Revisiting Tobin's Q: Integrating Intangible Capital into the Neoclassical Framework

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Abstract

This paper seeks to replicate and extend the seminal work of Peters and Taylor (2017) on the relationship between intangible capital and the investment q ratios. Our study spans 1975 to 2021, investigating dynamics in firms' physical and intangible investments. We examine data from 1975 to 2021. Our analysis reveals significant variability in both intangible and physical capital among the sampled firms. Due to measurement errors affecting the reliability of slopes, we rely on the R-squared (R^2) statistic as our primary analytical tool. We highlight the superior reliability and stability of total q compared to the conventional q ratio, with total q, which includes intangible capital, substantially enhancing the explanatory power (R^2) when assessing various investment metrics. As such, we observe a substantial increase in R^2 values when transitioning from physical to intangible investment, further underscoring the importance of intangible assets in firms' capital allocation strategies. Across all industries and examined time periods, our findings consistently demonstrate the superiority of total q, enhancing its utility for assessing investment opportunities. Overall, our research underscores the growing importance of intangible assets in firms' capital allocation strategies.

Keywords: *Intangible capital, Tobin's Q, Organizational capital, Investment, R&D*

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“Take all the physical assets owned by all the companies in the S&P 500, all the cars and office buildings and factories and merchandise, then sell them all at cost in one giant sale, and they would generate a net sum that doesn’t even come out to 20% of the index’s $28 trillion value. Much of what’s left comes from things you can’t see or count: algorithms and brands and lists. This is, in the broadest sense, a new phenomenon. Back in 1985, for instance, before Silicon Valley came to dominate the ranks of America’s biggest companies, tangible assets tended to be closer to half the market’s value" - Bloomberg News October 2020 [1]

1. Introduction

In this section, we provide a concise overview of prior literature on intangible capital and its relationship with the investment-q ratio, encompassing both tangible and intangible assets. We outline key concepts, such as the investment-q ratio and intangible capital, emphasizing the latter’s importance in investment dynamics. We also introduce a theoretical framework that elucidates the connection between the investment-q ratio and intangible capital. Our conceptual framework is presented alongside our research questions to provide context for our study.

1.1. Intangibles are Eating the World

In the fast-evolving landscape of modern business, intangible assets have emerged and been acknowledged as the silent architects of business success. In stark contrast to tangible assets, intangible assets defy conventional sensory perception, yet their impact on organizational outcomes is profound and widely acknowledged within the realms of business leadership and industry practice. Despite their non-physical nature, these assets possess substantial intrinsic value and occupy a central role in determining the success and competitive positioning of organizations, as affirmed in scholarly discourse (Kogan and Papanikolaou, 2019). Some commonly referenced examples of intangible capital are goodwill, brand recognition, and intellectual property like patents, trade-

[1] https://www.bloomberg.com/news/articles/2020-10-21/epic-s-p-500-rally-is-powered-by-assets-you-can-t-see-or-touch

marks, and copyrights. The concept of intangible capital extends to various dimensions within an organization, contributing to its overall value and competitiveness which include::

- **Human Capital**: Human capital encompasses the skills, competencies, and experiences of employees and managers within an organization. It plays a crucial role in driving the organization's productivity and success (Mamun et al., 2021).
- **Relationship Capital**: Relationship capital involves the external connections and relationships that are vital to an organization's operations. This includes interactions with customers, partners, suppliers, financing institutions, and outsourcing partners. The organization's brand and reputation are integral components of relationship capital.
- **Structural Capital**: Structural capital refers to the supportive infrastructure and systems that enable an organization to function efficiently and effectively. It encompasses the processes, technologies, and knowledge management systems that underpin an organization's operations (Aramburu and Sáenz, 2011).
- **Strategic Capital**: Strategic capital represents the intellectual assets and knowledge that inform an organization's strategic decisions and long-term planning. This includes proprietary methodologies, market insights, and strategic thinking.
- **Network Capital**: Given the increasing importance of inter connectivity and collaboration in modern business environments, organizations are placing greater emphasis on what can be termed as "network capital." Network capital acknowledges the significance of networking organization structures, where an organization's success is intricately tied to its ability to foster and leverage external relationships and networks (Huda, 2019).

In short, intangible capital encompasses a wide range of non-physical assets and resources that are critical to an organization's value, competitiveness, and long-term success. Recognizing and effectively managing these forms of capital is essential for modern organizations striving to thrive in an increasingly knowledge-driven and interconnected world.

The amount of intangible assets has risen in the past few decades as software companies "eat the world" [2] and as the global economies shift towards being more tech and service-based. Significantly,

[2] https://future.a16z.com/software-is-eating-the-world/

of the total capital of a firm, Corrado and Hulten (2010) estimate that intangibles constitute 34% of this and, as of 2009, Corrado et al. (2009b) estimated that businesses were spending around $1 trillion on intangibles per year, which is just as much as they were spending on tangible assets. Fig 1.1 from Mauboussin and Callahan (2020) showcases this rise of intangible investments in the economy. This transformation underscores the critical role of intangible assets in today's business landscape, emphasizing their influence on investment decisions and firm performance.

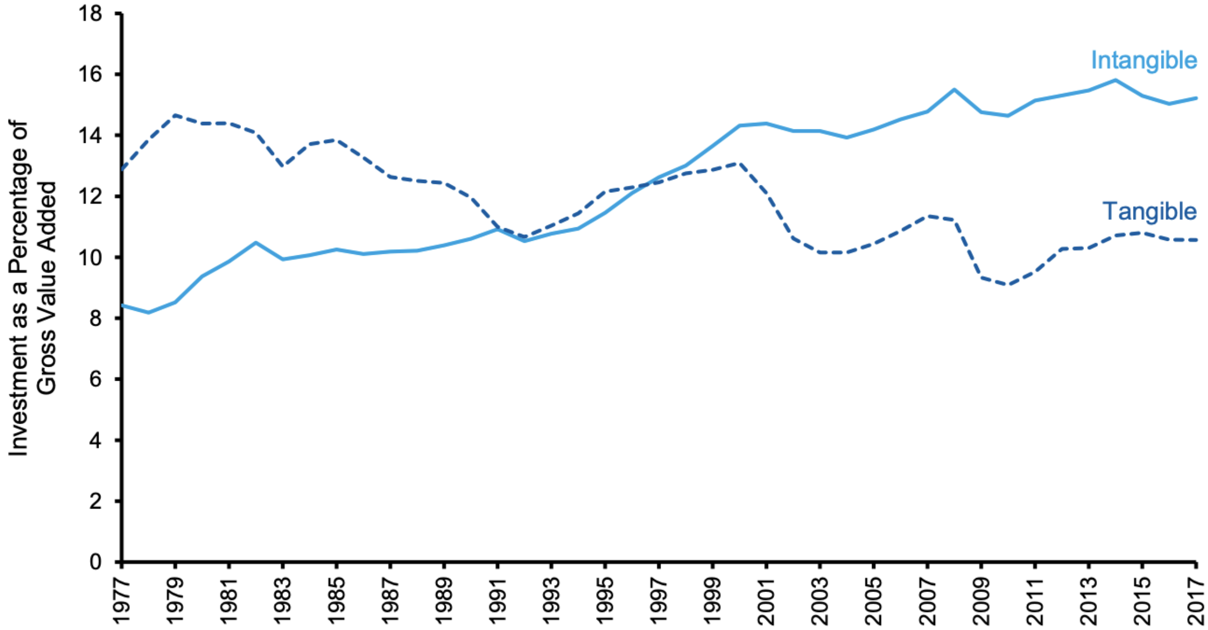

Fig. 1. The Rise of Intangible Investments in the US, 1977-2017

A more detailed examination of specific components of intangible capital, such as human capital, research and development (R&D), and patents, further emphasizes their significance. Human capital embodies the economic value derived from employees' extensive tenure within organisations (Flores et al., 2020). This encompasses a broad spectrum of factors, including their educational backgrounds, specialized training, intellectual prowess, and a plethora of unique skills. Employees, often regarded as an organization's most vital resource, bring forth not only their qualifications but also their accumulated experiences, intuitive problem-solving abilities, and unwavering loyalty. Their contributions are, therefore, irreplaceable, fostering a culture of innovation and adaptability. In contrast, research and development (R&D) represents a pivotal step in an organization's journey toward new product development and service innovation. The costs incurred during R&D endeavors are typically recorded in financial statements only when they culminate in successful outcomes; otherwise, they are relegated to the category of sunk costs (Vieira et al., 2018). Embracing R&D as an integral part of their strategic vision, organizations position themselves on the path to future innovation and sustained competitive advantage. It is worth noting that R&D investments are synonymous with forward-looking organizations striving to stay ahead in rapidly evolving markets. Research and development (R&D) is the primary step an organisation incorporates when it plans to develop a new product or introduce a new service. The research and development costs are added to the company's financial statements only when they are successful. In other cases, they are treated as sunk costs and are not capitalised (Vieira et al., 2018). R&D is considered a step towards the future and all the organisations investing in this area are more likely to achieve competitive advantage. Patents are the exclusive rights attained by organisations once they invent something new. The innovation's technical information is disclosed to the public in the patent application so that no other competitor can use this to make a similar product or service (Daliu et al., 2018).

In summary, intangible capital, composed of various critical dimensions, has become indispensable for organizations in strategic positioning, fostering innovation, and safeguarding intellectual assets in the competitive landscape of today. The growing prominence of intangible assets underscores their substantial influence on investment decisions and firm performance.

1.2. Intangible Capital and Tobin's Q

The classic q-theory of investment developed by Hayashi (1982) predicts that a firm's rate of investment is given by the ratio of the firm's market value to its replacement cost. The reasoning here is that a firm should invest in new assets whose Tobin's q is more than 1 meaning that the market's valuation of the assets exceeds their replacement value (Tobin, 1969). This theory has been arguably the most common element of corporate finance that elaborates the firm's value as well and has become increasingly important in financial circles because of its *"intuitive appeal, simplicity, and sound theoretical underpinnings"* (Erickson and Whited, 2000).

The neoclassical investment theory primarily focused on physical investments, partly because tangible assets dominated corporate balance sheets when the theory originated. Intangible capital received comparatively less attention mostly due to measurement challenges (Erickson and Whited, 2000; Peters and Taylor, 2017). Back in the 1980s, tangible assets prevailed. However, the 1990s witnessed a significant transformation, with intangible assets surpassing tangible ones in prevalence and importance, a shift that persists today (Rappaport and Mauboussin, 2021). This can be seen in Fig 1.1. The enduring nature of this transformative shift underscores the pressing need for a comprehensive reevaluation of prevailing investment theories. It is imperative to adjust and realign these theories to adequately incorporate intangible capital. Therefore, a fundamental shift in our conceptualization and modeling of investment dynamics is essential. It is in this context that the traditional neoclassical investment theory finds itself at a crossroads, necessitating adaptation to the changing realities of the modern business world. As such, this re-calibration is not merely a matter of theoretical adjustment; it reflects a compelling imperative to align investment theories with the dynamics of a rapidly evolving economic environment, where intangible assets have become the linchpin of value creation.

One salient reason for the notable omission of intangible capital in prior studies is rooted in the prevailing accounting regulations, which predominantly categorize most Research and Development (R&D) and Sales, General, and Administrative (SG&A) expenditures as operational or capital expenses. As such, these expenditures invariably traverse the income statement as expenses and seldom find their place on the balance sheet as capitalized assets. Moreover, despite the fact that SG&A is a significant component of costs in knowledge-intensive firms, it is not broken down into its constituent items other than R&D and advertising (Enache and Srivastava, 2018). Amending accounting rules to incorporate intangibles has generated concerning the delineation of what ought to be included and what should remain excluded from the ambit of intangible capital (Thum-Thysen et al., 2017).

The omission of intangible assets, while not justifiable, can be comprehended in light of the gradual acknowledgment within the finance domain of the significance of software companies with substantial investments in intangible assets, as observed by Microsoft Founder Bill Gates: [3]

It took time for the investment world to embrace companies built on intangible assets.

[3] https://www.linkedin.com/pulse/enough-people-paying-attention-global-economic-trend-bill-gates/

When we were preparing to take Microsoft public in 1986, I felt like I was explaining something completely foreign to people. Our pitch involved a different way of looking at assets than our option holders were used to. They couldn't imagine what returns we would generate over the long term. The idea today that anyone would need to be pitched on why software is a legitimate investment is laughable, but a lot has changed since 1986. It's time the way we think about the economy does, too.

Several researchers have presented empirical evidence demonstrating the influence of intangible capital on Tobin's Q. Corrado et al. (2009b) contends that if investments in intangible assets, despite reducing present cash flows, are aimed at enhancing future profitability, they should be classified as investments. In the same vein, Belo et al. (2014) incorporate brand value, as indicated by advertising expenditures, into their investigation of the impact of intangible assets on market value and corporate risk. Additionally, both Kogan and Papanikolaou (2019) and Huda (2019) demonstrate that the inclusion of intangible capital within an organization's capital structure contributes to an enhanced Tobin's Q.

Peters and Taylor (2017) took a step forward by introducing intangible capital into Tobin's q. They call the new metric Total q. It signifies the ratio of a firm's market value to the combined replacement costs of its physical and intangible assets. Their research demonstrates that this innovative measure offers a more comprehensive assessment of a firm's investment prospects, indicating that the traditional neoclassical investment theory remains applicable, if not more so, in an era where intangible assets play an increasingly significant role. Consequently, the classic q theory exhibits superior performance in periods and among companies characterized by substantial intangible capital. Li et al. (2014) took this metric a step further and applied it to the cross-section of returns. They show that the q-theory which includes tangible capital explains cross-sectional stock returns significantly better than the q-theory with only tangible assets. Interestingly, Park (2019) show that an intangible-adjusted book-to-market ratio where they capitalise previously expensed expenditures that were used to develop intangibles internally while excluding goodwill, is a better explainer of cross-sectional variations on stock returns than the original ratio.

In summary, adding intangible capital into the mix seems to strengthen the investment-q relationship. Recognizing the increasing significance of intangible assets in the last few decades, it is crucial to incorporate them as a vital aspect when assessing investment opportunities. This comprehensive approach ensures that investment strategies align effectively with the contemporary economic landscape, ultimately facilitating more informed and robust investment decisions.

1.2.1. Accounting and the Measurement of Intangible Capital

There are differences in how U.S. accounting standards and global accounting standards address the measurement and presentation of intangible capital. We begin with U.S. accounting standards as these are the focal point of our research since the data we will use is U.S. data. In examining, the U.S standards governing intangible capital, nuanced distinctions emerge based on the genesis of these assets, whether they arise from internal development or external acquisition. This categorization significantly influences the treatment of intangible assets, thereby exerting a profound impact on their presentation within financial statements:

- *Internally developed intangibles:* When companies internally create intangible assets, for instance through research and development, software development, or patent creation, they are typically recorded as expenses on the income statement. These assets are not included as tangible assets on the balance sheet, except in rare exceptions.
- *Externally acquired intangibles:* When firms acquire intangible assets externally, for instance through corporate acquisitions, they are capitalized on the balance sheet under the category Intangible Assets, which includes Goodwill and Other Intangible Assets. The classification within this category depends on whether the asset is separately identifiable. Assets with clear identities like patents or software are categorized as Other Intangible Assets, while less distinct assets like human capital are labeled as Goodwill.
- *Impairment recognition:* Firms need to promptly recognize impairments of intangible assets. In the event of asset impairment, companies must reduce the asset's book value, ensuring that financial statements accurately reflect its diminished value.

In short, U.S. accounting practices for intangible capital hinge on asset origin, shaping their reporting in financial statements: internally developed intangibles are expensed, while externally acquired ones are capitalized, with impairment recognition essential for accurate financial reporting.

On the other hand for International Financial Accounting Standards, the relevant standard in handling intangibles is IAS 38, adopted in 2001. The handling of intangible assets in financial reporting exhibits some notable differences between U.S. Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS). One significant divergence lies in the treatment of research and development (R&D) costs. Under U.S. GAAP, these costs are generally expensed as incurred, with limited capitalization opportunities. In contrast, IFRS allows for the capitalization of qualifying development costs, resulting in more intangible assets being recognized on the balance sheet.

Additionally, IFRS provides comprehensive criteria for the recognition of internally generated intangible assets, leading to a potentially broader range of assets being acknowledged compared to U.S. GAAP. Another pivotal distinction pertains to the measurement and impairment testing of intangible assets. While both frameworks allow for the initial measurement of intangibles at cost, U.S. GAAP and IFRS diverge in subsequent treatment. U.S. GAAP mandates specific amortization methods and impairment testing criteria, while IFRS offers more flexibility in choosing amortization methods and requires regular impairment testing for both finite and indefinite-life intangibles.

In short, these differences emphasize the importance of understanding and applying the appropriate accounting standards, as they can significantly impact the financial statements and disclosures of entities reporting under U.S. GAAP or IFRS.

1.3. The Neoclassical Theory of Investment

This section explores the assumptions and limitations of the theory presented in Peters and Taylor (2017) which posits that the concept of total q can play a crucial role in explaining both physical and intangible investments, as well as the overall investment when these are adjusted by the firm's total capital. Additionally, it sheds light on how investment regressions can help identify the convex component (referred to as λ) of capital adjustment costs. The theory posits that incorporating intangible capital into the analysis can result in more accurate investment regressions and improved estimates of adjustment costs.

1.3.1. *Model Formulation and Limitations*

In this section, we present the concepts outlined in the model developed by Peters and Taylor (2017) as a foundation for our discussion. The model focuses on a competitive firm that manages both physical and intangible capital to maximize its overall value through investment decisions while accounting for capital depreciation. Specifically, it introduces Firm i, which operates as a perfectly competitive entity with perpetual existence, possessing two distinct types of capital at time t: physical capital denoted as K_{it}^{phy} and intangible capital denoted as K_{it}^{int}. The firm's total capital, K^{tot}, is computed as the sum of these two components, where $K^{tot} = K_{it}^{phy} + K_{it}^{int}$.

At each time period t, the firm must make investment choices for both its physical and intangible capital, referred to as I^{phy} and I^{int}, respectively. The primary objective is to maximize the firm's value, denoted as V_{it},:

$$V_{it} = \max_{I_{i,t+s}^{phy}, I_{i,t+s}^{int}} \int_0^\infty E_t[\Pi \left(K_{i,t+s}^{tot}, \epsilon_{i,t+s}\right) - c_i^{phy} \left(I_{i,t+s}^{phy}, K_{i,t+s}^{tot}, pI_{i,t+s}^{phy}\right) - c_i^{int} \left(I_{i,t+s}^{int}, K_{i,t+s}^{tot}, pI_{i,t+s}^{int}\right)] e^{-rs} ds, \tag{1}$$

subject to the dynamic evolution of capital, given by:

$$dK^m = (I^m - \delta K^m)dt, \quad m = \text{phy}, \ \text{int}. \tag{2}$$

Both types of capital experience depreciation at the same rate, denoted as δ. The profit function Π depends on a shock variable ϵ and is assumed to be linearly homogeneous with respect to K^{tot}. Additionally, the two investment cost functions, c, are defined as:

$$c_i^m \left(I^m, K^{tot}, p^m\right) = p^m I^m + K^{tot} \left[\xi_i^m \frac{I^m}{K^{tot}} + \frac{\gamma_i^m}{2} \left(\frac{I^m}{K^{tot}}\right)^2\right], \quad m = \text{phy}, \ \text{int}, \tag{3}$$

where $\gamma_i > 0$. The first term of the equation signifies the immediate expenses associated with acquiring or disposing of investments. This cost is incurred for each unit of capital and is quantified at a rate of p^m. The second term reflects the expenditure linked to the modification of the capital stock pertaining to type m.

Capital prices, p_{it}^{phy} and p_{it}^{int}, as well as the profitability shock ϵ_{it}, fluctuate over time according to a general stochastic diffusion process:

$$dy_{it} = \mu(y_{it})dt + \sum(y_{it})dB_{it}, \tag{4}$$

where $y_{it} = \begin{bmatrix}\epsilon_{it} & p_{it}^{phy} & p_{it}^{int}\end{bmatrix}'$.

The model makes the following predictions:

Prediction 1. *Marginal q equals average q, the ratio of firm value to its total capital stock*

This means that:

$$\frac{\partial V_{it}}{\partial K_{it}^{phy}} = \frac{\partial V_{it}}{\partial K_{it}^{int}} = \frac{\partial V_{it}}{\partial K_{it}^{tot}} = \frac{V_{it}}{K_{it}^{tot}} = q^{tot}\left(\epsilon_{it}, p_{it}^{phy}, p_{it}^{int}\right) \tag{5}$$

Marginal ($\frac{\partial V}{\partial K}$) measures the benefits of adding one unit of physical or intangible capital and it equals average q due to assumptions like constant returns, perfect competition, and substitutes. This justifies using Tobin's q as q^{tot}, which is given by firm value divided by K^{tot}, the sum of physical and intangible capital and which is dependent on shocks ϵ and the two capital prices.

Prediction 2. *Optimal investment rates vary with total q*

Therefore,:

$$l_{it}^{phy} = \frac{I_{it}^{phy}}{K_{it}^{tot}} = \frac{1}{\gamma_i^{phy}}\left(q_{it}^{tot} - \xi_i^{phy} - p_{it}^{phy}\right) \tag{6}$$

$$c = \frac{I_{it}^{int}}{K_{it}^{tot}} = \frac{1}{\gamma_i^{int}}\left(q_{it}^{tot} - \xi_i^{int} - p_{it}^{int}\right) \tag{7}$$

Prediction 2 suggests that the rates of investment in tangible and intangible assets, when adjusted for the total capital, change in response to variations in q^{tot}. This means that investment rates (physical and intangible) adjust with total capital (q^{tot}), showing a correlation. However, imperfections may arise due to differing adjustment-cost parameters and price variations (p_{it}^{phy} and p_{it}^{int}) among firms and over time.

Prediction 3, stemming from Prediction 2, forms the foundation of our empirical investigation and revolves around a group of firms indexed by i. We assume constant values for parameters γ^{phy}

and γ_{int} across firms, while other parameters and shocks are subject to variation. We break down the capital prices p_{it}^{m} into $p_i^m + p_t^m$.

Prediction 3. *Total q explains all three investment measures in panel regressions*

In OLS panel regressions, when we regress l_{it}^{int} on q_{it}^{tot} with firm and time fixed effects (FEs), the q coefficient is $\frac{1}{\gamma^{phy}}$. If we switch to l_{it}^{int} as the dependent variable, the q coefficient becomes $\frac{1}{\gamma_i^{int}}$. If it's l_{it}^{tot}, the q coefficient becomes $\frac{1}{\gamma^{phy}} + \frac{1}{\gamma^{int}}$. The inclusion of additional variables like free cash flow should not have a substantial impact on these regressions.

Prediction 3 affirms that total q accounts for all three investment measures and that OLS slopes reveal the adjustment-cost parameters γ. Firm and year fixed effects are essential to address the terms $\xi_i - p_{it}$ in equations (6) and (7).

For Prediction 4, we establish $q_{it} = V_{it}/K_{it}^{phy}$ and $l_{it} = I_{it}^{phy}/K_{it}^{phy}$. When conducting an OLS panel regression of i_{it} on q_{it} while accounting for firm and time fixed effects, the resulting slope coefficient provides an underestimated estimate of $1/\gamma^{phy}$. Additionally, R^2 exhibits a lower magnitude in comparison to the regression outcomes presented in Prediction 3.

Prediction 4. *Regression using only physical capital as a scaling factor produces biased results.*

The theory indicates that this regression is flawed because the ratio $-K_{it}^{tot}/K_{it}^{phy}$ contributes to the regression's disturbance and cannot be explained by the FEs. The q-slope is biased downward, leading to overestimations of the adjustment-cost parameter γ^{phy} since q_{it}^{*} depends on the $K_{it}^{tot}/K_{it}^{phy}$ ratio, causing the regressor to have a negative correlation with the disturbance. In the end, because we were unable to remove the bais from the slopes of our regressions as has been hoped for in Prediction 3, we were unable to use the slopes in our analysis.

To gauge its empirical relevance, they introduced Prediction 5 as a consistency check by linking a firm's use of intangible capital to its adjustment costs and q-slopes, assuming that physical and intangible capital share the same linear adjustment cost parameters and purchase prices. By imposing the assumptions that physical and intangible capital share identical linear adjustment cost parameters ($\xi_i^{phy} = \xi_i^{int}$) and acquisition prices ($p_i^{phy} = p_i^{int}$), we can deduce the following:

$$\lim_{t\to\infty} \frac{K_{it}^{int}}{K_{it}^{tot}} = \frac{\gamma^{phy}}{\gamma^{phy} + \gamma^{int}} = \frac{\beta^{int}}{\beta^{int} + \beta^{phy}}, \tag{8}$$

where β^{int} and β^{phy} represent the slopes from Prediction 3 for I^{int} and I^{phy}, respectively, concerning q^{tot}.

Prediction 5. *If intangible capital is costlier to adjust ($\gamma^{int} > \gamma^{phy}$), firms will hold relatively less intangible capital.*

Prediction 5 is supposed to be examined in Sub-section 3.4 by comparing the ratio of regression slopes across firms with varying intangible capital.

1.3.2. Model Discussions

The conceptual foundation of the theory hinges on the idea that spending on intangible assets can be classified as a form of capital investment, given that it involves sacrificing current cash flows to augment future cash flows. Empirical support for this notion is derived from various sources, including the work of Corrado et al. (2009a), which underscores the impact of intangible investments on firms' future profits.

The theoretical underpinning of this framework centers on the premise that expenditures directed toward intangible assets can be categorized as a type of capital investment. This categorization is based on the principle that such expenditures entail the sacrifice of current cash flows in order to enhance future cash flows. Substantiating this concept, empirical evidence is drawn from diverse sources, one of which is the research conducted by Corrado et al. (2009a). Their work underscores the significant influence of intangible investments on the future profitability of firms. Furthermore, a substantial body of research, including studies such as Lev and Sougiannis (1996), highlights the positive effect of R&D investments on firms' future profitability a concept that has been acknowledged by institutions like the Bureau of Economic Analysis (BEA).

In the early 1990s, the Bureau of Economic Analysis (BEA) embarked on research about the treatment of R&D in economic accounts which led to a significant change in 2013 and 2014 when BEA reclassified R&D spending as investments rather than current expenses (Crawford et al., 2014). This reclassification was a pivotal moment in the field of economic accounting, as it recognized the intrinsic value of R&D activities in shaping a firm's future prospects. By acknowledging R&D as an investment, the BEA effectively acknowledged its role in generating future revenue streams and enhancing a company's competitive edge. This shift in perspective not only reflected the evolving nature of modern businesses but also aligned economic accounting practices with the economic reality of the 21st century. Furthermore, Eisfeldt and Papanikolaou (2013) demonstrate that firms that invest more in organizational capital exhibit increased productivity, even after accounting for physical capital and labor.

This theory also addresses the issue of risk in investments, emphasizing that while investments like employee training and brand-building may carry relatively lower risk, endeavors such as R&D projects are associated with higher risks and the potential for failure. As such, the inclusion of intangible capital in the neoclassical framework is justified, as it can effectively accommodate investments with uncertain payoffs. It also acknowledges the existence of depreciation risk in both tangible and intangible assets, noting that the true depreciation rate is likely random for both categories which in essence highlights that there is no fundamental conceptual difference between the depreciation risk of physical and intangible capital.

Peters and Taylor (2017) points out a common practice in empirical research where investments are measured as CAPX and capital as PP&E, despite the conceptual differences among physical assets. Similarly, the theory combines various types of intangible assets into K^{int} and assumes that a firm's profits depend on K^{tot} which encompasses both physical and intangible capital. While this approach treats all assets as substitutes in profit generation, it acknowledges the possibility of different adjustment costs associated with each type of asset therefore initially treating intangible capital similarly to physical capital, as has been the tradition, may be a practical approach.

In summary, the theory presented here serves as a comprehensive framework that addresses the role of total q in understanding various forms of investments, highlights the significance of intangible capital, and offers insights into the limitations of investment regressions in identifying adjustment costs. It underscores the practicality of integrating intangible capital into the neoclassical framework and challenges the assumption of perfect substitution between physical and intangible assets in empirical research. Ultimately, the theory provides a valuable tool for understanding investment dynamics and their relationship with firm performance.

1.4. The Theoretical Framework

In the classical q theory, Tobin's q, as originally formulated by Hayashi (1982), stands as a fundamental metric that encapsulates an organization's investment opportunities. Tobin's q is a key concept in finance and economics, representing the ratio of the market value of a company's capital to its replacement cost. This ratio provides a concise and insightful summary of a firm's investment prospects, serving as a yardstick for decision-making. Over time, Tobin's q has evolved into a pivotal element in the field of corporate finance. It not only sheds light on investment opportunities but also plays a significant role in determining the intrinsic value of a firm (Erickson and Whited, 2012). This dual function of Tobin's q has made it a valuable tool for both investors and financial analysts, guiding them in assessing a company's potential for growth and profitability. It's worth noting that the classical q theory was initially developed in an era when organizations were predominantly characterized by their physical assets. Consequently, much of the subsequent research in this area has focused on physical capital. However, as the business landscape has evolved, encompassing a broader spectrum of intangible assets and intellectual property, the relevance and applicability of Tobin's q have extended beyond physical assets to encompass intangible investments as well. This expansion reflects the changing nature of modern businesses and the need for a comprehensive framework to assess their investment opportunities.

In the intervening years, both the United States and the global economy have experienced profound transformations, reshaping the very nature of economic activity. These shifts have seen a substantial transition from traditional industries to service-oriented and technology-driven sectors. The backbone of these modern sectors is intangible capital, a diverse category encompassing a wide range of assets, such as innovative products, human capital, brand recognition, patents, and software. The importance of intangible capital in today's economic landscape cannot be overstated. Studies, such as the work by Corrado and Hulten (2010), have estimated that intangible capital now constitutes a substantial portion, approximately 34%, of an organization's total capital. Nakamura (2010) demonstrated the essential role of intangible assets in the U.S. economy, highlighting the annual growth of intangible investments from 4% of the GDP in 1977 to around 10% in 2006. These underscore the pivotal role played by intangible assets in driving economic growth, innovation, and competitiveness on a global scale. However, despite the undeniable and growing significance of intangible capital, empirical examinations of the classical q theory have historically tended to overlook this crucial component. The traditional focus of research within the framework of the classical q theory has predominantly revolved around physical assets, leaving the role and impact of intangible assets relatively understudied. This omission represents a notable gap in our understanding of modern firms' investment decisions and their assessment of capital allocation strategies. Recognizing and addressing this gap in empirical research is paramount in the contemporary economic landscape. Incorporating intangible capital into the analysis of Tobin's q theory is not only an academic imperative but also a practical necessity. It allows us to gain a more comprehensive and accurate understanding of how organizations evaluate their investment opportunities.

We assess the impact of intangible capital on the investment-q relationship, an inquiry of particular relevance within the field of corporate finance. The primary research query central to this investigation revolves around the proposition: *"To what extent does the inclusion of intangible capital augment and refine the investment-q relationship?"*. Our research is firmly grounded in the work of Peters and Taylor (2017), and we aim not only to replicate their findings but also to extend and build upon them. By doing so, we seek to contribute valuable insights to the existing body of knowledge in corporate finance and provide a more comprehensive understanding of the intricate dynamics that govern firms' investment decisions in a rapidly evolving economic landscape. In essence, our study serves as a bridge between the traditional notions of capital and the modern realities of intangible assets, shedding light on how these assets influence the investment-q relationship and, in turn, impact the strategic decisions made by organizations in today's dynamic and knowledge-driven economy.

2. Data and Methodology

In this section, we examine the data and define some key measures.

2.1. Data

The research methodology adopted in this study is rooted in quantitative analysis, a strategic choice that aligns seamlessly with the intrinsic nature of the research inquiry. To investigate the core objectives of this research, we employ panel regression analysis, leveraging the computational capabilities of the R programming language. This analytical framework stands as the central pillar of our data analysis strategy. We build upon the methodological foundation laid by Peters and Taylor (2017).

The dataset that forms the nucleus of our analysis is comprehensive, encompassing all firms in the Compustat database. However, to ensure the precision and relevance of our investigation, we have judiciously implemented specific exclusion criteria. Firms falling within the purview of regulated utilities, demarcated by Standard Industrial Classification (SIC) Codes 4900-4999, as well as those operating in the financial sector under SIC Codes 6000-6999, have been deliberately excluded from our dataset. Furthermore, entities categorized under the domains of public service, international affairs, or non-operating establishments, defined by SIC Codes 9000 and above, have been purposefully omitted from our analysis. As in established conventions within the academic literature, additional refinement of our sample has been undertaken. Firms lacking complete data records or exhibiting non-positive book values of assets or sales have been meticulously filtered out. Moreover, a stringent threshold has been set, excluding those firms with physical capital holdings below the threshold of $5 million. These methodical exclusions ensure that our dataset adheres to the highest standards of data integrity and is attuned to the specific objectives of our study.

In contrast to the analytical framework employed by Peters and Taylor (2017), whose study drew upon data pertaining exclusively to publicly traded U.S. firms during the period spanning from 1975 to 2011, our research extends the temporal horizon of investigation through to 2021. Extending the dataset's temporal scope allows us to comprehensively analyze evolving intangible capital trends over an extended period, enhancing our understanding. While we incorporate historical data preceding the pivotal year of 1975 into our dataset, it is essential to note that this early historical information is not utilized in our regression analyses. However, for the empirical estimations and hypothesis testing that form the core of our research objectives, we focus exclusively on the data from 1975 onwards. The year 1975 holds particular significance in our study, as it marks the pivotal point when the Financial Accounting Standards Board (FASB) instituted the mandatory reporting of Research and Development (R&D) expenditures by firms. By starting our sample from this watershed year, we align our research with a period characterized by more standardized and comprehensive financial disclosures, which enhances the reliability and comparability of our dataset. Finally, in pursuit of analytical robustness, to enhance the robustness of our analysis, we apply a 1% winsorization to all regression variables to mitigate the potential influence of outliers within our data. Outliers, while occasionally informative, can also exert undue influence on regression results, potentially distorting the validity of our findings.

Our literature review noted that the investment-q relation tends to have a significant influence on intangible capital, that intangible capital provides firms with the opportunity to increase their capital productivity and growth, and that the investment-q relationship represents the value of the firm as well. There are many studies conducted on identifying the impact of intangible capital on firm value and Tobin's Q. Based on those studies, the current study evaluates whether the investment-q relation is strengthened by the presence of intangible capital in firms.

In summary, our methodological choices, such as expanding the dataset's time frame, handling pre-1975 data thoughtfully, complying with FASB reporting regulations, and applying winsorization, bolster the rigor and credibility of our analysis, establishing our research as a robust exploration of intangible capital dynamics in the broader economic context.

2.2. Tobin's Q

We begin with defining Tobin's q. The traditional Tobin's q as employed in established studies like Erickson and Whited (2012), among others is given by:

$$q^*_{it} = \frac{V_{it}}{K^{phy}_{it}}, \tag{9}$$

where the replacement cost of physical capital (K^{phy}) is measured by the book value of Plant, Property, and Equipment (Compustat item *ppegt*) and the market value of the firm (V) is given by the market value of equity (Compustat items $prcc\_f$ times *csho*) plus the book value of debt (Compustat items *dltt* + *dlc*) minus the firm's current assets (Compustat item *act*), which is the sum of cash, inventory, and marketable securities.

We also define the new Tobin's q which is referred to as Total q. Total q (q^{tot}) is measured by the value of the firm divided by the sum of physical and intangible capital as given by:

$$q_{it}^{tot} = \frac{V_{it}}{K_{it}^{phy} + K_{it}^{int}}. \tag{10}$$

The replacement cost of intangible capital (K^{int}) is defined in Section 2.3. We find that the correlation between q^* and q^{tot} is 0.73. Compare this to the correlation of 0.82 that Peters and Taylor (2017) get.

2.3. *Measuring Intangible Capital*

This sub-section defines the key measures.

2.3.1. *Intangible Capital*

We now define our measures. The replacement cost of intangible capital (K^{int}) is given by the sum of the firm's externally purchased (intangible assets from the balance sheet) and internally created intangible capital. We start with the externally purchased intangible capital which is measured by the total Intangible Assets from the balance sheet (Compustat item *intan*). This value is set to zero when missing. We will exclude goodwill from the intangible assets where this is present as Park (2019) shows that excluding it does not affect the results.

We then calculate the internally generated internal capital. This is the sum of knowledge capital and organization capital. First, to obtain a firm's internally created knowledge capital, we use the perpetual inventory method:

$$KC_{it} = (1 - \delta_{R\&D})KC_{i,t-1} + R\&D_{it}, \tag{11}$$

where KC_{it} is the end-of-period knowledge capital, $\delta_{R\&D}$ is the depreciation rate, and $R\&D_{it}$ is the R&D expenditures during period t (R&D is measured by the Compustat variable *xrd*). For the depreciation rates, given the finding in Peters and Taylor (2017) that using the widely-used industry-specific R&D depreciation rates from the U.S. Bureau of Economic Analysis (BEA) does not have an impact on results, we apply a standard rate of 15% to all firms in the industry. We estimate the initial knowledge capital stock as below:

$$KC_{i0} = \frac{R\&D_{i1}}{(g + \delta_{R\&D})}, \tag{12}$$

where $R\&D_{i1}$ is the firm's first non-missing record of R&D expenditure, and g is the average R&D growth rate for the sample.

Then, we use SG&A expenses as a proxy for investment in organization capital and estimate it as 30% of SG&A expenses with the rest (70%) being allowed to be expensed in that period. A firm's organization capital is then given by:

$$OC_{it} = (1 - \delta_{S\&GA})OC_{i,t-1} + \theta * SG\&A_{it}, \tag{13}$$

where OC_{it} is the end-of-period organization capital, $\delta_{S\&GA}$ is the depreciation rate of 20%, and θ of 30%. We use an equation similar to Equation 11 to calculate the initial organization capital stock. To isolate the company's SG&A, we have to subtract *xrd* from *xsga*:

$$SG\&A = xsga - xrd - rdip$$

Additionally, we apply the following screening criteria as in Peters and Taylor (2017): If xrd exceeds $xsga$ but is less than the cost of goods sold ($cogs$), or if $xsga$ is missing, we measure SG&A as $xsga$ with no further adjustments. If $xsga$ is also missing, we assign a value of zero to SG&A. If $xsga$, xrd, or $rdip$ are missing, we set them to zero for consistency.

2.4. *Investment and Intangible Intensity*

A firm's investment rate is given for its physical, intangible, and total assets is then given by:

$$i_{it}^{phy} = \frac{I_{it}^{phy}}{K_{i,t-1}^{tot}}, \qquad i_{it}^{int} = \frac{I_{it}^{int}}{K_{i,t-1}^{tot}}, \qquad i_{it}^{tot} = i_{it}^{phy} + i_{it}^{int} \tag{14}$$

The physical investment I_{it}^{phy} is given by capital expenditures (Compustat item *capx*), and intangible investment, I^{int} is given by $R\&D + 0.3XSG\&A$

The intangible intensity is given as the ratio of intangible assets to total assets. We calculate each firm's intangible asset intensity as:

$$IAI_{it} = \frac{K_{it}^{int}}{K_{it}^{phy} + K_{it}^{int}}. \tag{15}$$

2.5. *Cash Flows*

As in Erickson et al. (2014), Peters and Taylor (2017) and Almeida and Campello (2007), we measure free cash flows as:

$$FCF_{it}^{*} = \frac{IB_{it} + DP_{it}}{K_{i,t-1}^{phy}}, \tag{16}$$

where IB_{it} is income before extraordinary items and DP_{it} is the depreciation expense.

We augment this by using an alternate cash-flow measure that recognizes R&D and part of SG&A as investments. We add back intangible investments into the free cash flow as below:

$$FCF_{it}^{*} = \frac{IB_{it} + DP_{it} + I_{i,t}^{int}(1-k)}{K_{i,t-1}^{phy} + K_{i,t-1}^{int}}, \tag{17}$$

In summary, this section analyzes our quantitative approach to this analysis using panel regression analysis in R with a refined Compustat dataset. We exclude specific sectors and apply data integrity standards, extending our dataset until 2021. Winsorization is applied for robustness. Key measures, including intangible capital, investment rates, intangible asset intensity, and cash flows, are defined within this framework. This concise summary encapsulates our research methodology.

3. Results and Analysis

This section discusses the results of our analysis.

3.1. Descriptive Statistics

Table 1 presents a comprehensive overview of the summary statistics derived from our dataset. At the core of our analysis is the estimation of intangible capital stock (K^{int}) through the application of the perpetual inventory method, combining expenditures on research and development ($R\&D$) with 30% of selling, general, and administrative expenses ($SG\&A$). To this estimate, we further incorporate firms' balance-sheet intangibles, resulting in a composite measure of intangible capital.

Variable	**Mean**	**Median**	**Stdev**	**Skewness**
Intangible capital stock ($M)	181.29	17.36	964.75	21.94
Physical capital stock ($M)	2243.38	97.74	14529.13	18.14
Intangible intensity	0.32	0.26	0.26	0.64
Knowledge capital/intangible capital	0.22	0.00	0.30	1.10
New Measures				
Total q (q^{tot})	1.89	0.81	6.04	29.70
Physical investment (i^{phy})	0.09	0.07	0.10	8.47
Intangible investment (i^{int})	0.17	0.12	0.17	1.43
Total investment (i^{tot})	0.26	0.22	0.19	1.97
Standard Measures				
Standard q (q^*)	5.14	1.14	23.96	40.68
CAPX/PPE (i^*)	0.14	0.10	0.14	9.36
Standard cash flow (c^*)	0.05	0.14	1.57	-33.98

Table 1: Descriptive Statistics

Starting with the measures of capital, the average intangible capital stock is approximately $181.29 million, significantly lower than the mean physical capital stock of about $2,243 million. This is also reflected in the respective medians, with intangible capital at $17.36 million and physical capital at $97.74 million. Both intangible and physical capital exhibit substantial variation among the sampled firms, as indicated by their high standard deviations and positive skewness values, suggesting a right-skewed distribution with a few firms holding exceptionally large amounts of both intangible and physical capital. There is, therefore, significant heterogeneity in both intangible and physical capital across the diverse spectrum of firms included in the sample.

In Equation 17, we defined intangible intensity as the proportion of a firm's intangible capital to its total capital, considering replacement cost. We find that the mean intangible intensity stands at 32%, indicating that, on average, a significant portion of a firm's capital is invested in intangible assets. Furthermore, when we examine the median intangible intensity, we find it to be slightly lower at 26%, highlighting the presence of variation within our dataset, with some firms placing a more significant emphasis on intangible capital than others. The skewness value is close to zero (0.64), suggesting a relatively balanced distribution. Peters and Taylor (2017) find an average intangible intensity of 43% and median of 45 %.

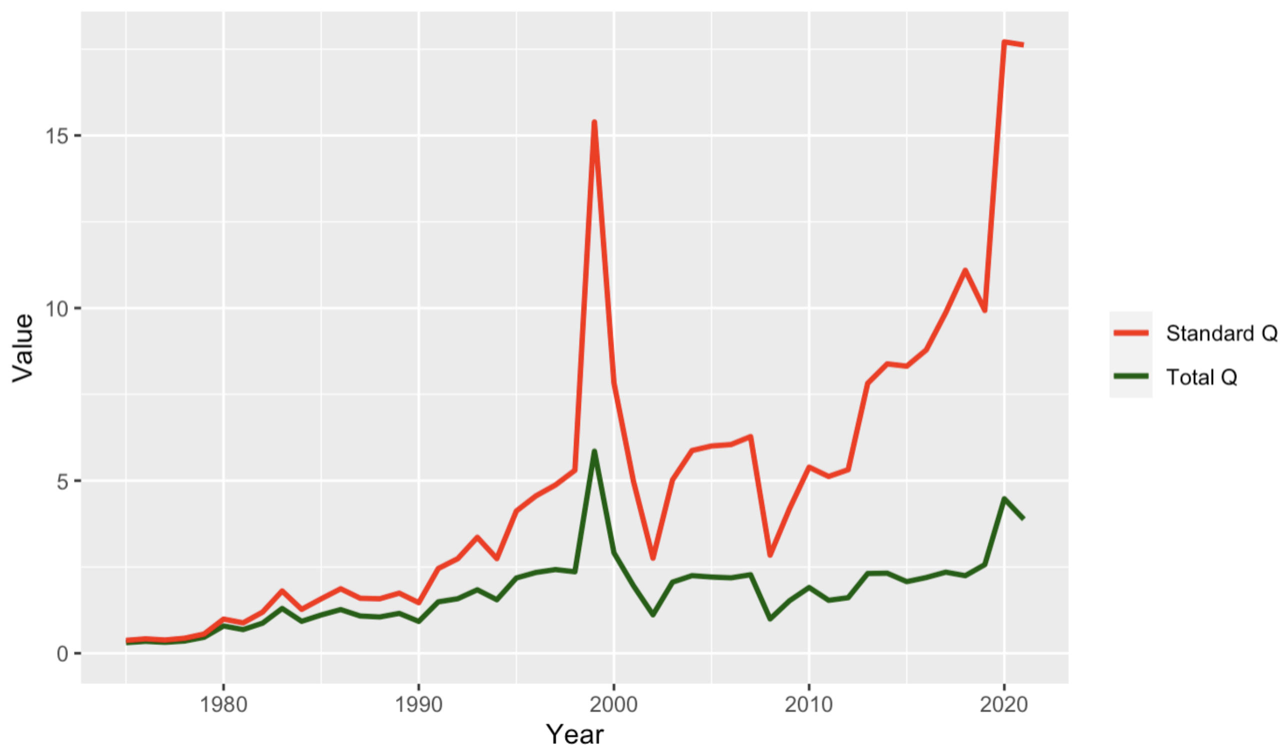

Fig. 2. Variability in Total Q and Standard Q over Time

Figure 2 visualizes the disparity between total q (q^{tot}) and standard q (q^{*}). It is evident that total q is approximately one-third the magnitude of standard q (1.89 compared to 5.14). This discrepancy is not unexpected since total q incorporates a larger denominator by considering both physical and intangible capital. Additionally, total q demonstrates a narrower standard deviation, signifying reduced variability compared to standard q^*. This implies a broader spectrum of values for Standard q as can be seen in Figure 3. Notably, the discrepancies between the two measures can be substantial. For example, in 2007, Microsoft exhibited a q^* of 25.2 and a q^{tot} of 8.9, while Apple recorded a q^{tot} of 22.69 and a q^* of 39.39 during the same year.

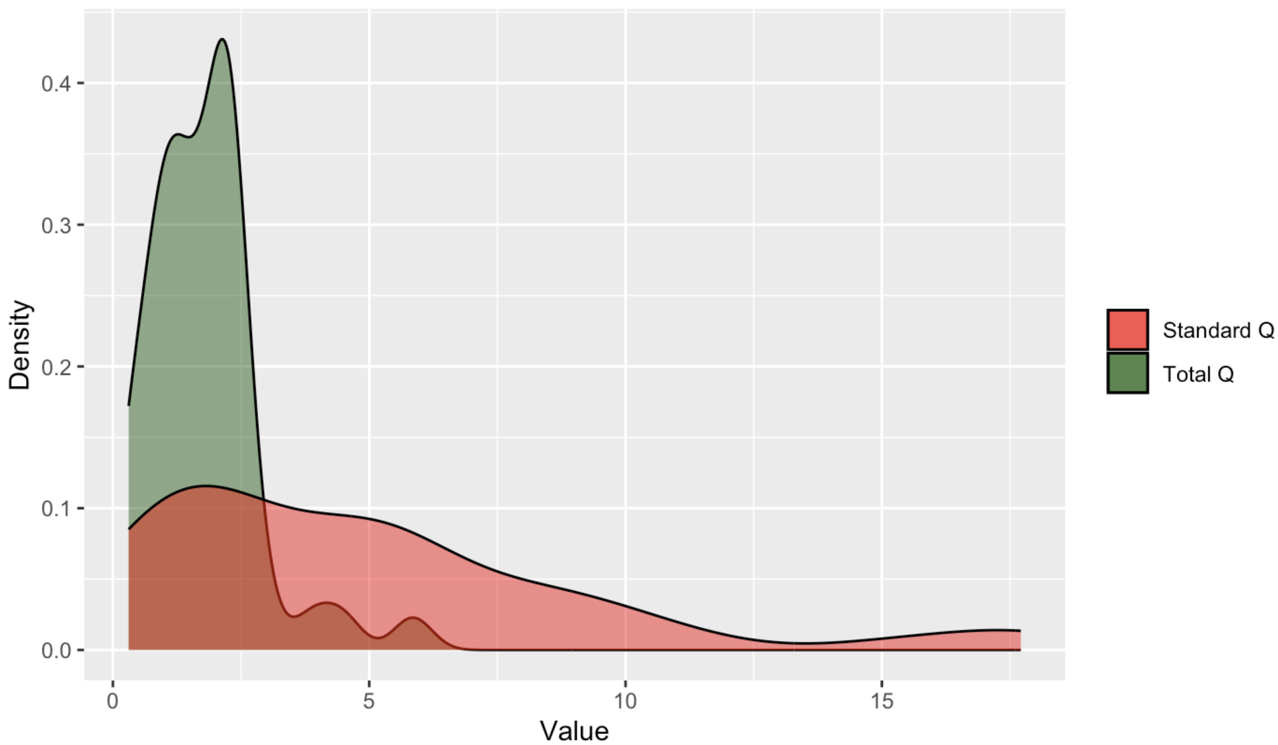

Fig. 3. The Density of Total Q and Standard Q

Many researchers commonly opt to exclude cases where the q value exceeds the conventional threshold of 10, citing concerns about unrealistically high values that could pose analytical challenges. In our dataset, we find that the total q value surpasses this threshold in only 2.9% of cases. This stands in stark contrast to the standard q, where we observe an exceedance rate of 10.4%. This disparity underscores a significant and meaningful distinction between the two metrics. It implies that total q offers enhanced reliability and stability in comparison to its standard counterpart. Notably, the standard deviation of total q is 6.04, which is approximately 75% lower than that of standard q at 23.96, highlighting a substantial difference in variability.

Figure 4 provides a comprehensive overview of the evolving landscape of intangible capital

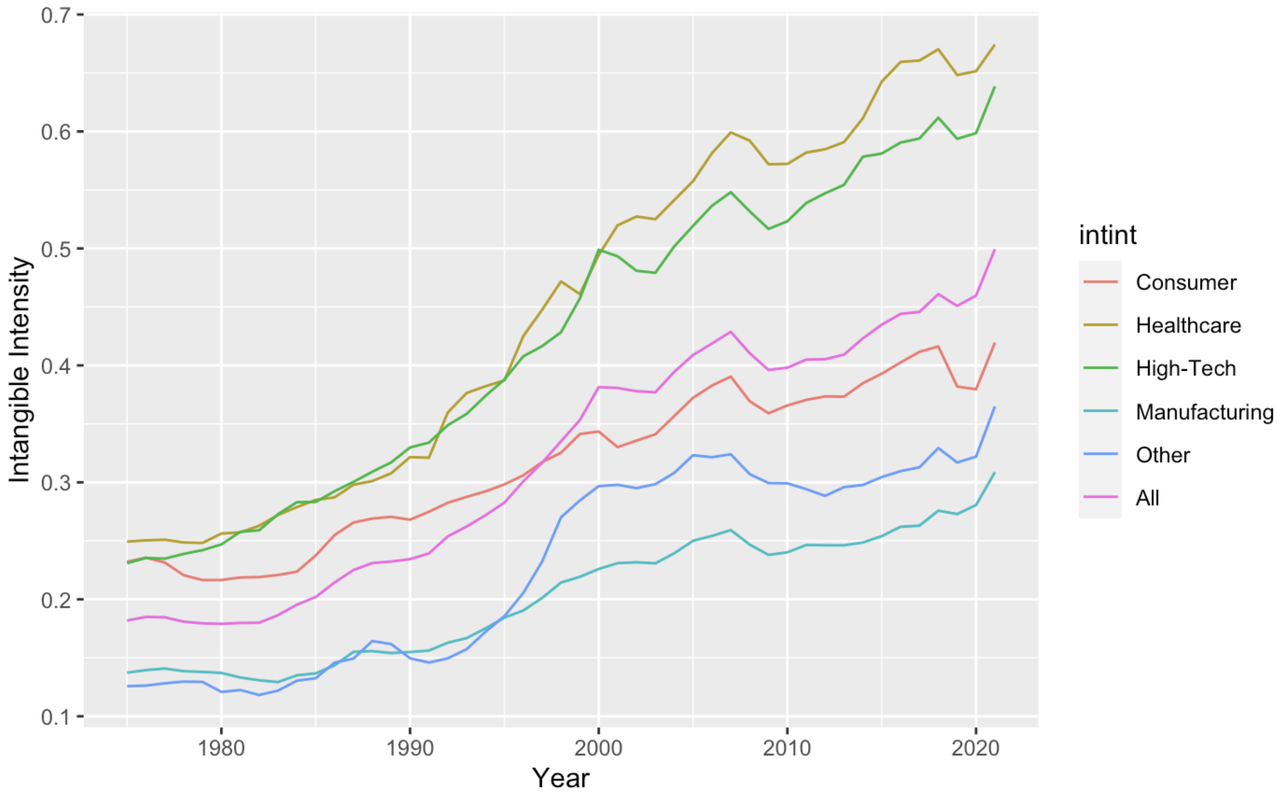

Fig. 4. Capital Intensity Over Time

intensity trends within our dataset over time. We conduct our analysis on the entire sample and further categorize firms based on Fama-French's well-established industry classifications, which encompass Manufacturing, Consumer, Healthcare, High-Tech, and Others. These classifications are widely used in research to facilitate asset pricing and portfolio performance evaluations. A noteworthy and consistent trend is the continuous increase in the average intangible capital intensity across all firms and industry categories, dating back to the 1970s. This upward trajectory serves as a compelling testament to the growing significance of intangible assets in the contemporary business landscape. Notably, industries such as High-Tech and Healthcare, known for their emphasis on innovation and intellectual property, exhibit notably higher levels of intangible intensity. Conversely, sectors like Consumer and Manufacturing, which rely more on tangible assets, tend to display comparatively lower levels of intangible intensity. There are discernible dips in intangible intensity that coincide with significant economic events, such as the 2008 financial crisis and the COVID-19 pandemic. These downturns are likely indicative of temporary constraints on investments in intangible assets during periods of heightened economic uncertainty. However, following the post-financial crisis period, we observe a degree of stability in intangible intensity, particularly within the Consumer and Healthcare sectors. Overall, there is a pronounced shift towards greater intangible capital intensity over the years.

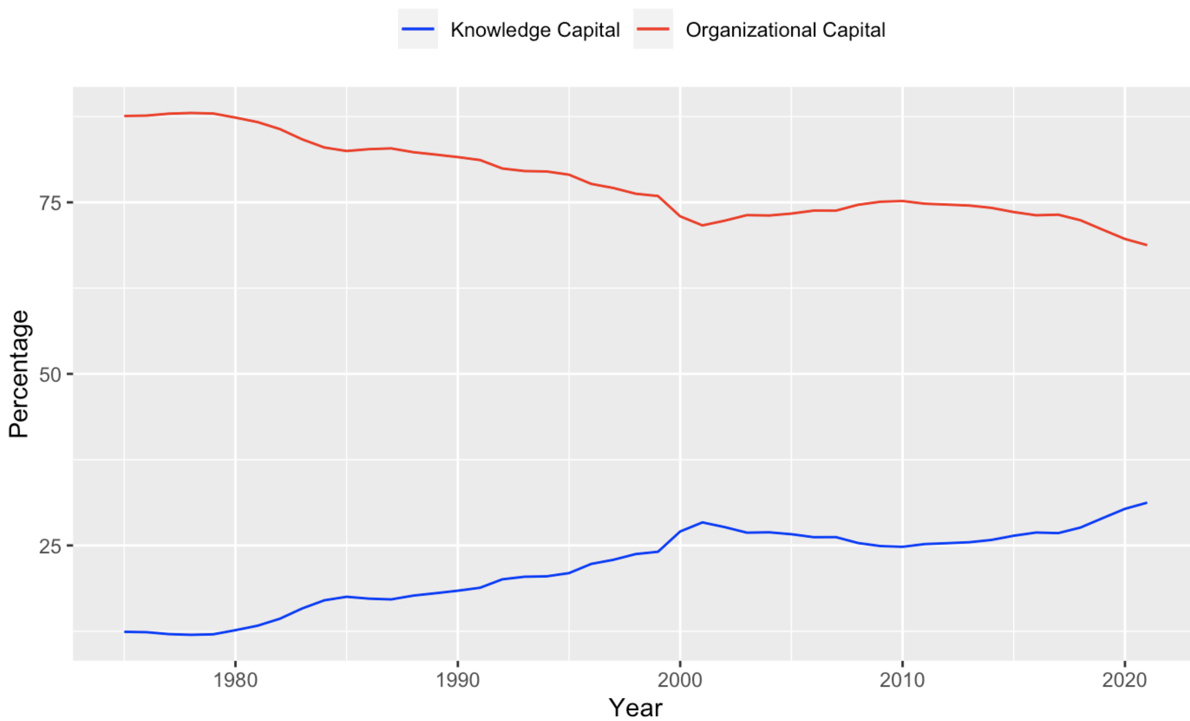

Fig. 5. Knowledge and Organizational Capital as a percentage of Intangible Capital

Figure 5 shows the dynamic changes occurring in the composition of intangible capital over time. Notably, knowledge capital has been on an upward trajectory, steadily gaining prominence, while organization capital has experienced a decline as a proportion of the overall capital structure. Further insight into this transformation can be gleaned from our analysis, presented in Table 1. Our findings reveal that, on average, knowledge capital constitutes approximately 22% of the total intangible capital with organizational capital accounting for the remaining 78%. This highlights the predominant role played by organizational capital in shaping a firm's intangible asset composition and the importance of the underlying organizational structures and systems that form the bedrock of a company's operational framework. Many firms in the sample rely more on organizational efficiency and structure rather than purely knowledge-based assets to drive their intangible capital.

As depicted in Figure 6, the median share of knowledge capital is situated at 0.00, indicating that a significant number of firms allocate only a minimal portion of their intangible capital to knowledge-based assets. However, the presence of a positive skewness value of 1.74 implies the existence of specific firms within our dataset that exhibit a substantial proportion of knowledge capital within their intangible assets. This suggests a diverse range of strategic approaches among firms, with some placing significant emphasis on knowledge capital. This emphasis may reflect robust intellectual property portfolios or a competitive advantage rooted in research and innovation-driven initiatives.

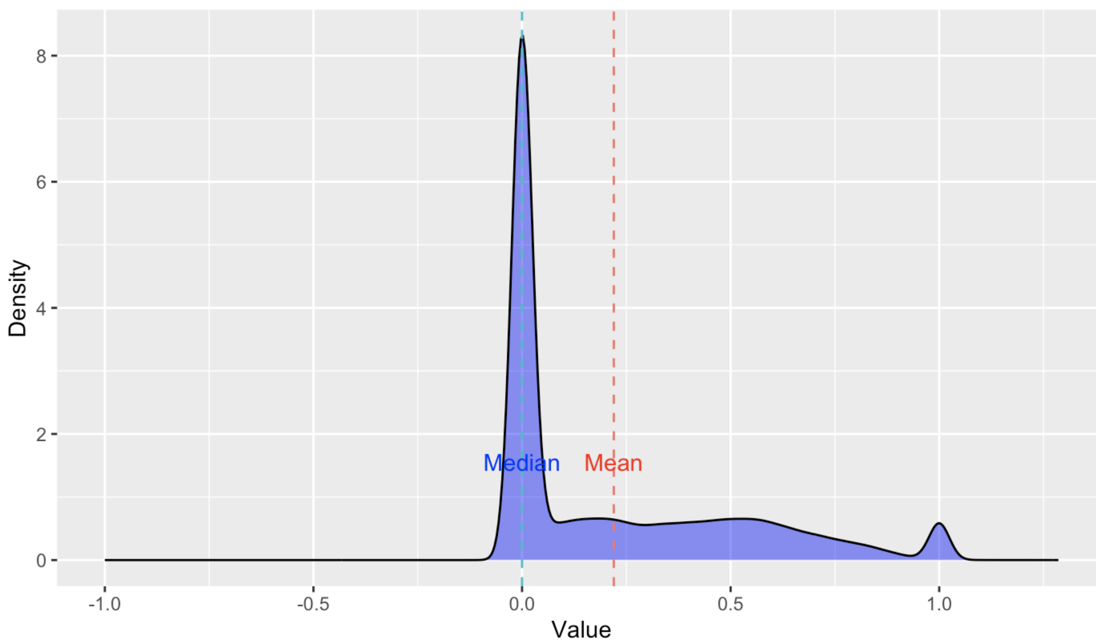

Fig. 6. Distribution of Knowledge Capital

In summary, the summary statistics reveal substantial variation in both intangible and physical capital among the sampled firms, highlighting heterogeneity in capital structures. The rise in intangible capital intensity over time underscores its growing importance across industries. Knowledge capital, while a significant component, is often overshadowed by organizational capital, emphasizing the critical role of efficient operations and infrastructure.

3.2. OLS Regressions

This section delves into the application of classic Ordinary Least Squares (OLS) panel regressions by Fazzari et al. (1987) in their seminal work on financing constraints. The aim is to examine the relationship between investment and Tobin's q. Our regressions incorporate firm and year-fixed effects, offering a robust framework for examining investment dynamics over time.

Our primary evaluation metric for these regression models will be the coefficient of determination, represented as R^2. This metric holds significant importance as it serves as a dependable indicator of the model's goodness of fit, particularly when there is a presence of measurement error bias in the coefficients. Notably, measurement error bias is most pronounced in the case of the cash-flow coefficient (Erickson and Whited, 2000). To ensure the robustness and credibility of our results, we have chosen to exclude cash flow from our analysis in this section.

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.006^{***}	0.005^{***}	0.011^{***}	0.002^{***}	0.010^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.00005)	(0.0001)
Observations	154,842	156,073	154,842	156,073	154,842
R^2	0.527	0.889	0.792	0.913	0.505
Adjusted R^2	0.475	0.877	0.769	0.903	0.450
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 2: Regressions with total q

We begin with Table 2, which presents the results of ordinary least squares (OLS) regressions of investment on lagged total q with firm and year fixed effects. Each column represents a different investment measurement. Our theoretical framework employed predicts an ideal scenario where the coefficient of determination (R^2) attains 100% when utilizing i^{phy}, i^{int}, or i^{tot} as proxies for investment measurement. However, upon examining the empirical data, our analysis reveals that the actual R^2 values fall short of this theoretical prediction. Several factors may contribute to this disparity, including measurement inaccuracies in the q variable, potential heterogeneity in firms' slope coefficients, or external perturbations affecting firms' marginal adjustment cost functions. Remarkably, the predictive accuracy of the theoretical model is more pronounced for intangible investment (R^2 = 88.9%) compared to physical investment (R^2 = 52.7%) and total investment (R^2 = 79.2%). It is worth noting that the R^2 for intangible investment surpasses that of total investment, which is somewhat surprising given the findings in Peters and Taylor (2017). Furthermore, when focusing on the R&D component within intangible investment, known for its lower susceptibility to measurement errors compared to SG&A, we observe a substantial R^2 of 91.3%, which closely aligns with the R^2 value of 88.9% for the broader intangible investment metric (i^{int}). Interestingly, the R^2 for the regression of CAPX/PPE against total q emerges as the lowest among all the investment variables assessed.

Table 3 presents the results from the OLS regressions of investment on lagged standard q with firm and year fixed effects with each column using a different investment measure. Here again, we focus on the R^2 since the coefficients have measurement error bias.

	Dependent variable:				
	physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Standard q	0.001***	0.001***	0.002***	0.001***	0.002***
	(0.00002)	(0.00002)	(0.00003)	(0.00001)	(0.00003)
Observations	154,842	156,073	154,842	156,073	154,842
R^2	0.510	0.886	0.779	0.912	0.495
Adjusted R^2	0.456	0.874	0.755	0.902	0.439
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 3: Regressions with standard q

According to our theoretical framework, we expected that the coefficient of determination (R^2) in the conventional regression model, which examines the relationship between CAPX/PPE concerning the standard q variable, would be comparatively lower. Our empirical findings support this hypothesis, as the regression analysis conducted on our dataset yielded an R^2 value of 49.5%. This value is notably lower when contrasted with the R^2 values obtained for other investment categories, such as total investment (79.2%), physical investment (52.7%), intangible investment (57.3%), and research and development (R&D) investment (91.3%). This outcome deviates slightly from the findings reported in Peters and Taylor (2017), wherein a similar relationship was observed, except in the case of physical investment. They attribute this anomaly in the relationship measurement errors in intangible capital, which could offset the potential enhancements brought about by the inclusion of intangible capital in the denominator for the calculation of total q. In essence, the key takeaway from our analysis, in line with the insights from Peters and Taylor (2017), underscores the critical importance of meticulous examination of measurement precision, particularly in the context of intangible capital. Such discrepancies in measurement accuracy have the potential to influence the explanatory power of the empirical models employed in research analyses.

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Total q	0.527	0.889	0.792	0.913	0.505
Standard q	0.510	0.886	0.779	0.912	0.495
Differences	**0.017**	**0.003**	**0.013**	**0.001**	**0.010**

Table 4: Differences between standard and total q in R^2

Tobin's q often serves as a proxy for evaluating firms' investment opportunities. In Table 4, we examine the R^2 values to gauge the effectiveness of these proxies by comparing total q with the conventional standard q measures prevalent in the literature. Tables 2 and 3 have already showcased the extent to which standard q can account for the five different investment metrics. Table 4 now conducts a comparative analysis between total q and standard q, evaluating their respective explanatory power. Our analysis reveals a noteworthy trend across the spectrum of five investment metrics. total q consistently surpasses the standard q measure, as evidenced by higher R^2 values. The most substantial enhancement in explanatory power is discerned in the context of the physical investment metric and the least is in the R&D metric.

In the context of investigating the interrelationship between physical and intangible investments within firms, our theoretical framework posits the existence of a robust correlation between these two types of capital. This expectation arises from the premise that physical and intangible capital possess equivalent marginal productivity, leading to equivalent marginal q values. In simpler terms, we anticipate a strong positive correlation between physical and intangible investments, suggesting that when firms invest more in one type of capital, they are likely to invest more in the other as well. Our empirical evidence appears to align with this expectation. We observed a correlation of 4.7% between physical and intangible investments once we accounted for firm and time fixed effects. This correlation indicates a modest but discernible positive association between the two types of capital.

However, in alignment with our theoretical framework, we hypothesized that this co-movement would diminish when we controlled for the influence of total q. Our analysis supports this hypothesis. After controlling for the effect of total q, we observed a reduced correlation of 3.7% between physical and intangible investments. This decrease in correlation suggests that when we account for the broader market valuation, the relationship between these two capital types becomes somewhat weaker. Nevertheless, it's important to acknowledge that the remaining correlation may potentially be attributed to measurement errors in total q. Measurement errors can introduce noise into our analysis, potentially affecting the accuracy of our results. Therefore, it becomes essential to scrutinize and consider the reliability of our total q measurements, as any inaccuracies in this variable could confound our findings.

One might consider conducting a regression analysis that includes both the total and standard q variables in one regression. However, such an approach is discouraged since these variables serve as proxies for q and are susceptible to measurement errors. This could potentially lead to biased and complex-to-interpret results, as highlighted by previous research (Klepper and Leamer, 1984). This underscores the importance of carefully considering the potential impact of measurement precision when working with these variables in empirical analyses. Consequently, we have chosen not to present the detailed outcomes of such an analysis.

When we juxtapose our findings with those of Peters and Taylor (2017), a notable observation emerges: our R^2 values surpass theirs. Directionally, our analysis aligns with theirs when comparing standard and total q. However, the substantial differences in the absolute values of these metrics raise intriguing questions. Upon closer examination, one plausible explanation for these disparities could be variations in sample compositions, or methodologies employed between our study and Peters and Taylor (2017). Such nuances in sample composition, or analytical techniques can potentially yield dissimilar results in spite of directional alignment. Further investigation into these underlying factors is warranted to gain a comprehensive understanding of the observed differences.

In summary, total q does emerge as a superior explanatory variable for intangible investment when compared to that for physical investment within our data as it tends to exhibit even greater explanatory power when it comes to total investment. The theory had predicted strong co-movements between physical and intangible investments, stemming from their shared q and this is found to hold in our dataset hence supporting the robust interplay between the marginal productivities of physical and intangible capital. These results seem to support the applicability of the neoclassical theory of investment, which traditionally pertains to physical capital, to intangible capital. Furthermore, we show that for the most part, total q does emerge as a superior proxy for quantifying investment opportunities which can reinforce the utility and versatility of total q in capturing the investment landscape, irrespective of the nuances in the measurement of investments. Some of the findings do deviate from theoretical expectations, suggesting measurement inaccuracies in total q and heterogeneity in firms' coefficients. The importance of meticulous measurement precision, especially for intangible capital, is emphasized.

3.3. Bias-Corrected Results

Our research methodology revolves around the preference for total q over standard q as an approximation of the true q, despite acknowledging that total q may introduce noise due to inherent errors in measuring intangible capital. While Tobin's q measures the average q, we recognize that investment decisions are theoretically influenced by marginal q which can lead to measurement errors when relying solely on a q proxy.

As discussed in the previous subsection, OLS slopes we've calculated are susceptible to measurement-error bias owing to our reliance on a q proxy. To address this issue, our initial intention was to correct for bias in this subsection using the higher-order cumulant estimator as proposed by Erickson et al. (2014). Erickson and Whited employed measurement error-consistent Generalized Method of Moments (GMM) estimators and found that a significant portion of the empirical patterns derived from investment-q cash flow regressions may be artifacts resulting from measurement inaccuracies. Notably, the influence of cash flow on investment was observed to be minimal, even within the context of financially constrained firms. This finding is particularly relevant to our research, as it suggests that Tobin's q can demonstrate robust explanatory power once the confounding effects of measurement error are effectively mitigated.

The cumulant estimator would not only allow us to generate unbiased q-slopes but would also offer two valuable test statistics. The first of these statistics is denoted as ρ^2 and represents a hypothetical R^2 value. In simpler terms, ρ^2 serves as an indicator of how effectively the true, unobservable q variable can explain variations in investment. When ρ^2 equals 1, it implies a perfect relationship between q and investment. Notably, our theory suggests that even when q is subject to measurement errors, ρ^2 can theoretically equal 1. The second statistic, τ^2, is associated with the hypothetical R^2 value. It evaluates how accurately our q proxy can represent the true q variable. A τ^2 value of 1 suggests that the proxy serves as a perfect representation of the true q variable, indicating its effectiveness in explaining q.

During the course of our research, we encountered a significant practical challenge when attempting to implement the Erickson-Whited (EW) estimator in our analysis. Unfortunately, there is no readily available and straightforward method for computing the EW estimator within the R statistical environment. In response to this limitation, a notable contribution by Erickson et al. (2017) came in the form of a novel command introduced in the statistical software Stata, aptly named *xtewreg*. This specialized command was specifically designed to harness the full potential of the two-step Generalized Method of Moments (GMM) and minimum distance estimators, offering a solution to researchers seeking to leverage the rich overidentifying information embedded within high-order cumulants or moments of their dataset to estimate parameters effectively.

Despite our best efforts and commitment to replicating the functionality of the *xtewreg* command in R, we encountered various complexities and limitations that hindered our progress. Regrettably, our endeavors to fully replicate the command's functionality in the R programming environment proved unsuccessful. Consequently, we made the strategic decision to shift our analytical focus towards utilizing the R^2 statistic as an alternative approach.

While we acknowledge that this choice presents certain limitations, we firmly believe that by diligently examining the explanatory power of our models using the R^2 metric, we can still extract valuable insights into the relationships we sought to investigate. It is essential to emphasize that we remain committed to further enhancing the robustness of our research in the future. Should we succeed in developing a method to compute an unbiased q-slope, we will incorporate these advancements into our analysis to strengthen the validity of our findings.

3.4. Comparing Subsamples

We now compare results across various subgroups to test the theory, assess adjustment costs, and check the robustness of our main findings. We reanalyze the models in subgroups defined by three variables: prior-year intangible intensity quartiles, Fama-French industry categories (Manufacturing, Consumer, Healthcare, and High-Tech), and periods (early (1975-1995) vs. late (1996-2011) vs latest (2012-2023 sample periods).

3.4.1. Time-Periods

In this section, we compare the results from OLS regressions for the sub-periods early (1975-1995), late (1996-2011), and latest (2012-2023) sample periods).

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.015^{***}	0.004^{***}	0.019^{***}	0.001^{***}	0.021^{***}
	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(0.0003)
Observations	62,299	62,957	62,299	62,957	62,299
R^2	0.536	0.921	0.787	0.933	0.555
Adjusted R^2	0.465	0.909	0.755	0.923	0.486
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 5: Regressions with total q for the early period (1975 to 1995)

Table 5 presents the results from the OLS regressions of investment on lagged standard q with firm and year fixed effects with each column using a different investment measure specifically for the period 1975 to 1995. In the early period, the coefficient of determination (R^2) values in the regression analysis vary between 53.6% and 92.1%. The highest R^2 is in *R&D* at 93.3%, followed closely by intangibles at 92.1%. The lowest R^2 is with physical investment and not with CAPX/PPE as in the previous section. What's interesting here also is that all the R^2 here are larger than the overall R^2 we got in the previous sections except for total investment. Finally, when regressing the standard literature model of CAPX/PPE against standard q we get an R^2 of 54.27% which is lower than that of all but one of the investment metrics, that is physical.

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.004***	0.005***	0.010***	0.002***	0.008***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	62,183	62,736	62,183	62,736	62,183
R^2	0.602	0.903	0.829	0.918	0.578
Adjusted R^2	0.535	0.886	0.800	0.904	0.506
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 6: Regressions with total q in the late period (1996 to 2011)

Table 6 presents the results from the OLS regressions of investment on lagged standard q with firm and year fixed effects with each column using a different investment measure specifically for the period 1996 to 2011. In the late period, the R^2 values in the regression analysis vary between 57.8% and 91.8% with the highest R^2 still in R&D at 91.8%, followed closely by intangibles at 90.3%. The lowest R^2 is with CAPX/PPE unlike what we saw in the early period. Compared to the early period, all the R^2 are higher except for the intangible and R&D. All the R^2 here are larger than the overall R^2 we got in the previous sections. Finally, when regressing the standard literature model of CAPX/PPE against standard q, we get an R^2 of 57.5% which is lower than that of all of the investment metrics.

Table 7 presents the results from the OLS regressions of investment on lagged standard q with firm and year fixed effects with each column using a different investment measure specifically for the period 2012 to 2021. In the latest period, the R^2 values in the regression analysis vary between 61.5% and 96.0% with the highest R^2 still in *R&D* at 91.8%, followed closely by intangibles at

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.002^{***}	0.004^{***}	0.006^{***}	0.002^{***}	0.004^{***}
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
Observations	30,360	30,380	30,360	30,380	30,360
R^2	0.619	0.949	0.908	0.960	0.615
Adjusted R^2	0.541	0.938	0.889	0.952	0.536
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 7: Regressions with total q in the latest period (2012 to 2021)

94.9%. The lowest R^2 is with CAPX/PPE unlike what we saw in the early period but similar to what we saw in the late period. Compared to the late period, all the R^2 are higher except for the intangible and R&D. All the R^2 here are larger than the overall R^2 we got in the previous sections. Finally, when regressing the standard literature model of CAPX/PPE against standard q, we get an R^2 of 57.5% which is lower than that of all of the investment metrics.

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Early Period	0.536	0.921	0.787	0.933	0.555
Late Period	0.602	0.903	0.829	0.918	0.578
Latest Period	0.619	0.949	0.908	0.960	0.615

Table 8: Differences in R^2 with total q over the three periods

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Early Period	0.519	0.922	0.781	0.934	0.543
Late Period	0.589	0.900	0.819	0.917	0.575
Latest Period	0.614	0.948	0.906	0.960	0.616

Table 9: Differences in R^2 with standard q over the three periods

Table 8 and Table 9 compare the R^2 over the 3 time periods. We note that the R^2 is highest in the latest time period and that the R^2 have been improving over time for all of them, especially for total investment which improved by 1,120 basis points. The least improvement is in the R&D investment. This signifies that total q has become more important with time.

3.4.2. *Industry Categories*

In this section, we compare the results from OLS regressions for the Fama-French industry categories namely Manufacturing, Consumer, Healthcare, and High-Tech.

Table 10 covers manufacturing. The R^2 values in the regression analysis vary between 48.8% and 88.7% with the highest R^2 in intangible investment, followed closely by R&D at 87.1%. The lowest R^2 is again with CAPX/PPE. Comparing the standard regression of CAPX/PPE on standard q against the total q regressions, we find the R^2 of 47.3% is below that of the other investments when regressed on total q.

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.013***	0.004***	0.017***	0.002***	0.017***
	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(0.0003)
Observations	39,808	40,164	39,808	40,164	39,808
R^2	0.526	0.887	0.684	0.871	0.488
Adjusted R^2	0.482	0.876	0.655	0.859	0.440
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 10: Regressions with total q in the manufacturing industry

Table 11 covers Healthcare. The R^2 values in the regression analysis are in the range of 41.7% and 90.8% with the highest R^2 in R&D, followed by intangible investment at 87.5%. The lowest R^2 is again with CAPX/PPE. Also here, when comparing the standard regression of CAPX/PPE on standard q against the total q regressions, we find the R^2 of 41.6% is below that of the other investments when regressed on total q as expected in theory.

Table 12 covers the consumer category. The R^2 values in the regression analysis are in the range of 50.5% and 86.8% with the highest R^2 in R&D, followed closely by intangible investment

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.003***	0.005***	0.009***	0.003***	0.006***
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0003)
Observations	16,303	16,399	16,303	16,399	16,303
R^2	0.479	0.875	0.823	0.908	0.417
Adjusted R^2	0.407	0.858	0.798	0.896	0.336
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 11: Regressions with total q in the healthcare industry

at 85.9%. The lowest R^2 is again with CAPX/PPE. Again we find the same thing to be true here: the standard regression of CAPX/PPE on standard q yields an R^2 of 49.0% which is below that of the other investments when regressed on total q as expected in theory.

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.010***	0.006***	0.017***	0.0004***	0.016***
	(0.0002)	(0.0002)	(0.0003)	(0.0001)	(0.0003)
Observations	37,638	37,900	37,638	37,900	37,638
R^2	0.514	0.859	0.769	0.868	0.505
Adjusted R^2	0.464	0.844	0.745	0.855	0.454
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 12: Regressions with total q in the consumeriIndustry

Table 13 covers the tech industry. The R^2 values in the regression analysis are in the range of 56.8% and 85.6% with the highest R^2 in intangible investment which is almost the same as the one for R&D at 85.5%. The lowest R^2 is again with CAPX/PPE. Once more, our findings reinforce a consistent pattern: when comparing the standard regression of CAPX/PPE on standard q, we obtain an R^2 of 56.0%. This R^2 value falls below those observed for other investment metrics when regressed on total q, aligning with our theoretical expectations

	Dependent variable:				
	Physical	Intangible	Total	R&D	CAPX/PPE
	(1)	(2)	(3)	(4)	(5)
Total q	0.004***	0.005***	0.010***	0.003***	0.008***
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
Observations	38,580	38,893	38,580	38,893	38,580
R^2	0.603	0.856	0.805	0.855	0.568
Adjusted R^2	0.553	0.838	0.780	0.837	0.513
Note:			*p<0.1; **p<0.05; ***p<0.01		

Table 13: Regressions with total q in the Tech Industry

Comparing across industries as in Table 14, the analysis shows thattotal q plays a consistent and valuable role in explaining variations in intangible investments across these diverse industries.

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Manufacturing	0.526	0.887	0.684	0.871	0.488
Healthcare	0.479	0.875	0.823	0.908	0.417
Consumer	0.514	0.859	0.769	0.868	0.505
Tech	0.603	0.856	0.805	0.855	0.568

Table 14: Comparing R^2 for total q across industries

The R^2 values are highest in tech under physical investment and CAPX/PPE, in manufacturing under intangible investment and in healthcare under total and R&D investment. Generally, R^2 is highest in the intangible and R&D investment. The differences between the R^2 for intangible and physical investment are highest in healthcare and manufacturing and lowest in tech. In essence, R^2 values increase dramatically when moving from the physical investment to intangible investment. For instance, in the healthcare sector, it moves from 47.9% to 87.5%, an improvement of around 396 basis points by merely using intangible investment and not physical investment in the regression. Furthermore, across all the four industries, total q is found to be superior to standard q.

3.5. Discussion

Over time, we have observed an increase in intangible intensity, indicating that firms are allocating a significant portion of their capital towards intangible assets. However, this trend has remained stable since the financial crisis. On average, the mean intangible intensity stands at 32%, underscoring the importance of intangible assets in a firm's capital structure. Both intangible and physical capital exhibit substantial variation among sampled firms, with high standard deviations and positive skewness values, suggesting a right-skewed distribution where a few firms hold exceptionally large amounts of both types of capital.

Comparatively, total q has shown greater reliability and stability when compared to its standard counterpart. The standard deviation of total q is notably 75% lower than that of standard q, emphasizing a substantial difference in variability. In terms of industry sectors, high-tech and health industries, characterized by innovation and intellectual property, exhibit higher intangible intensity, while the consumer and manufacturing sectors, reliant on tangible assets, have lower levels. We noticed dips in intangible intensity during significant economic events, such as the 2008 financial crisis and the COVID-19 pandemic. These downturns likely reflect temporary constraints on intangible asset investments during uncertain times. Post-financial crisis, stability in intangible intensity is observed, particularly in the consumer and healthcare sectors.

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Manufacturing	0.519	0.922	0.781	0.934	0.543
Healthcare	0.465	0.874	0.817	0.909	0.416
Consumer	0.490	0.857	0.754	0.868	0.490
Tech	0.584	0.851	0.791	0.853	0.560

Table 15: R^2 for standard q across industries

We chose R as our analysis tool but faced challenges in replicating certain aspects due to the absence of an R-equivalent for xtewreg. Consequently, we focused onR^2 as our primary analytical tool, primarily because measurement errors made the slopes unreliable. When comparing R^2across various investment metrics, we found that total q substantially enhances our ability to assess a firm's investment opportunities compared to standard q. The most significant improvement in explanatory power was observed in the context of physical investment metrics, while the least improvement was in the R&D metric. However, it's important to acknowledge persistent measurement issues related to intangible capital. Our theoretical framework had initially posited a robust correlation between physical and intangible capital, assuming equivalent marginal productivity and q values. Our empirical evidence supports this expectation, showing a 4.7% correlation between physical and intangible investments after accounting for firm and time fixed effects. This correlation suggests a positive association between the two capital types. Yet, in line with our theoretical framework, we hypothesized that this correlation would diminish when controlling for the influence of total q. Our analysis confirms this hypothesis, revealing a reduced correlation of 3.7% after accounting for total q. The remaining correlation may potentially be attributed to measurement errors in total q or heterogeneity in firms' coefficients, deviating from theoretical expectations.

The analysis of R^2 values reveals some noteworthy trends over time and across different types of investments. Firstly, we observe that the highest R^2 is recorded in the most recent time period, indicating an increasing explanatory power of the regression models over time. Notably, all categories of investment show improvements in their R^2 values over time, with the most substantial enhancement observed in the case of total investment, which exhibits a remarkable increase of 1,120 basis points. Conversely, the increase in R&D investment's R^2 is comparatively modest.

	Physical	**Intangible**	**Total**	**R&D**	**CAPX/PPE**
Late Period - Early Period	0.066	-0.018	0.042	-0.015	0.023
Latest Period - Late Period	0.017	0.046	0.079	0.042	0.037
Latest Period - Early Period	0.083	0.028	0.121	0.027	0.060

Table 16: Comparing the R^2 with total q over the three periods

These findings suggest a growing significance of total q as a determinant of investment decisions over the years. When examining the R^2 values across different investment types, we observe that intangible and R&D investments consistently yield the highest R^2 figures. Additionally, there are notable variations in the R^2 values between intangible and physical investment, with the largest differences observed in the healthcare and manufacturing sectors and the smallest in the tech sector. In essence, the R^2 values experience substantial improvements when transitioning from physical to intangible investment. For instance, within the healthcare sector, this shift results in an increase from 47.9% to 87.5%, representing an improvement of approximately 396 basis points by solely choosing to use intangibles. Furthermore, across all four industries examined, total q consistently outperforms standard q as a predictor of investment behavior.

Notably, upon comparing our research findings to those of Peters and Taylor (2017), a notable disparity becomes evident: our study exhibits significantly higher R^2 values. While our analyses align directionally, especially when comparing standard and total q, the substantial variations in the absolute values of these metrics raise intriguing questions. Further scrutiny reveals that these differences may be attributed to variances in sample compositions and methodological approaches between our study and Peters and Taylor (2017). These subtle discrepancies in sample selection or analytical techniques can yield divergent results despite the fundamental alignment in findings. To fully grasp the root causes of these differences, additional in-depth investigation is necessary, offering insights into the nuanced factors influencing our results relative to the prior study.

In summary, our research sheds light on the complex interplay between physical and intangible investments, the importance of total q as a measurement tool, and the ongoing challenges associated with accurately measuring intangible capital in empirical analysis.

4. Conclusion

The traditional neoclassical investment theory has predominantly centered on physical capital, reflecting the historical economic landscape. We establish the theory's applicability to intangible capital, which now dominates the contemporary U.S. economy. Tobin's q, a key investment metric, emerges as a reliable factor for explaining both forms of capital investment, even without considering potential measurement errors in q estimation. Leveraging the enhanced Tobin's q measure introduced by Peters and Taylor (2017) tailored to intangible capital, we unveil a strong correlation between physical and intangible capital, though controlling for total q reveals a nuanced relationship.

Our analysis has shed light on the evolving landscape of capital allocation among firms, with intangible assets gaining increasing importance. Covering the period 1975 to 2021, our research delved into the evolving dynamics of physical and intangible investments within firms. Over time, we noted a significant increase in intangible intensity, with a stable trend following the financial crisis. On average, firms allocate approximately 32% of their capital to intangible assets, underscoring their growing significance. High-tech and healthcare sectors exhibited higher intangible intensity, while consumer and manufacturing sectors exhibited lower intangible intensity as they rely more on tangible assets. We observed a decline in intangible intensity during the 2008 financial crisis and the 2020 covid-19 pandemic. Post-financial crisis, stability was notably observed, particularly in the consumer and healthcare sectors. The theoretical framework suggested a strong correlation between physical and intangible capital and this moderately holds in the data. Controlling for total q revealed a diminished correlation. The remaining correlation can be attributed to measurement errors and heterogeneity in firms' coefficients.

Despite challenges in replicating certain aspects due to the absence of an R-equivalent for $xtewreg$, we focused on R^2 as a robust analytical tool. Our findings highlighted the substantial improvement offered by total q in assessing investment opportunities, with the most significant enhancement seen in physical investment metrics. Notably, comparing our results to Peters and Taylor (2017), we find notably higher R^2 values, although the directional alignment persists. The substantial differences in these metrics' absolute values likely stem from variances in sample compositions and methodologies, highlighting the need for further investigation into the underlying factors driving these disparities. Due to measurement errors affecting the reliability of slopes, we rely on the R^2 statistic as our primary analytical tool. Notably, we highlight the superior reliability and stability of total q compared to the conventional q ratio, with total q substantially enhancing the explanatory power (R^2) when assessing various investment metrics, especially on physical investments. Furthermore, controlling for total q leads to a reduction in the correlation between physical and intangible investments from 4.7% to 3.7%. Our study identifies the latest time period as having the highest R^2 values, reflecting evolving trends, particularly emphasizing the significance of intangible and R&D investments. Additionally, we observe a substantial increase in R^2 values when transitioning from physical to intangible investment, further underscoring the importance of intangible assets in firms' capital allocation strategies. Across all four industries studied, total q consistently outperforms standard q.

Our analysis reveals significant variability in both intangible and physical capital among the sampled firms and highlights the pronounced diversity among firms, particularly in their holdings of intangible and physical capital. Moreover, the superior reliability and stability of total q compared to standard q emphasize its significance as a tool for assessing investment opportunities. Overall, our findings provide valuable insights into the dynamics of capital allocation and the role of total q as a predictor of investment behavior. Future research can explore interactions, pricing dynamics, responses to constraints, market values, and why classic q-theory fits well in high-intangible settings. It can also focus on correcting for measurement errors in the constants we obtained in this paper, expanding the research to outside the U.S. (which has not been done so far) and helping in further advancements in the measurement of intangible capital.

In conclusion, our research underscores the growing importance of intangible assets in firms' capital allocation strategies. Our analysis unveils considerable variability in intangible and physical capital among firms, with total q emerging as a more reliable and stable metric compared to the standard q. It emphasizes the growing significance of intangible assets and provides insights into capital allocation dynamics, highlighting the pivotal role of total q in understanding investment behavior.

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