Scalable Intangibles: To Buy or to Build?*

Anshu Chen† Jihong Song‡ Sifan Xue§

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

Abstract

This paper studies how firms invest in intangibles and explore the variations in investment patterns across the firm size distribution. We show that among US public firms, larger firms tend to acquire intangibles more through merger and acquisition (M&A) rather than in-house research and development (R&D). We propose that the scalability of intangibles, a defining characteristic, 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 hypotheses regarding firms' spending shares over M&A, R&D, and tangibles, as well as the price scheme of intangibles in M&A transactions. 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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†Department of Economics, Princeton University. Email: anshuc@princeton.edu.

‡Department of Economics, Princeton University. Email: jihongs@princeton.edu.

§Department of Economics and the International Economics Section, Princeton University. Email: sifanx@princeton.edu.

1 Introduction

In the United States today, investments in intangibles, as defined in national accounts, match the scale of investments in tangibles (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). 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 M&A and R&D 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 two datasets to test these hypotheses: data on US public firms from Compustat, and information on M&A deals derived by matching Refinitiv's M&A Standard with Compustat.

The first step in our analysis involves calculating spending shares on M&A and R&D for each firm. Intangible assets acquired through M&A are recorded on the firm's balance sheet, whereas R&D costs are recorded immediately as expenses, not appearing on the balance sheet. We follow the state-of-the-art methodology (Ewens et al. 2020) to estimate the capitalized R&D intangible assets. With these adjusted asset measures and corresponding spending shares, we find that the proportion of

[1] 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.

spending on M&A significantly increases, while that on R&D decreases strongly, as the firm size (measured by sales) grows. When examining the combined spending on M&A and R&D — the total intangible investment — we observe a positive correlation with the size of the firm.

We show that the divergence in spending shares between M&A and R&D not only exists across different firm sizes but also strengthens over time. We segment our firms into different size categories and analyze the time series of their average spending and asset shares in M&A, R&D, 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%. In contrast, the gap in R&D asset shares between large and small firms is negative, growing from around -5% to -10%.

The increasingly important role of M&A in intangible investments, especially for large firms, has 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 and R&D 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.

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 R&D. We show that more productive firms, under realistic parameters, will select a larger scope and have larger sales. Due to the scalability of intangibles, this larger scope results in a lower effective cost for intangible investments. Consequently, a higher productivity level correlates with an increased spending share on intangibles. When these firms become targets in the M&A market due to their intangible assets, a direct corollary under certain assumptions from the model, reflecting the increasing intangible spending share, is that the unit price of their intangibles decreases as the quantity of intangibles increases for a given firm. 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.

Second, when firms in our model have two ways to acquire intangibles: through in-house R&D 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 R&D and are seen as potential targets, those with access to both R&D and M&A options are thought of as acquirers. The more productive acquirers have even larger incentives to choose larger scopes due to intangible scalability, and thus tend to spend even more in total intangibles. However, their spending on R&D and M&A are further affected by the unit price of acquired intangibles, which decreases as the quantity of purchased intangibles increases. Consequently, when R&D and M&A intangibles are sufficiently substitutable, more productive firms might counterintuitively reduce their spending shares on R&D, despite the scalability of R&D intangibles.

We develop hypotheses from our stylized model and test them empirically. Our model predicts that the divergent spending patterns on M&A and R&D are more pronounced when intangibles play a more important role in a firm's production function. To test this, we calculate the average share of intangible assets for each firm's sector, and interact it with firm size. Our empirical analysis using Compustat data reveals that regression coefficients of firm size interacted with sector-specific intangible asset shares are positive for M&A spending shares and negative for R&D spending shares. This result emphasizes the significant impact of intangibles in dictating cross-sectional spending patterns, rather than other underlying factors.

We next look at the set of M&A deals where both the acquirer and target are public firms with information in Compustat. This allows us to calculate the unit price of the target firm's intangible assets that are subject to acquisition. We show a strong decreasing unit price scheme of these acquired intangibles. Furthermore, consistent with a hypothesis from our model, we observe that when the target firm is from a sector where intangibles are more crucial, the pricing scheme starts at a lower level, but exhibits a less steep decline.

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 serves to motivate our empirical tests, highlighting the role of intangibles and how their scalability can lead to counterintuitive findings regarding a firm's spending shares. We test our model hypotheses 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 complementarities (Rhodeskropf and Robinson 2008). 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

[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 (2022).

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. 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); Cunningham et al. (2021); Grullon et al. (2019) 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 spending shares on M&A, R&D 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: R&D and M&A

We categorize firm assets into three components: R&D, M&A and others, with the first two classified as intangibles. R&D investments, under accounting standards, are expensed in the year they occur and do not add to the firm's balance sheet capital. We construct capitalized R&D assets following the methodology of Ewens et al. (2020)).[4] We replace missing and negative R&D values with zero.

On the other hand, intangible assets acquired through M&A are recorded on firms' balance sheets. 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.

We classify other assets as tangibles, which include total property costs, equipment costs or other tangible assets (PPE), along with capitalized organizational capital.[5] We opt for not including organizational capital as intangibles due to the ambi-

[4] 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.

[5] Organizational spending (or SG&A: Selling, General, and Administrative expenses), like R&D, is not initially capitalized, so we construct its capitalized value following Ewens et al. (2020).

guity in determining what proportion of this spending is analogous to scalable R&D intangibles (such as spending that enhances the value of a brand) versus operational costs that scale with firm size. Moreover, literature estimates suggest that less than one-third of SG&A expenses should be capitalized, aligning them more closely with tangible assets from an economic standpoint.

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 (AT_ADJ_AVG) by adding capitalized R&D and Organizational capital to the firm's total assets (AT) and averaging this over the current year and previous year. Firm size is measured using the standardized log of sales. We winsorize these variables at the 2.5% and 97.5% percentiles, and drop observations with negative total spending. We sometimes refer to the R&D intangibles Off-BS (Off-Balance Sheet), and M&A intangibles as On-BS (On-Balance Sheet).

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] to control for the impacts of financial constraints 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.

[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).

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 other control variables including each firm's cash flow, leverage ratio, Tobin's Q, and firm age. We observe that as firm size, measured by sales, increases, the spending share on M&A rises from less than 10% to almost 30%, while spending on R&D correspondingly decreases, resulting in a net increase in total intangible spending. Given that the average spending ratios on R&D and M&A are similar, and larger firms conduct more M&A, M&A actually accounts for a larger share of firm investments in intangibles.

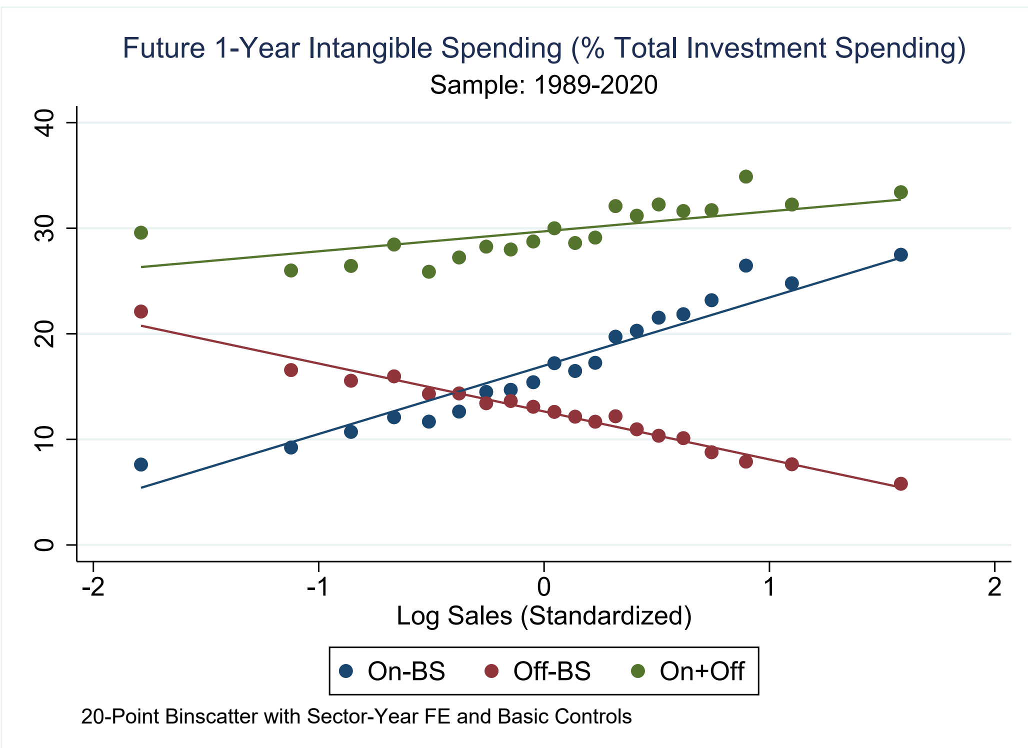

Figure 1: Cross-section Intangible Spending Shares

Figure 2 examines these spending shares over time. We categorize firms into small, medium, and large based on their annual sales, and calculate the mean spending share for M&A, R&D, and the total. Over time, as intangibles become more and more important in production, the gaps in spending shares on M&A and R&D between large and small firms widen. Mirroring the cross-sectional pattern, larger firms progressively spend more on M&A compared to smaller firms, while the reverse is true for R&D.

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 assets between large and small firms enlarges from about -5% to -10%.

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.

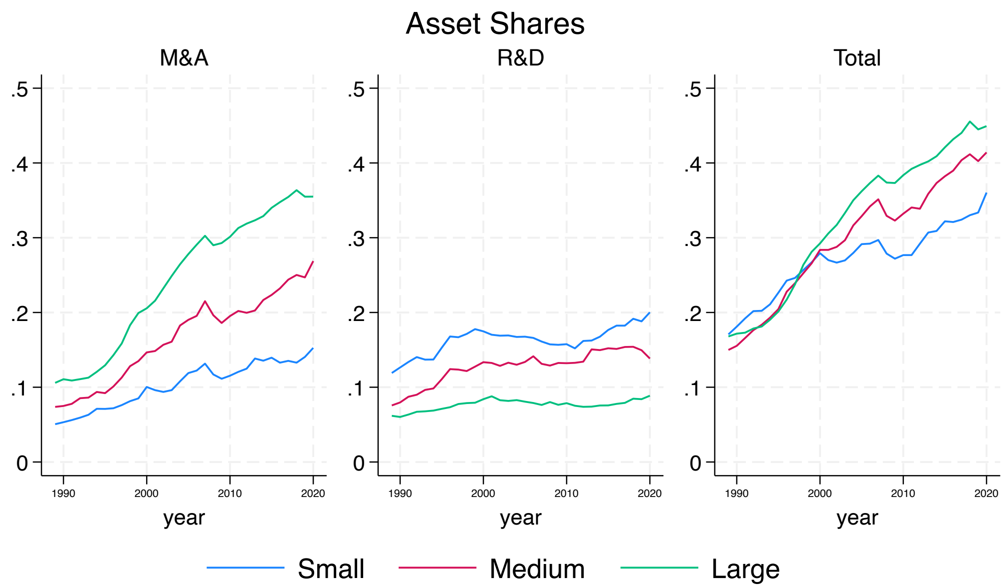

Figure 3: Over-time Intangible Asset Shares across Firm Size Groups

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 R&D and uses tangible assets. The second type, in addition, has the option to make M&A. We consider the first type as potential targets and the second type as acquirers. All firms solve a static problem, maximizing their equity value by choosing optimal R&D (and M&A 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 ζ captures the importance of tangibles in the production function.

Each product produced by the firm is sold in a monopolistic competitive market, facing a demand function[8]

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

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 scaled across multiple product 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,

[8] 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.

like tangibles, are limited to one product line. When $\rho \to 1$, intangibles become fully scalable with $N(s) = N$.

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 assumed to incur a linear cost.[9]

3.2 Building Intangibles

In this section, we study a firm's spending decisions in tangibles and R&D, excluding 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 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]

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

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.

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

[10] Using symmetry across product lines, we have

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

Now, consider when firms can optimally select their scope. We assume that a firm also incurs a fixed cost of operating that depends on its scope $\frac{F}{\omega}x^{\omega}$.[11] The firm's problem then becomes:

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

Taking the first order condition w.r.t. both $K(s)$ and $I(s)$, we derive

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

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 substitutes, higher productivity firms show an increasing spending share on intangibles as the within-product-line input ratio increases. The within-product-line quantity share, in turn, depends on the prices of the two inputs, given the CES aggregation function. Intuitively, given the scalable nature of intangibles, the effective price of within-product-line intangibles decreases as firm scope gets larger, leading to the following proposition.

Proposition 1. *Under reasonable parameter values and when tangibles and intangibles are substitutes, higher productivity firms have larger scopes and greater spending*

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

shares on intangibles, i.e.,

$$\frac{I(z)}{I(z)+K(z)}$$

is increasing in z.

Proof. See Appendix B. $\square$

Proposition 1 also implies that spending on intangibles I grows faster than firm value V as productivity increases. This leads to a corollary regarding the market price of a firm's intangibles.

Corollary 1. *In a set of firms optimizing their scope, tangibles, and intangibles, and acting as targets in an M&A market without market power in price bargaining, the unit price of a firm's intangibles, denoted by $P(I)$, is decreasing in its productivity.*

In the next section, we will demonstrate how this effect on intangible unit prices drives spending patterns for acquirers.

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 $P(I)$ 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. This can be conceptualized as the acquirers adjusting their optimal tangible assets based on the tangible and intangible assets of the target. Given that tangible assets can be bought and sold in the market at a constant unit price, it effectively means that acquirers are primarily purchasing the target's intangibles.

The option to acquire intangibles through M&A impacts the spending behavior of acquirer firms in two ways. First, a decreasing price scheme for M&A makes the total intangibles, N, even cheaper for a firm with larger scope, when productivity z increases. Thus, the M&A option reinforces the increasing spending share on intangibles. Second, 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 even result in a decrease in R&D spending as a proportion of total expenditures.

The following examples show the spending shares of the three inputs, solving numerically for the acquirer firms' problem with both M&A and R&D options across productivity levels. We set $\epsilon = 0.5, \zeta = 0.5, \sigma = 2, F = 1, \omega = 3, \eta = 0.5$, and vary ν, which governs the elasticity between acquired and built intangibles. Figure 4 shows the spending shares for two scenarios: $\nu = 2$ or $\nu = 6$.

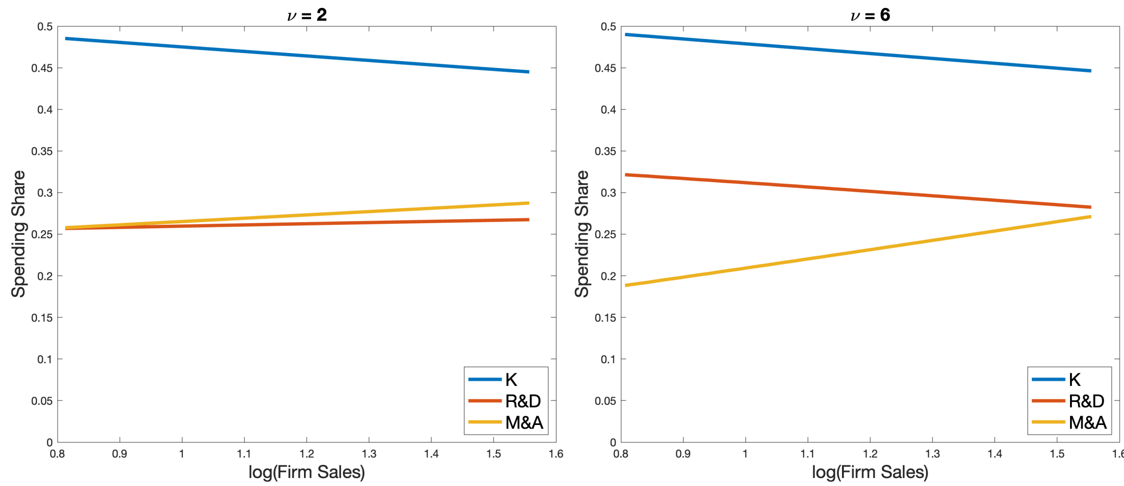

Figure 4: Spending Shares: Low vs. High Substitutability between M&A and R&D

When $\nu = 2$, the scalability effect that boosts R&D spending shares outweighs the substitutability effect that reduces them. Conversely, when $\nu = 6$, the impact of substitutability between R&D and M&A is more pronounced, leading to reduced R&D spending shares. We will show later that empirical patterns in firms' spending behaviors align more closely with the latter scenario.

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.*

Next, we perform numerical comparative statics with respect to ζ, the parameter that determines the input share between tangibles and intangibles in production.

Our objective is to understand how changes in ζ, which directly relates to the importance of intangibles in production, affect spending shares and other cross-sectional variables, forming hypotheses for empirical testing. We think of these comparisons as representing different sets of firms, potentially in different industries, when the importance of intangibles for production differs.

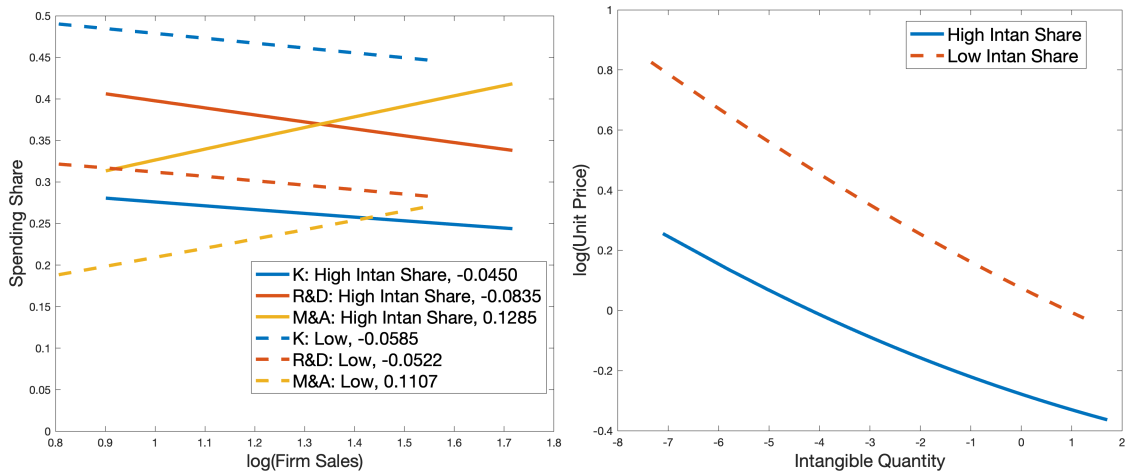

Figure 5: Spending Shares and Price Scheme: Low vs. High Intangible Shares

The left plot in Figure 5 compares the spending shares on K, R&D, and M&A across firm sizes for two different groups of firms. One group (dashed lines) has a production technology with $\zeta = 0.5$, while the other (solid lines) has $\zeta = 0.3$, indicating a greater reliance on intangibles. The plot also highlights the slopes of these spending share curves. When intangibles are more critical for production (lower ζ), the spending share on M&A exhibits a stronger increase with firm productivity (the solid yellow line has a steeper slope of 0.1285 compared to the dashed line's 0.1107). Conversely, the spending share on R&D declines more sharply with firm productivity when intangibles are more important.

Hypothesis 2. *For two sets of acquirer firms with differing reliance on intangibles in their production function, a higher importance of intangibles (lower ζ) leads to* *a more pronounced increase in M&A spending share and a steeper decline in R&D spending share as firm productivity grows.*

These comparative statics are based on a fixed target price scheme. The right plot in Figure 5 illustrates how varying the importance of intangibles for target firms (limited to R&D) affects price schemes. The solid line represents the price scheme for target firms with a greater dependency on intangibles. We empirically test this hypothesis using a dataset of M&A deals that allows us to measure the unit price of intangibles.

Hypothesis 3. *For target firms where intangibles are more significant in production, the unit price of their intangibles is lower and decreases less steeply with increasing firm productivity.*

4 Regression Analysis

4.1 Spending Shares Cross-sectionally and Over-time

We first conduct regression analyses to put numbers on our stylized facts earlier, which corresponds to our Hypothesis 1. Our focus is particularly on the spending patterns of acquirers who engage in both R&D and M&A, as outlined in our Hypothesis 1. To accurately capture this group, we narrow our sample to include only firms with a significant share of acquired intangibles. Specifically, we consider firms whose on-balance-sheet intangible asset share exceeds 10% of their adjusted total assets.

Table 1 reports our baseline findings. An increase of one standard deviation in log sales results in a 4.7% rise in the spending share on M&A and a 3.5% decrease in R&D spending share. The effect on total intangible spending is positive at around 1.7%. Given that larger firms tend to spend more on PPE in the data, the coefficient for PPE spending is also positive. Correspondingly, larger sales are associated with reduced spending shares on organizational capital.

	M&A	R&D	All Intan	PPE
	(1)	(2)	(3)	(4)
Log Sale (STD)	4.703**	-3.460**	1.658*	3.731**
	(0.582)	(0.348)	(0.617)	(0.554)
Log Leverage (STD)	-0.994**	-3.586**	-4.964**	-0.0266
	(0.260)	(0.338)	(0.405)	(0.305)
Cash Flow (STD)	-2.002**	-0.415	-2.218**	1.888**
	(0.375)	(0.251)	(0.425)	(0.377)
Firm Age (Cap=50)	0.165**	-0.0891**	0.0853*	0.187**
	(0.0309)	(0.0187)	(0.0344)	(0.0393)
Tobin's Q (STD)	1.344**	2.053**	3.703**	4.368**
	(0.325)	(0.230)	(0.451)	(0.556)
Subsector-Year FE	✓	✓	✓	✓
Within R^2	.011	.048	.014	.016
# Years	31	31	31	31
Dep. Var. Mean	8.38	13.19	20.81	25.03
Observations	57075	57075	57075	57075

Notes: The dependent variables are the forward 1-year spending shares for M&A, R&D, the sum of M&A and R&D, and PPE. The remaining of spending is Organizational capital spending. We constrain the sample to be those with on-balance-sheet intangible quantity share being higher than 10% over the adjusted total assets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1: Spending Shares over Firm Size

Unsurprisingly, firms with higher leverage ratios tend to invest less in intangible assets, and cash flows negatively impact M&A spending. These observations highlight the potential influence of financial constraints on firms'investment decisions. Firms also increase their M&A spending shares and reduce their R&D spending shares as they age. Finally, a higher Tobin's Q correlates with increased investments across all categories. These patterns illustrate why it is important to control for those variables in our analyses.

Figure 6 plots the regression coefficients of M&A and R&D spending shares on standardized Log Sales over time. With the growing importance of intangibles in the modern economy, these coefficients have become increasingly divergent.

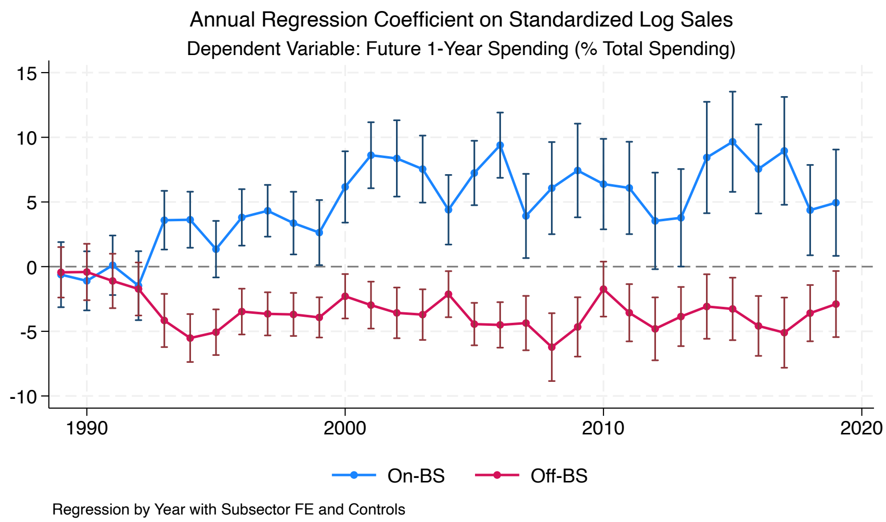

Figure 6: Spending Shares Regression Coefficients Over Time

4.2 Spending Shares Across Sectors of Varying Intangible Importance

We now focus on our Hypothesis 2, examining how critical intangibles are in influencing differential spending patterns across sectors. To this end, we compare sectors based on the role intangibles play in production. Figure 7 plots the regression coefficients of M&A and R&D spending shares on standardized Log Sales across different sectors. Note that the sectors in this analysis are more aggregated than those in our regression analyses.

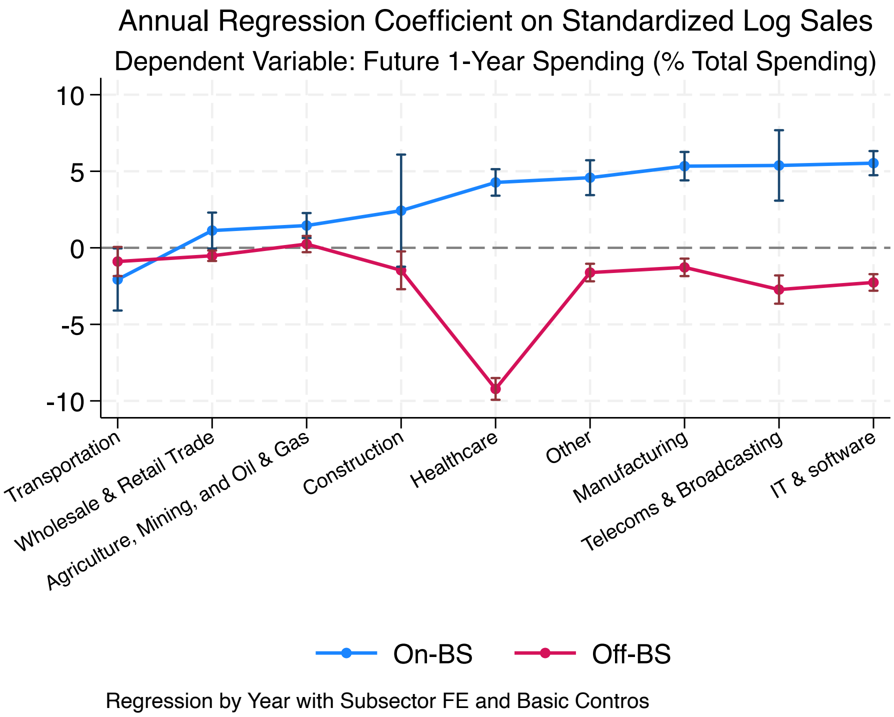

Figure 7: Spending Shares Regression Coefficients Over Sector

Sectors showing the most pronounced divergence in spending shares on M&A and R&D include IT & Software, Telecoms & Broadcasting, Manufacturing, Healthcare, and Other. Conversely, sectors like Transportation, Wholesale & Retail Trade, and Agriculture, Mining, and Oil & Gas exhibit minimal variation in these spending shares relative to firm size. 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, where intangibles are of different importance.

Next, we compute the average share of intangible assets over total adjusted assets for each sector and year, labeled as IntanShare-SBY. This measure is used as an interaction term to empirically test whether Hypothesis 2 holds true.

	M&A	R&D	All Intan	PPE
	(1)	(2)	(3)	(4)
Log Sale (STD)	1.195	4.428**	6.837**	2.056
	(1.351)	(0.784)	(1.594)	(1.516)
Log(Sale)_s × IntanShare-SBY	17.39**	-38.17**	-24.61**	7.906
	(5.593)	(4.256)	(7.339)	(7.011)
Subsector-Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Within R^2	.012	.06	.016	.017
# Years	31	31	31	31
Dep. Var. Mean	8.38	13.19	20.81	25.03
Observations	57075	57075	57075	57075

Notes: The dependent variables are the forward 1-year spending shares for M&A, R&D, the sum of M&A and R&D, and PPE. The remaining of spending is Organizational capital spending. We constrain the sample to be those with on-balance-sheet intangible quantity share being higher than 10% over the adjusted total assets. Control variables and their interactions with IntanShare-SBY are included in all regressions. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Spending Shares over Firm Size Interacted with Sectoral Intangible Share

Column (1) and (2) of Table 2 show that in sector-years where intangibles are more crucial to production, 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 sectors show a weaker positive correlation between total intangible spending share and firm size. These findings align with the predictions of Hypothesis 2.

4.3 Pricing Scheme across Target Sectors of Varying Intangible Importance

We now examine the last hypothesis of our model's central predictions, which underscores the role of intangible scalability in influencing M&A spending shares across firms—specifically, the decreasing unit price of intangibles as the target's quantity of intangibles increases (Hypothesis 3).

To test this hypothesis, we use detailed M&A deal data from Refinitiv's M&A Standard, merged with firm-level information from Compustat. Refinitiv's M&A Standard offers comprehensive global coverage of over 1.2 million M&A deals.[12] This dataset includes deals from 1980 onward for US targets and from 1985 for non-US targets.

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-book intangibles and capitalized R&D intangible assets, taking log. To determine the unit price of a firm's intangibles, we assume 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[13] times the acquisition percentage.

Table 3 reports the results of two regressions. Both regressions control for the acquirer's log of sales and cash flows (one year before the deal), ages of both the acquirer and target, and fixed effects including the acquirer's sector, the target's sector, and year.

[12]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.

[13]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).

	(1)	(2)
Target Intangible Size	-0.443**	-0.561**
	(0.0264)	(0.0396)
Target IntanShare-SBY		-4.658*
		(2.191)
Target Intangible Size X IntanShare-SBY		0.779**
		(0.252)
Acq, Target, Year FE	✓	✓
Within R^2	.357	.372
Dep. Var. Mean	.76	.76
Observations	1235	1235

Notes: The dependent variables are the forward 1-year spending shares for M&A, R&D, the sum of M&A and R&D, and PPE. The remaining of spending is Organizational capital spending. We constrain the sample to be those with on-balance-sheet intangible quantity share being higher than 10% over the adjusted total assets. Control variables and their interactions with IntanShare-SBY are included in all regressions. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Target Unit Intangible Price

Column (1) shows a strong 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 3, targets from sectors where intangibles are more crucial exhibit lower initial price levels, and the decrease in price relative to firm size is less steep.

Figure 8 visualizes the unit price scheme from matched deals. The comparison between target sectors with high (red dots) and low (blue dots) mean intangible shares further corroborates Hypothesis 3.

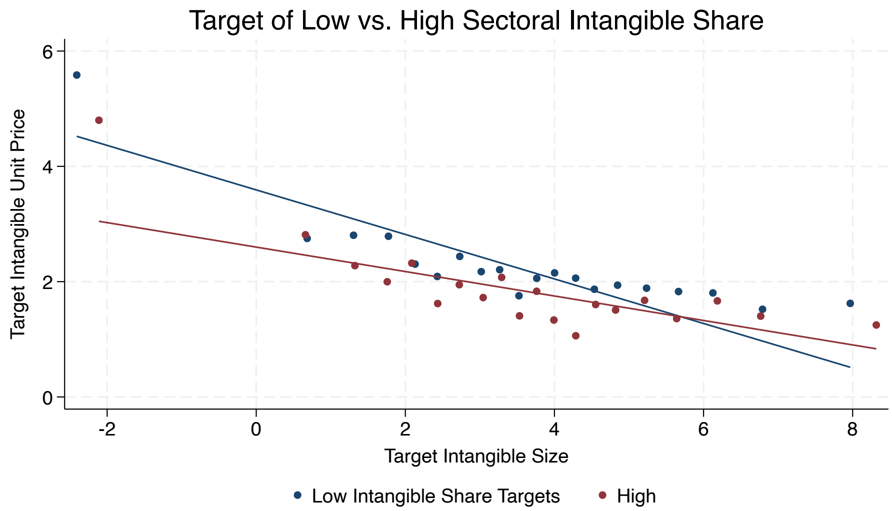

Figure 8: M&A Intangible Price Scheme: Target Sector with High vs. Low Intangible Shares

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 trends in R&D spending across the firm size distribution, offers an alternative perspective to the ongoing debate about large firms' potential negative impact on overall 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 Appendix One

B Proofs

Proof for Proposition 1

Proof. Next we show how the scalability of intangbiles 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 $K(s), r(s), x$:

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

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

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

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

Take the FOC wrt 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 wrt 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 wrt r gives

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

Taking log of the FOC wrt x, and differentiate wrt 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

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

One can show that under reasonable restrictions of the parameters (e.g., $\omega > \Lambda$ and $\frac{1-\epsilon}{\epsilon}(1-\rho)\rho < 1$ will be sufficient), this total derivative is positive. Thus, a firm with higher z has larger scope x in equilibrium, which also means larger within-product-line intangbile 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

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

The unit price of a firm's intangibles when it becomes a target is

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

Note that this ratio $\frac{V}{I}$ is also the effective unit price of a firm's intangbile I if it is sold at its firm value. In other words, a larger firm with larger share of intangibles is also priced less per unit of its intangibles. Once we know r, x for given z, we can also solve for the total R&D intangible for this firm, which equals

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

Thus, when such firms become targets to be acquired, the exogenous productivity maps into x, r, which maps into the quantity of intangibles I, which has a corresponding price scheme that we denote as $P(I)$, which is a decreasing function.

$\square$