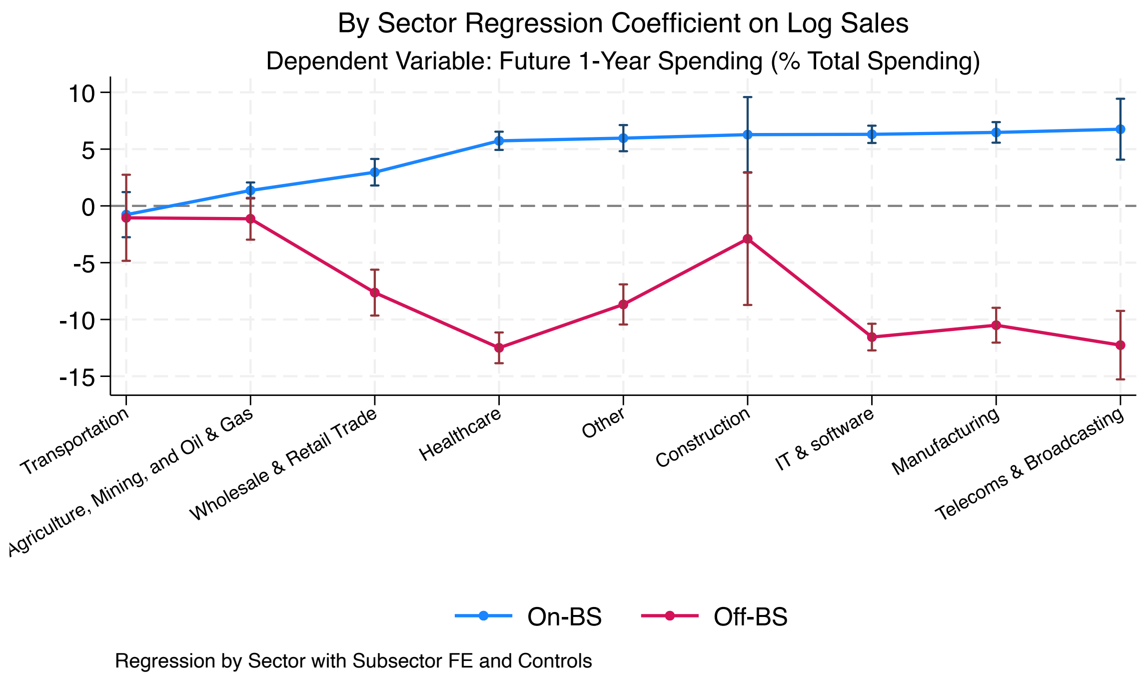


Figure 5: By-sector Intangible Spending Shares on Firm Sales: Regression Coefficient

3 Model

We present a stylized model in a static and partial equilibrium environment with two types of firms. The first type of firm only conducts in-house intangible investments (e.g., R&D and Organizational) and uses tangible assets. To simplify notations, we use R&D investments to represent the in-house intangible investments. The second type of firms, in addition, have the option to make M&A. We consider the first type as potential targets and the second type as acquirers.[8] All firms solve a static problem, maximizing their equity value by choosing optimal R&D (and M&A

[8]The difference between the two types of firms is obviously a counterfactual and simplifying assumption. The fact that small firms spend relatively little on M&A alleviates this concern. This simplifying assumption helps to derive sharper analytical results regarding firms' spending over different assets, and highlights the key mechanism. An extended model where a firm can be both acquirer and target is working in progress.

for acquirers), tangible investment, and scopes.

3.1 Demand and Technology

Each firm is exogenously assigned a productivity z. A firm chooses the number of production lines of operation x, with each product line requiring tangibles (K) and intangibles (N) inputs. The intangibles include only R&D for the targets, while include a combination of R&D and M&A for the acquirers. For a given product line $s \in [0, x]$, the output $q_z(s)$ equals

$$q_z(s) = z\Big((1-\zeta)^{\frac{1}{\sigma}} N(s)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}} K(s)^{\frac{\sigma-1}{\sigma}}\Big)^{\frac{\sigma}{1-\sigma}},$$

where σ is the elasticity of substitution between $N(s)$ and $K(s)$, and $1-\zeta$ captures the importance of intangibles in the production function.

Each product produced by the firm is sold in a monopolistic competitive market, facing a demand function[9]

$$p(s) = q(s)^{-\epsilon}, \quad 0 < \epsilon < 1.$$

Each unit of tangible asset can be used in only one product line

$$K = \int_0^x K(s)ds.$$

In contrast, intangible assets can be imperfectly scaled across multiple product

[9] A curvature in the demand function is necessary. Without it, given our production function's homogeneous degree of one, the optimal input usage would be either infinite or zero.

lines

$$N = \left(\int_0^x N(s)^{\frac{1}{1-\rho}} ds \right)^{1-\rho}, \quad 0 < \rho < 1.$$

The parameter ρ captures the scalability of intangibles. When $\rho \to 0$, intangibles, like tangibles, are limited to one product line. When $\rho \to 1$, intangibles become fully scalable, i.e., $N(s) = N$.

3.2 Building Intangibles

In this section, we study a firm's spending decisions in tangibles and R&D, without the M&A option. The core drivers of spending patterns across firms with varying productivities are the scalability of intangibles and the endogenous choice of operational scope. The next section extend this analysis to include both R&D and M&A options for acquirer firms.

To begin with, consider a firm constrained to a fixed number of production lines, normalized to $x = 1$. The firm maximizes the following value function:[10]

$$V_z = \max_{I,K} \left[z \left((1-\zeta)^{\frac{1}{\sigma}} I^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}} K^{\frac{\sigma-1}{\sigma}} \right) \right]^{\frac{(1-\epsilon)\sigma}{\sigma-1}} - K - I.$$

Tangibles assets are purchased at a constant market price, normalized to one, implying a linear cost function. Similarly, in-house development of intangible assets is also

[10] Using symmetry across product lines, we have

$$N(s) = Nx^{\rho-1},$$
$$K(s) = Kx^{-1}.$$

assumed to incur a linear cost.[11]

In this case, using the first order condition for $I(s)$ and $K(s)$, one gets $\frac{\zeta}{1-\zeta}\frac{I(s)}{K(s)} = 1$. With fixed scope and linear costs for both tangibles and intangibles, all firms, irrespective of productivity and size, maintain constant spending shares on these assets.

Next, consider the case where firms can optimally select their scopes. We assume that a firm also incurs a fixed cost of operating that depends on its scope $\frac{F}{\omega}x^{\omega}$.[12] The firm's problem then becomes:

$$V(z) = \max_{x,\{I(s),K(s)\}} \int_0^x \left[z\left((1-\zeta)^{\frac{1}{\sigma}} I(s)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}} K(s)^{\frac{\sigma-1}{\sigma}}\right)\right]^{\frac{(1-\epsilon)\sigma}{\sigma-1}} ds - K - I - \frac{F}{\omega}x^{\omega},$$
$$\text{s.t. } \int_0^x K(s)ds \leqslant K, \quad \left(\int_0^x I(s)^{\frac{1}{1-\rho}} \mathrm{d}s\right)^{1-\rho} \leqslant I;$$

Proposition 1. *Under reasonable parameter values, firm scope x and within-product-line spending ratio $\frac{I(s)}{K(s)}$ is increasing in z.*

When K and I are complements ($\sigma < 1$), the total spending ratio $\frac{I}{K}$ is decreasing in z. When K and I are substitutes ($\sigma > 1$), $\frac{I}{K}$ is increasing in z. When $\sigma = 1$, $\frac{I}{K}$ is constant over z.

Proof. See Appendix C. □

A sufficient condition for within-product-line intangible spending share $\frac{I(s)}{K(s)}$ and firm scope x being increasing over z is $\frac{1}{\omega} < \epsilon$. When ϵ is large, each product faces a less steep demand curve, which makes more productive firms (larger z) can profit more by having a larger operation for each product. When ω is large, having extra

[11]Introducing a convex cost for building intangibles could create an additional factor reducing the incentive to use intangibles as firms become more productive.

[12]Similar to the demand function, without extra cost for larger scopes, the optimal scope always goes to infinity.

product lines are not very costly, which makes less productive firms be willing to have larger scopes. When the opposite is true, more productive firms have larger scopes, which also leads to larger within-product-line intangible spending shares, as intangibles are scalable.

Going from the within-product-line to the aggregate spending share, we take the first order conditions w.r.t. both $K(s)$ and $I(s)$,

$$\frac{I}{K} = \left(\frac{\zeta}{1-\zeta}\right)^{-\frac{1}{\sigma}} \left(\frac{I(s)}{K(s)}\right)^{1-\frac{1}{\sigma}},$$

which says that the ratio of total spending on intangibles I and tangibles K depends on the within-product-line input ratio $\frac{I(s)}{K(s)}$ and the substitution parameter σ. When $\sigma = 1$, this ratio remains constant. When $\sigma < 1$, i.e., the two inputs are complements, higher productivity firms show an decreasing aggregate spending share on intangibles, as each unit of intangibles is scalable and more tangibles are needed.

We now derive the per unit intangible price for a firm described above when it is sold in an M&A market as a target. We make the following assumptions:

- K are homogeneous and rented in a competitive market with price normalized to 1;
- There is an exogenous constant multiplicative premium G to the intangibles.

Thus, the total acquisition price for a firm reflects only the value of intangibles, as they are specific to the target firms, while tangibles can be bought and sold in a perfect market. Given these assumptions, we have the following corollary. More precisely, we define the per unit intangible price for a target

$$P(I(z)) = G\frac{V(z) - K(z)}{I(z)}.$$

Corollary 1. *Assume the above assumptions hold, firm scope x is increasing in firm productivity z, and $\sigma < 1$. When $\frac{1}{\omega} > 1 - \frac{1-\epsilon}{\epsilon}$, the unit intangible price $P(I(z))$ is decreasing in z.*

Proof. See Appendix C. □

The parameter constraint $\frac{1}{\omega} > 1 - \frac{1-\epsilon}{\epsilon}$ means that the scope cost is not too large, while the product demand curve is steep enough. In this case, when a more productive firm have larger scopes, the complementary tangible spending increases faster than the firm value $V(z)$, and the spending on intangibles increases fast enough such that the unit of intangibles becomes cheaper. In the next section, we will demonstrate how this price implication derived from empirically consistent patterns on firm spending shares drives the spending patterns for acquirers, with both M&A and R&D options for intangibles.

3.3 Acquiring Intangibles

A key contribution of our paper to the intangibles literature is the introduction of a second channel for firms to acquire intangibles — through mergers and acquisitions (M&A). Let M represent the acquired intangibles. The total amount of intangibles within a firm is then an aggregate of both internally developed (R&D) and acquired (M&A) intangibles. Within each product line, these two types of intangibles, $I(s)$ for in-house R&D and $M(s)$ for M&A, are combined as follows:

$$N(s) = \left(\eta^{\frac{1}{\nu}} I(s)^{\frac{\nu-1}{\nu}} + (1-\eta)^{\frac{1}{\nu}} M(s)^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}},$$

where η is the elasticity of substitution between the two types of intangibles. The production function for combining tangibles $K(s)$ and this aggregated form of intangibles

$N(s)$ remains the same as in the previous section.

We assume that firms acquiring intangibles via M&A take the price scheme for intangibles $P(M)$ as given. This pricing is derived from the set of firms that can only build intangibles through R&D, as discussed earlier. The problem for an acquiring firm is therefore

$$
\begin{aligned}
V(z) = \max_{\{K(s),M(s),I(s)\},M,x} & z^{1-\epsilon} x \left[(1-\zeta)^{\frac{1}{\sigma}} N(s)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}} K(s)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}(1-\epsilon)} \\
& - K(s)x - I(s)x^{1-\rho} - MP(M) - \frac{F}{\omega} x^{\omega} \\
\text{s.t. } N(s) = & \left(\eta^{\frac{1}{\nu}} I(s)^{\frac{\nu-1}{\nu}} + (1-\eta)^{\frac{1}{\nu}} M(s)^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}}, \quad M = M(s)x^{1-\rho}.
\end{aligned}
$$

Note that acquirers are assumed to pay only for the intangibles of the target firms, thanks to the assumption that the tangible assets can be adjusted with a fixed unit price on a perfectly competitive market.

The option to acquire intangibles through M&A impacts the spending behavior of acquirer firms in two ways. First, when intangibles through R&D and M&A are substitutes, i.e., $\eta > 1$, and the unit price of M&A intangibles decreases when z increases and the optimal size of target increases, we would expect a growing spending share on M&A within the intangibles budget. When η is sufficiently high, this could also strengthen the decrease in R&D spending as a proportion of total expenditures. When η is sufficiently low, we might have both decreasing M&A and R&D spending shares. Second, as the effective price for the total intangibles, N, is affected by the target price scheme, it would affect both the levels and the speed of intangible share changes over firm productivity.

3.4 Numerical Comparative Statics and Hypotheses

We have shown how the scalability of intangibles and the substitutability (complementarity) across different categories of assets could drive the spending patterns for both the targets and the acquirers over firm size distribution. In this section, we start with parameters that are qualitatively consistent with the motivating facts on Compustat firms' spending shares over firm size distributions, and vary the key parameter of interest, the intangible scalability ρ, to develop testable hypotheses empirically.

We set $\epsilon = 0.5, \zeta = 0.5, \sigma = 0.7, F = 1, \omega = 3.5$, which are the same for both the set of targets and acquirers. For the parameters that are specific to the acquirers, we set $\eta = 0.8, \nu = 5$. Finally, for the scalability parameter, we set $\rho^{\text{Acquirer}} = 0.5$, while vary $\rho^{\text{Target}} = 0.5$ or 0.6.

Figure 7 show the corresponding targets' per unit intangible price over the size of intangibles of different scalabilities on the left panel, and the target intangible spending shares over firm productivity of different scalabilities on the right panel. Correspondingly, Figure 7 shows the acquirers' spending shares on tangibles K, R&D, and M&A, across log firm sales when the set of targets have either low scalability ($\rho^{\text{Target}} = 0.5$ on the left panel) or high scalability ($\rho^{\text{Target}} = 0.6$ on the left panel).

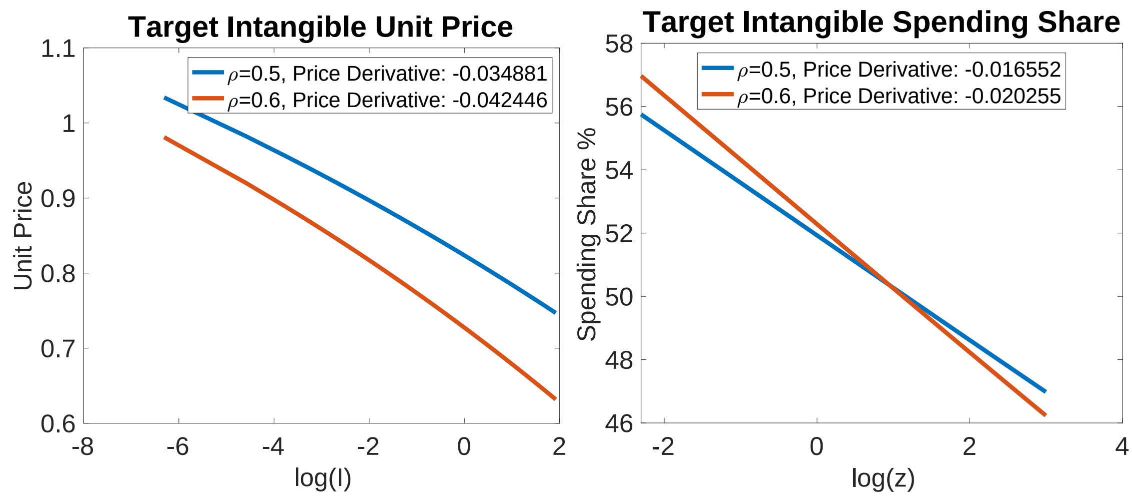


Figure 6: Target Intangible Price and Spending Shares: Low vs. High Scalability

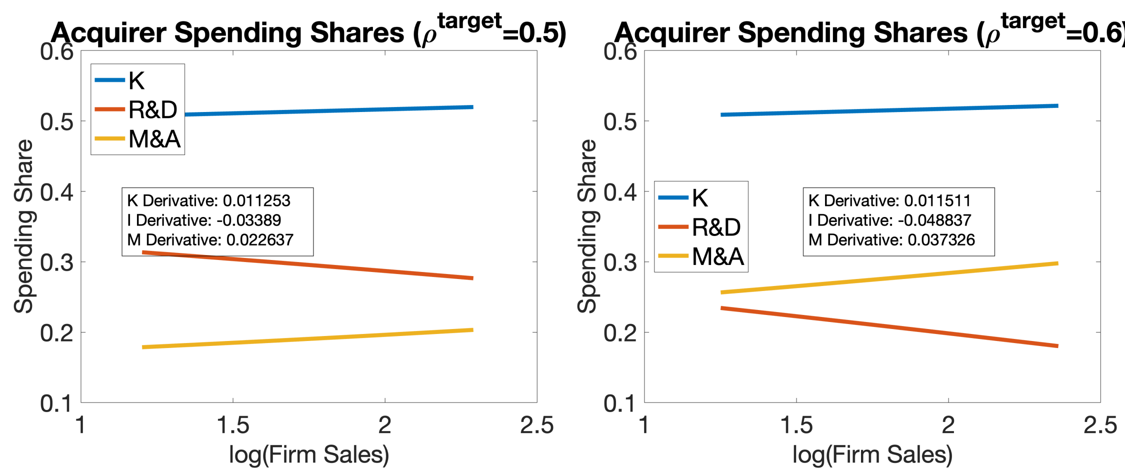


Figure 7: Acquirer Spending Shares: Low vs. High Target Scalability

When the target scalability increases, the intangible unit price decreases faster as the quantity gets larger. Correspondingly, M&A becomes increasingly cheaper for larger firms. Thus, the spending shares on M&A for the acquirers increase faster. Correspondingly, the spending shares on R&D for the acquirers decreases faster. We summarize the following hypotheses for empirical testing in the next section.

Hypothesis 1. *For firms acquiring intangibles through both M&A and R&D, the spending shares on M&A increase with firms productivity, while the spending shares* *on R&D and tangible assets decrease.*

Furthermore, when the acquirer firms' potential targets have higher intangible scalability, the spending shares over firm sales increases faster on M&A, and decreases faster on R&D.

Hypothesis 2. *The per unit price of firm intangibles decreases over the quantity of intangibles.*

Furthermore, for target firms whose intangibles are more scalable, the unit price of their intangibles decreases faster over the quantity of intangibles.

4 Hypotheses Testing

4.1 The Potential Targets' Scalability

Our model highlights how the scalability of targets' intangibles affect its effective per unit price, and in turn the spending shares for acquirers. To begin with, we need to have a measure of the scalability of an acquirer's potential set of targets, and to construct this, we in turn need a link between acquirers and targets.

We utilize detailed M&A deal data from Refinitiv's M&A Standard to understand that for an acquirer in a given sector, what sector are its targets likely to be in. Refinitiv's M&A Standard offers comprehensive global coverage of over 1.2 million M&A deals.[13] This dataset includes deals from 1980 onward for US targets and from 1985 for non-US targets.

First, we measure an SIC 2-digit (denoted by $s \in S$) sector's average scope,

[13]The dataset's content is sourced through direct deal submissions from global banking and legal contributors coupled with extensive research performed by a global team of dedicated research analysts and local language specialists who examine thousands of sources to provide global comprehensive coverage of the M&A market — private to private undisclosed value deals to large mega deals.

which is used as a proxy for this sector's scalability, using our Compustat sample and the scope measures from Hoberg and Phillips (2023). Let $\mathcal{N}_{s,t}$ be the number of firms in Compustat for s and year t, we calculate

$$\overline{S}_{s,t} = \frac{1}{\mathcal{N}_{s,t}} \sum_{i \in s} \text{Scope}_{i,t}.$$

Second, we construct a mapping of an acquirer's sector to its potential targets' sectors. Refinitiv records an acquirer's sector $u \in U$ (different classification and broader than SIC 2-digit), and both a target's u and SIC 2-digit code s. Thus, we construct to empirical probabilities:

$$F_s(u) \equiv \text{Prob}(i \in u | i \in s),$$

which is constructed using Refinitiv's target sectoral information averaged over 1989-2020, and

$$B_{u,t}(s) \equiv \text{Prob}(j \in s | i \in u),$$

which is constructed using Refinitiv's acquirer and target sectoral information for year t, where j is a potential target for i.

Thus, for a Compustat firm i in sector s year t, we calculate

$$\mathcal{S}_{s,t} \equiv \sum_{u} F_s(u) \sum_{s'} B_{u,t}(s') \overline{S}_{s',t}.$$

We also construct a measure of the importance of intangibles for an acquirer's potential set of targets, using the average share of the targets' intangible asset shares.

4.2 Interaction Regression: Firm Size $\times$ Target Scalability

We now focus on our Hypothesis 1, examining whether the buy-build-spending-divergence stronger among firms whose targets are more scalable, and $\mathcal{S}_{s,t}$ serves as a proxy for the potential target scalability for an acquirer in s at t. More specifically, we run the following regression

$$\begin{aligned}\text{SpendingShare}_{i,t} = \beta_1 \cdot \log(\text{Sale}_{i,t}) + \gamma_1 \cdot \log(\text{Sale}_{i,t}) \times \mathcal{S}_{s(i),t} \\ + \beta_2 \cdot \text{Scope}_{i,t} + \gamma_2 \cdot \text{Scope}_{i,t} \times \mathcal{S}_{s(i),t} \\ + \ldots + \delta \cdot \mathcal{S}_{s(i),t} + \text{Fixed Effects},\end{aligned}$$

and Table 2 reports the coefficients β_1 and γ_1.

	M&A	R&D+Org	Intangible
	(1)	(2)	(3)
Log Sale (STD)	5.085*	-4.332	0.293
	(2.210)	(3.298)	(2.067)
Log(Sale) $\times$ $\mathcal{S}_{s(i),t}$	0.522^{+}	-1.147*	-0.510^{+}
	(0.274)	(0.423)	(0.260)
$\mathcal{S}_{s(i),t}$	0.00466	-4.209*	-4.343**
	(1.131)	(1.720)	(1.155)
Controls	✓	✓	✓
Subsector-Year FE	✓	✓	✓
Within R^2	.023	.034	.015
# Years	31	31	31
Dep. Var. Mean	10.48	62.18	72.66
Observations	27403	28355	28317

Notes: Controls include scope, log leverage ratio, cash flow to asset, firm age, log adjusted asset, and Tobin's Q. Samples are constraint to those whose ratio of On-BS intangibles to total adjusted asset is larger than 0.05. Dependent variables winsorized at 2.5th and 97.5th percentiles. SE doubly clustered at firm and year level. Subsector-Year FE included. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Table 2: Spending Shares over Firm Size Interacted with Target Sectoral Scalability

Column (1) and (2) of Table 2 show that for acquirers in sector-years whose targets' have on average higher scopes and thus likely have more scalable intangibles, the positive effect of firm size on M&A spending is stronger, whereas its negative impact on R&D spending is also more pronounced. Net, these acquirers show a stronger decrease in total intangible spending share over firm sizes. These findings align with the predictions of Hypothesis 1. Table A2 in Appendix D shows the results for the subcategories of spendings.

Figure 8 plots the interaction coefficients γ_1 separately for the 9 broad sectors. Again, there are large difference across sectors on how much the potential targets' scalability affect the effect of firm size on acquirers' spending shares. For example, the IT & software sector stands out where we see the strongest effect among all sectors. Figure A3 in Appendix D further breaks down the Off-BS intangibles into R&D and Organizational intangibles. The large positive coefficient of Off-BS intangibles for the Construction and Transportation sectors, and large negative coefficient of Off-BS intangibles for the Manufacturing sector, are driven by the Organizational intangibles. On the other hand, the Healthcare and Telecom & Broadcasting sector have significantly negative interaction coefficients for the R&D intangibles.

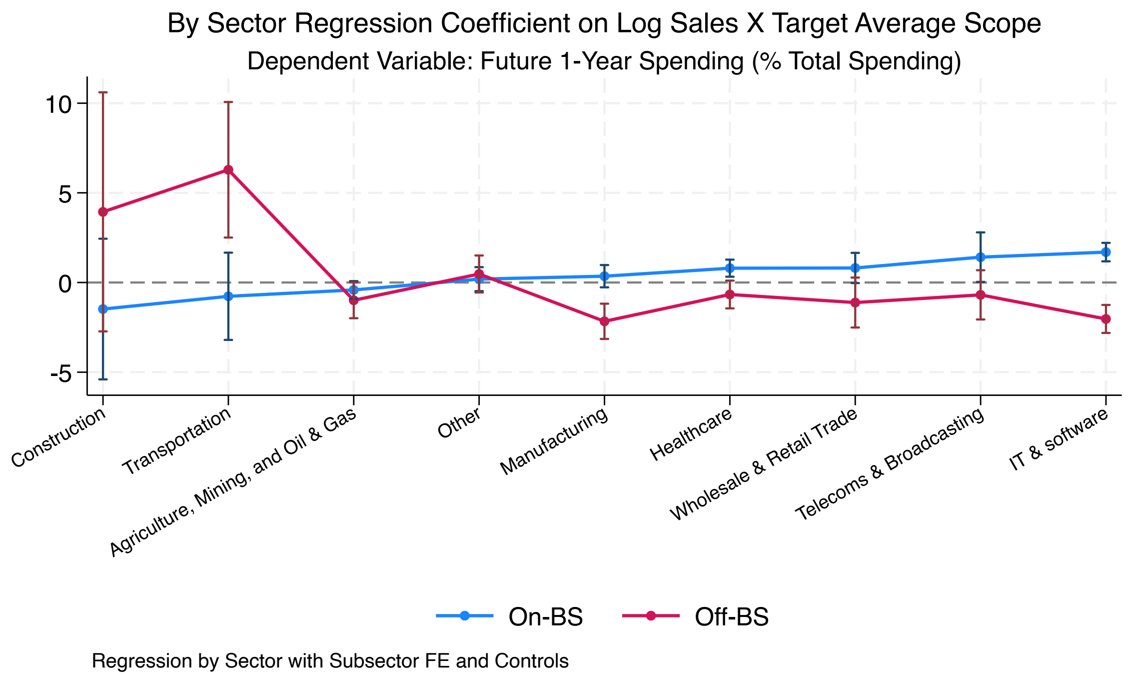


Figure 8: By-sector Intangible Spending Shares on Firm Sales × Target Scalability

4.3 Target Per Unit Intangible Price

We now examine Hypothesis 2, which underscores mechanisms through which intangible scalability influences On-BS and Off-BS spending shares.

To measure the per unit intangible price for targets, we again use detailed M&A deal data from Refinitiv's M&A Standard, merged with firm-level information from Compustat. For consistency with our spending share analysis focusing on public firms, we select deals where both the acquirer and target are public firms listed in Compustat. Additionally, we only consider deals with an acquisition percentage above 75%, resulting in a sample of 1235 deals from 1989 to 2019.

The key variable of interest is the Target Intangible Size, which we calculate as the sum of the target's On-BS and Off-BS intangible assets, taking log. To determine the unit price of a firm's intangibles, we assume, as in the model, the target's tangibles are valued at their book value, which is one dollar per unit. The unit price is then computed as

$$\text{Unit Price} = \frac{\text{Rank Value} + \text{Target's Liabilities} - \text{Target's Tangible Assets}}{\text{Target Intangible Size}},$$

where Rank Value equals Deal Rank Value[14] times the acquisition percentage.

Now index a deal by i, we run a similar regression as in the spending share alanlysis, with or without interaction terms $\mathcal{S}_{\text{target}(i),t}$:

$$\begin{aligned}\log \text{Unit Price}_{i,t} = {} & \beta_1 \cdot \log\Big(\text{Target Log Intan}_{i,t}\Big) + \gamma_1 \cdot \log\Big(\text{Target Log Intan}_{i,t}\Big) \times \mathcal{S}_{\text{target}(i),t} \\ & + \beta_2 \cdot \text{Target Scope}_{i,t} + \gamma_2 \cdot \text{Target Scope}_{i,t} \times \mathcal{S}_{\text{target}(i),t} \\ & + \ldots + \delta \cdot \mathcal{S}_{\text{target}(i),t} + \text{Fixed Effects.}\end{aligned}$$

As we have information on both the acquirer and the target in this regression, we control for both the acquirer's and target's scope, cash flow divided by asset, log leverage ratio, age, log sales, Tobin's Q, intangible asset share, and the acquirer's intangibles. The interaction regression also includes all interaction terms using the target's SIC 4-digit sector average intangible shares. Table 3 reports the results of two regressions, without and with interaction terms.

[14]Rank value is calculated by subtracting the value of any liabilities assumed in a transaction from the transaction value and by adding the target's net debt ($mil).

	Baseline	Interaction
	(1)	(2)
Target Log Intan	-0.179^{+}	-0.125
	(0.0937)	(0.281)
Target SIC4d Scope		-0.0833
		(0.0686)
Target Log Intan X Target SIC4d Scope		-0.0401^{+}
		(0.0229)
Controls	✓	✓
Subsector-Year FE	✓	✓
Within R^2	.453	.483
# Years	32	31
Dep. Var. Mean	.81	.64
Observations	1275	1003

Notes: Controls include acquirer's and target's scope, cash flow divided by asset, log leverage ratio, age, log sales, Tobin's Q, intangible asset share, and the acquirer's intangibles. Column (2) also include all interaction terms using the target's SIC 4d sector average intangible shares. The dependent variable is winsorized at 2.5th and 97.5th percentiles. SE clustered at the year level. Acquirer-Subsector-Target-Subsector-Year FE included. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Table 3: Regression: Target Unit Intangible Price

Column (1) shows a negative correlation between the unit price of intangibles and the log of Target Intangible Size. One concern is that there could be measurement errors in target intangible size. Since target intangible size is also used for constructing unit price in the denominator, this could introduce mechanical downward bias in the regression coefficient.

In Column (2), we include interactions with the target's sector's average intangible share. Consistent with Hypothesis 2, targets from sectors where intangibles are more scalable have faster decrease in the unit intangible price as the size of intangible increases.

Figure 9 visualizes the unit price over intangible size in the regression. The comparison between target sectors with high (red dots) and low (blue dots) scalability further corroborates Hypothesis 2.

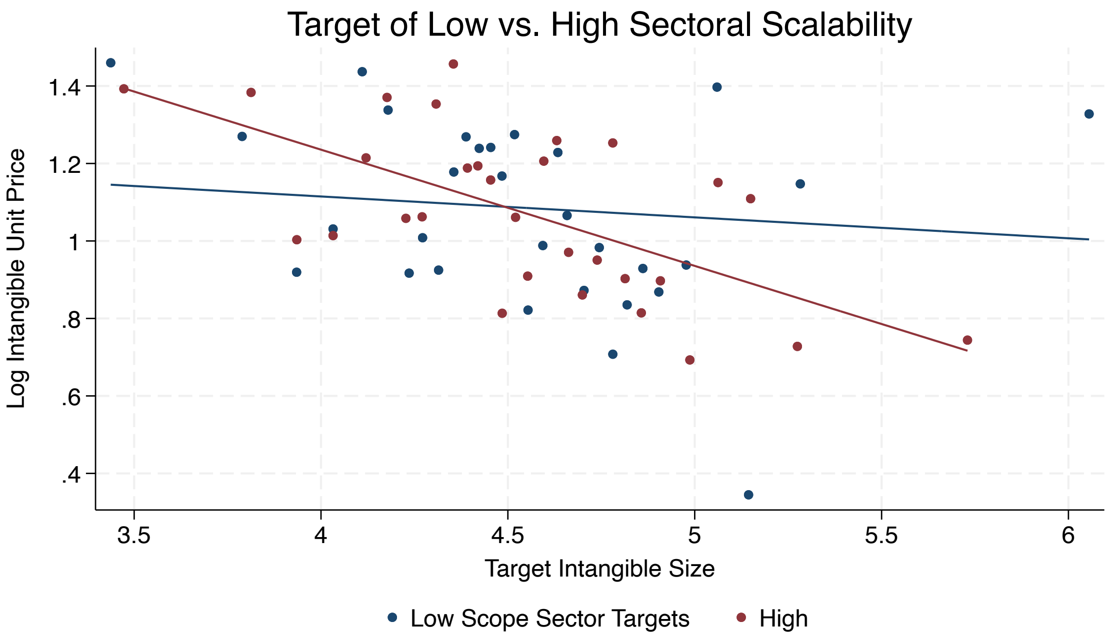


Figure 9: M&A Intangible Price Scheme: Target Sector with High vs. Low Scalability

5 Conclusion

In this paper, we have investigated the impact of intangible scalability on investment patterns across varying sizes of firms. By analyzing data from US public firms, we have identified notable patterns and demonstrated that a straightforward model can help explain these observations. Our proposed mechanism, which accounts for the somewhat counterintuitive patterns in R&D (and Organizational) intangible spending across the firm size distribution, offers an alternative perspective to the ongoing debate about large firms' potential negative impact on aggregate innovation. This perspective enriches the existing literature by highlighting the nuanced role of intangible assets in shaping corporate investment behavior.

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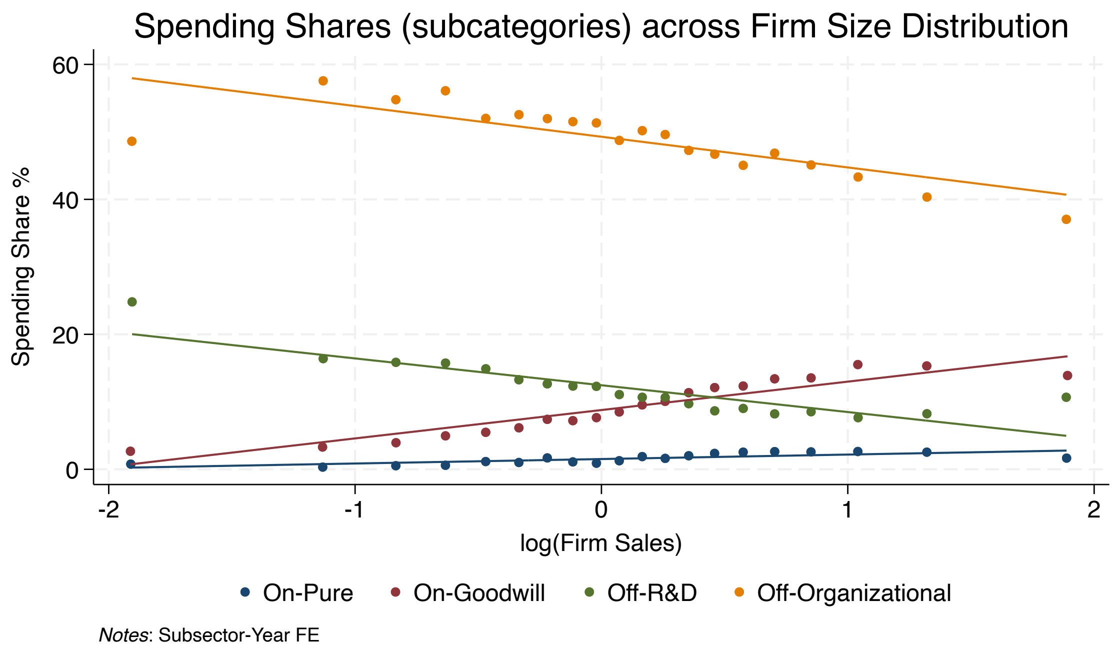
A Data Appendix

B Extra Facts

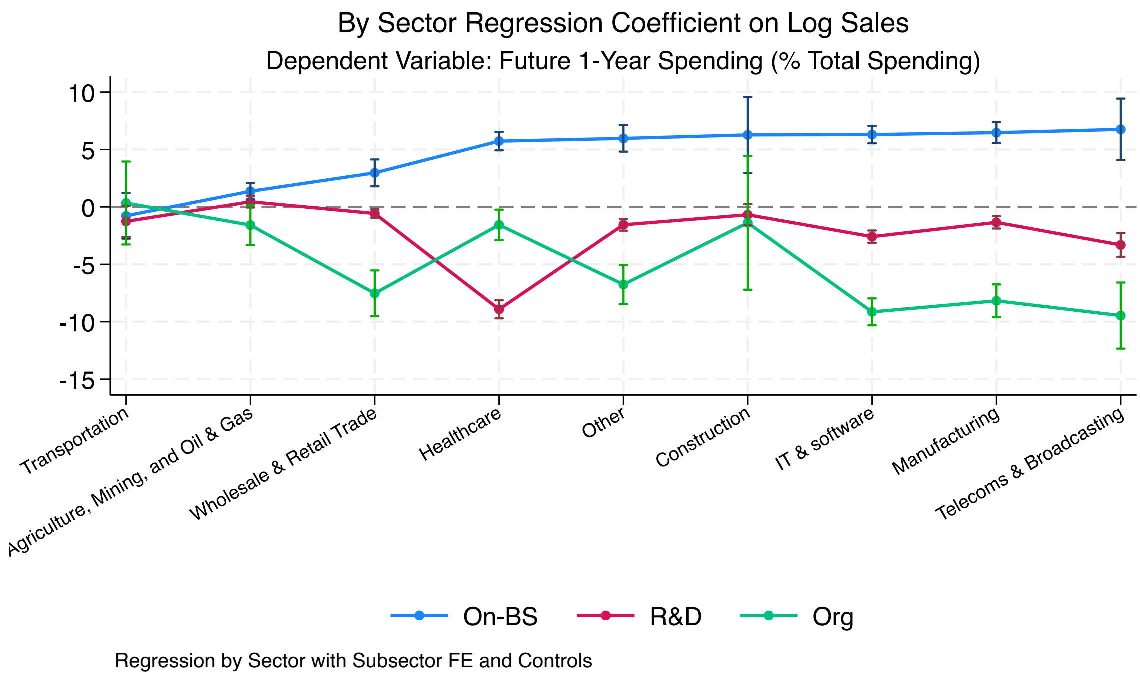


Appendix Figure A1: Cross-sectional Intangible Spending Shares: Subcategories

	Pure Acq	Goodwill	M&A	R&D	Org	Off-BS	Intangible	PPE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Sale (STD)	1.662**	6.766**	8.702**	-2.566**	-8.495**	-12.64**	-3.572**	3.572**
	(0.306)	(0.472)	(0.651)	(0.370)	(0.785)	(0.908)	(0.565)	(0.565)
Scope	-0.0594*	0.00231	-0.0836	0.304**	-0.381**	0.0164	-0.0489	0.0489
	(0.0277)	(0.0450)	(0.0620)	(0.0352)	(0.0785)	(0.0910)	(0.0512)	(0.0512)
Firm Age (Cap=50)	0.0476*	0.0202	0.0664+	0.0138	-0.200**	-0.149**	-0.0438	0.0438
	(0.0205)	(0.0215)	(0.0382)	(0.0168)	(0.0408)	(0.0464)	(0.0361)	(0.0361)
Log Leverage (STD, W)	-0.572*	-1.467**	-2.073**	-1.261**	4.520**	3.122**	1.512**	-1.512**
	(0.255)	(0.319)	(0.501)	(0.255)	(0.840)	(0.799)	(0.397)	(0.397)
F1_CF_Asset_w_s	-0.429	-2.560**	-3.307**	0.823**	2.842**	3.201**	-0.624	0.624
	(0.320)	(0.435)	(0.571)	(0.277)	(0.845)	(0.904)	(0.419)	(0.419)
Tobin's Q (STD, W)	1.307**	-0.0377	1.953**	1.478**	-7.220**	-5.833**	-3.649**	3.649**
	(0.262)	(0.358)	(0.497)	(0.223)	(0.558)	(0.622)	(0.516)	(0.516)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Subsector-Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Within R^2	.006	.033	.021	.03	.029	.031	.012	.012
# Years	31	31	31	31	31	31	31	31
Dep. Var. Mean	1.09	9.63	10.48	11.93	48.86	62.18	72.66	27.34
Observations	27290	27204	27403	28603	28467	28355	28317	28317

Notes: Controls include scope, log leverage ratio, cash flow to asset, firm age, log adjusted asset, and Tobin's Q. Samples are constraint to those whose ratio of On-BS intangibles to total adjusted asset is larger than 0.05. Dependent variables winsorized at 2.5th and 97.5th percentiles. SE doubly clustered at firm and year level. Subsector-Year FE included. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Appendix Table A1: Regression: Cross-sectional Intangible Spending Shares: Subcategories



Appendix Figure A2: By-sector Intangible Subcategory Spending Shares on Firm Sales: Regression Coefficient

C Proofs

Proof for Proposition 1 and Corollary 1

Proof. Next we show how the scalability of intangibles drive the effective within-product-line price of intangibles and thus the ratio of within-product-line intangibles to tangibles, and thus the total spending share of the two.

Denote the input aggregator as

$$\left((1-\zeta)^{\frac{1}{\sigma}} I(s)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}} K(s)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} = K(s)\left((1-\zeta)^{\frac{1}{\sigma}}\left(\frac{I(s)}{K(s)}\right)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \equiv K(s)A\left(r(s)\right),$$

where $r(s) = \frac{I(s)}{K(s)}$. Thus, the firm's problem can be written with choice variables being $K(s), r(s), x$:

$$V_z = \max_{x,K(s),r(s)} z^{1-\epsilon} x K(s)^{1-\epsilon} A(r(s))^{1-\epsilon} - K(s)x - I(s)x^{1-\rho} - \frac{F}{\omega}x^{\omega}.$$

Maximize over $K(s)$ and plug back into the objective function, it becomes

$$V_z = \max_{x,r} \bar{\epsilon} \left(\frac{Az}{x + x^{1-\rho} r} \right)^{\frac{1-\epsilon}{\epsilon}} x^{\frac{1}{\epsilon}} - \frac{F}{\omega} x^{\omega},$$

where $\bar{\epsilon} \equiv (1-\epsilon)^{\frac{1-\epsilon}{\epsilon}} - (1-\epsilon)^{\frac{1}{\epsilon}}$ is a positive constant.

Take the FOC w.r.t. r first,

$$A'(x + x^{1-\rho} r) = A x^{1-\rho}.$$

Note that $A'(r) = A(r) \frac{r(s)^{\frac{-1}{\sigma}}}{(1-\zeta)^{\frac{1}{\sigma}} r(s)^{\frac{\sigma-1}{\sigma}} + \zeta^{\frac{1}{\sigma}}}$, and thus the above FOC becomes $r = \frac{1-\zeta}{\zeta} x^{\sigma\rho}$. We denote r as a function of x

$$r = R(x) \equiv \frac{1-\zeta}{\zeta} x^{\sigma\rho}.$$

Take the FOC w.r.t. x next,

$$\bar{\epsilon} (Az)^{\frac{1-\epsilon}{\epsilon}} \left(1 + x^{-\rho} r\right)^{-\frac{1}{\epsilon}} \left(1 + \Lambda x^{-\rho} r\right) = F x^{\omega - 1},$$

where the constant $\Lambda = \frac{1}{\epsilon} - \frac{1-\epsilon}{\epsilon}(1-\rho) > 1$ for $\rho > 0$. Using this FOC, we can similarly define an implicit function of x that depends on r and z: $x = X(r; z)$.

With these two functions, the solution is a fixed point of x that depends on z:

$$x = X(R(x); z).$$

The total derivative of x wrt the exogenous firm characteristic z is thus

$$\frac{d\ln x}{d\ln z} = \frac{\frac{\partial \ln x}{\partial \ln z}}{1 - \frac{\partial \ln X}{\partial \ln r}\frac{\partial \ln R}{\partial \ln x}}.$$

Thus, we use the above two FOCs to get these partial derivatives. The FOC w.r.t. r gives

$$\frac{\partial \ln R}{\partial \ln x} = \sigma\rho.$$

Taking log of the FOC wrt x, and differentiate w.r.t. z and r respectively, taking the other as given, one can show

$$\left[\omega - 1 + \frac{\rho}{\epsilon}\frac{x^{-\rho}r}{1+x^{-\rho}r} - \rho\frac{\Lambda x^{-\rho}r}{1+\Lambda x^{-\rho}r}\right]\frac{\partial \ln X}{\partial \ln z} = \frac{1-\epsilon}{\epsilon},$$
$$\left[\omega - 1 - \frac{\rho}{\epsilon}\frac{x^{-\rho}r}{1+x^{-\rho}r} + \rho\frac{\Lambda x^{-\rho}r}{1+\Lambda x^{-\rho}r}\right]\frac{\partial \ln X}{\partial \ln r} = -\frac{x^{-\rho}r}{1+x^{-\rho}r}.$$

Thus, the total derivative of x is

$$\frac{d\ln x}{d\ln z} = \frac{\frac{1-\epsilon}{\epsilon}\left[\omega - 1 + \frac{\rho}{\epsilon}\frac{x^{-\rho}r}{1+x^{-\rho}r} - \rho\frac{\Lambda x^{-\rho}r}{1+\Lambda x^{-\rho}r}\right]^{-1}}{1 + \sigma\rho\frac{x^{-\rho}r}{1+x^{-\rho}r}\left[\omega - 1 - \frac{\rho}{\epsilon}\frac{x^{-\rho}r}{1+x^{-\rho}r} + \rho\frac{\Lambda x^{-\rho}r}{1+\Lambda x^{-\rho}r}\right]^{-1}}.$$

Denote $U \equiv \frac{x^{-\rho}r}{1+x^{-\rho}r}$. Note that

$$\frac{\rho}{\epsilon}\frac{x^{-\rho}r}{1+x^{-\rho}r} - \rho\frac{\Lambda x^{-\rho}r}{1+\Lambda x^{-\rho}r} = \frac{1-\epsilon}{\epsilon}\frac{\frac{1}{\epsilon}\rho U + 1 - \rho}{1 + \frac{1-\epsilon}{\epsilon}\rho U} > 0.$$

Since $\rho < 1$ and $U < 1$, we also have

$$\frac{1-\epsilon}{\epsilon}\frac{\frac{1}{\epsilon}\rho U + 1 - \rho}{1 + \frac{1-\epsilon}{\epsilon}\rho U} < \frac{1-\epsilon}{\epsilon}.$$

Thus, one sufficient condition for $\frac{d\ln x}{d\ln z} > 0$ is $\omega - 1 > \frac{1-\epsilon}{\epsilon}$ or $\omega > \frac{1}{\omega}$ and $\omega > 1$. In this case, a firm with higher z has larger scope x in equilibrium, which also means larger within-product-line intangible share r. With the substitution $\sigma > 1$, we have that more productive and thus and larger firms have large spending share on intangibles. To see this more clearly, one can show that

$$\frac{I}{I+K} = \frac{x^{-\rho}r}{1+x^{-\rho}r} = \frac{\left(\frac{1-\zeta}{\zeta}\right)^{\frac{1}{\sigma}} r^{\frac{\sigma-1}{\sigma}}}{1+\left(\frac{1-\zeta}{\zeta}\right)^{\frac{1}{\sigma}} r^{\frac{\sigma-1}{\sigma}}}.$$

Unit Intangible Price

The unit price of a firm's intangibles when it becomes a target is $P(z) \equiv G\frac{V(z)-K(z)}{I(z)}$, where we have

$$V(z) = S\frac{\bar{\epsilon}}{(1-\bar{\epsilon})^{\frac{1}{\epsilon}}}\left(1 - \frac{1}{\omega}\frac{1+\Lambda x^{-\rho}r}{1+x^{-\rho}r}\right),$$

$$K(z) = S(1-U),$$

$$I(z) = SU,$$

where $S \equiv \bar{\epsilon}\left(\frac{Az}{x+x^{1-\rho}r}\right)^{\frac{1-\epsilon}{\epsilon}} x^{\frac{1}{\epsilon}}$. Thus, plug these into $P(z)$, we have

$$G\frac{V(z)-K(z)}{I(z)} = G\left[\left(\frac{\epsilon}{1-\epsilon} - \frac{\Lambda}{\omega}\right) + \frac{\frac{\epsilon}{1-\epsilon}\left(1-\frac{1}{\omega}\right)-1}{x^{-\rho}r}\right].$$

When $\frac{\epsilon}{1-\epsilon}\left(1-\frac{1}{\omega}\right)-1 > 0$ or $\frac{1}{\omega} > 1 - \frac{1-\epsilon}{\epsilon}$, $P(z)$ is increasing in $x^{-\rho}r$, which is in turn decreasing in z.

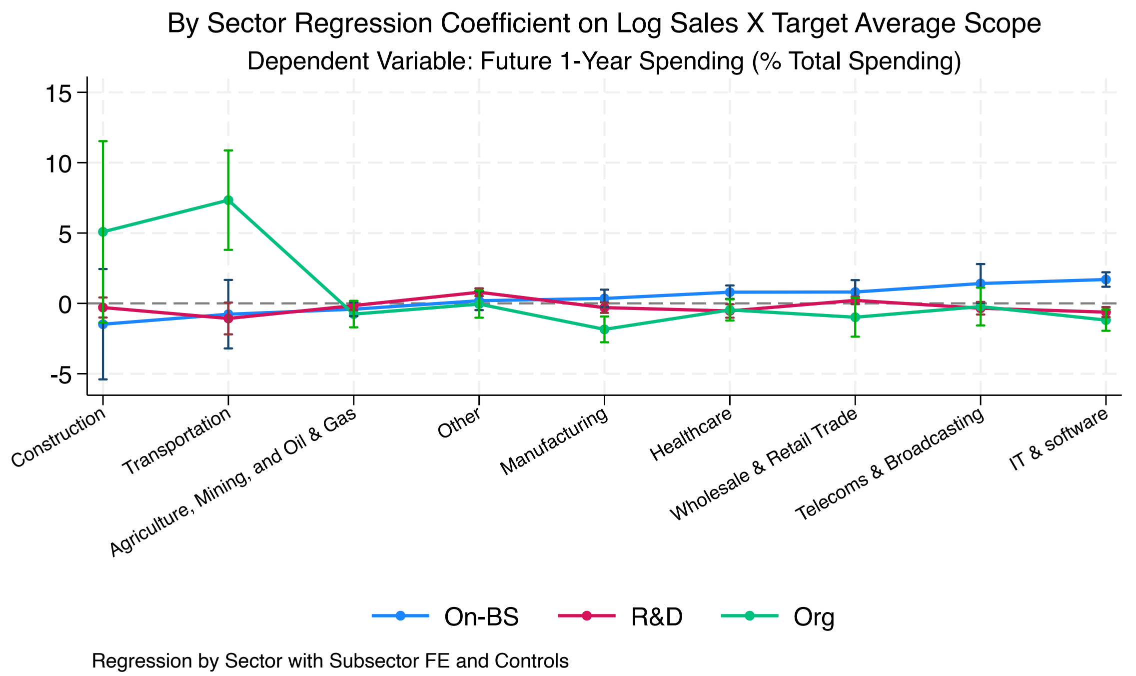
□

D Extra Regression Results

	Pure Acq	Goodwill	M&A	R&D	Org	Off-BS	Intangibles	PPE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Sale (STD)	-1.902$^+$	5.285**	5.085*	1.230	-4.468	-4.332	0.293	-0.293
	(1.118)	(1.694)	(2.210)	(1.307)	(3.200)	(3.298)	(2.067)	(2.067)
Log(Sale) × $\mathcal{S}_{s(i),t}$	0.499**	0.215	0.522$^+$	-0.522**	-0.562	-1.147*	-0.510$^+$	0.510$^+$
	(0.162)	(0.220)	(0.274)	(0.180)	(0.403)	(0.423)	(0.260)	(0.260)
$\mathcal{S}_{s(i),t}$	0.786	-1.118	0.00466	-0.981$^+$	-3.214$^+$	-4.209*	-4.343**	4.343**
	(0.541)	(0.709)	(1.131)	(0.542)	(1.586)	(1.720)	(1.155)	(1.155)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Subsector-Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Within R^2	.008	.036	.023	.034	.032	.034	.015	.015
# Years	31	31	31	31	31	31	31	31
Dep. Var. Mean	1.09	9.63	10.48	11.93	48.86	62.18	72.66	27.34
Observations	27290	27204	27403	28603	28467	28355	28317	28317

Notes: Controls include scope, log leverage ratio, cash flow to asset, firm age, log adjusted asset, and Tobin's Q. Samples are constraint to those whose ratio of On-BS intangibles to total adjusted asset is larger than 0.05. Dependent variables winsorized at 2.5th and 97.5th percentiles. SE doubly clustered at firm and year level. Subsector-Year FE included. $^+$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Appendix Table A2: Expanded Spending Shares over Firm Size Interacted with Target Sectoral Scalability



Appendix Figure A3: By-sector Intangible Spending Shares on Firm Sales × Target Scalability: Subcategories