The Strategic Impact of IT: An Update on the Relationship between IT Investments and Competitive Dynamics

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THE STRATEGIC IMPACT OF IT: AN UPDATE ON THE RELATIONSHIP BETWEEN IT INVESTMENTS AND COMPETITIVE DYNAMICS

Research Paper

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Abstract

McAfee and Brynjolfsson (2008) provided evidence that the steep rise of information technology investments in the 1990s did not only yield higher overall productivity but also accelerated the competitive nature of U.S. industries. These changes have, among others, been attributed to a more efficient and quick propagation of innovative business processes due to information technology. Our paper sets out (a) to replicate their findings and (b) to extend their study by analyzing more recent trends. We compare over 60 U.S. industries between 1987 and 2018 by regressing IT intensity on three different measures of industry competition: sales turbulence, industry concentration, and performance spread of gross profit margin. The regression models indicate that industries that spend more on IT still display relatively higher competitive dynamics, but that, after a strong uprise between 1995 to 2005, there has been a substantial slowdown and trend reversal after 2005. Together, this indicates both a shift from information technology being a strategic differentiator to a strategic "must-have" commodity in firms and an indication that the majority of digital innovations are rather of a combinatorial than of a disruptive nature as they help top performers to continuously build out their superior market position.

Keywords: IT Impact, Competitive Dynamics, Longitudinal Analysis, Industry Comparison

1 Introduction

In the late 1980s, despite heavy spendings on information technology (IT), IT business value researchers often failed to find empirical evidence for a link between information technology investments and improved productivity and other performance metrics (e.g., Solow, 1987). The discrepancy between IT being regarded as a strategic weapon to enhance productivity and competitiveness yet researchers failing to find evidence for improved performance in aggregate statistics was commonly referred to as the productivity paradox of information technology (Brynjolfsson and Hitt, 1996). In the 1990s, better availability of data made it possible to assess a variety of firm-level metrics, shedding light upon the root cause of the paradox. It became evident that the paradox was particularly caused by measurement inaccuracies in aggregate data and time lags between investments and performance benefits (Brynjolfsson, 1993). While most studies in the 1990s focused on firm-level performance, studies that investigate the link between IT investments and industry-level changes emerged more recently. A well-cited HBR article by McAfee and Brynjolfsson in 2008 examined the information technology-induced changes to the competitive landscape in industries of the U.S. The study illustrated that spendings on IT intensified the competitiveness of industries. Those industries that had spent the highest amounts on IT also showed...
the strongest acceleration in competition. But, even in more traditional, low-IT-spending, industries, the
competition had become notably fiercer. The results of the study revealed the strategic importance of
effective IT investment decisions for a company to stay competitive in their markets.

In another strongly debated article of the 2000s, Carr (2003) argued that at some point in time most
information technologies become commoditized, thus their strategic value diminishes and only propri-
etary technologies that are difficult to replicate can yield competitive advantages. The mainstream adop-
tion of manifold information systems and technologies by companies of both high and low IT industries
suggests a high-level commoditization. What got partly ignored in this discussion is that companies’
focus of IT investments does structurally change over time1. New technological advancements, such as
cloud computing, IoT, or AI, give room for reaping new, at least temporary, competitive advantages and
an increasing number of even large firms gets wiped out of the market because they do not fast and
massively enough invest into innovation and new digital business models (Desmet et al., 2015).

Given the increased dynamics in technological developments and resulting variation in areas of IT in-
vestments, it is stunning that only very few studies have investigated the nature of the link between IT
capital and competitiveness more recently (see below). Hence, our objectives are to replicate the find-
ings of McAfee and Brynjolfsson and update their analysis with current data to provide new insights
into information technology-induced changes to the competitive environment of industries.

In the following section, we introduce the theoretical foundation, related works, and our hypotheses.
The third section will then provide the details about the applied empirical methodology. Section 4 pre-
sentsthe statistical findings, which will be discussed in the subsequent section. The sixth section covers
concluding remarks and directions for future research.

2 Theoretical Foundations and Hypotheses

2.1 Conceptualization of IT

We study the influence of information technology (IT) on an industry’s competitive dynamics. Here, IT
refers to information and communication technologies, encompassing all software, computer hardware,
and telecommunications equipment. Depending on the research objective, there are different ways to con-
ceptualize IT. Orlikowski and Iacono (2001) distinguish between different IT artifact conceptuali-
zations: tool view, ensemble view, computational view, and proxy view. The tool view sees IT as an
“engineered artifact, expected to do what its designers intend it to do.” (Orlikowski and Iacono, 2001,
p.123). The intended purpose for a tool can be labor substitution, productivity enhancements, infor-
mation processing or changing social relations. The ensemble view takes into account socio-economic
aspects and considers the interaction between people and information systems e.g., workplace practices.
The computational view concentrates primarily on the computational power of information technology,
particularly on the capabilities to manipulate, store and transmit data.

The proxy view assumes that “the critical aspects of information technology can be captured through
some set of surrogate (usually quantitative) measures” (Orlikowski and Iacono, 2001, p. 124). These
metrics usually represent either perception, diffusion, or capital. Measures of perception examine the
users’ perception of an IT artefact, e.g., usefulness. Diffusion metrics may quantify the adoption rate of
new technologies within companies. Measures of capital provide a more generalized view of IT and
focus on the value of IT. When using capital metrics, IT artifacts are represented by homogenous quanti-
tifiable amounts such as capital stock measures. Overall, IT conceptualizations that belong to the proxy
view, and, usually, to the capital dimension, are the most frequently used in IT business value research
(Melville et al., 2004). As we start our study by replicating McAfee and Brynjolfsson’s work, we will
also adopt this view.

1 For example, the results of the annual SIM survey provide a good overview about CIOs’ changes in investment focus over
time. Combining Kappelman et al. (2021) and Luftman and Ben-Zvi (2010) allows for comparing the last 20 years.
2.2 The Resource Based View of IT

The main aim of IT business value research is to examine the organizational performance impacts of IT resources, “including productivity enhancement, profitability improvement, cost reduction, competitive advantage, inventory reduction, and other measures of performance” (Melville et al., 2004, p. 287). Melville et al. (2004) distinguish performance measures of efficiency and effectiveness. Efficiency metrics are used to assess firm-level impacts, for instance, the productivity or cost structure of business processes. In contrast, measures of effectiveness express “organizational objectives concerning a firm’s external environment” (Melville et al., 2004, p. 287). Since internal process enhancements may not necessarily have a competitive performance impact, it is therefore important to distinguish between firm-centric efficiency impacts and collective-level competitive impacts (Melville et al., 2004).

We focus on the competitive impacts of IT; hence, the scope of this paper is restricted to measures of effectiveness in the form of standard performance measures such as sales and gross profit margin.

One of the most commonly applied theories in IT business value research is the resource-based view (“RBV”) of the firm (Wade and Hulland, 2004), which argues that resources are heterogeneously distributed across firms and that there exist some resources that allow a firm to gain temporary short-term or even long-term (i.e., “sustainable”) competitive advantages. Such a resource needs to be valuable (contributing to effectiveness and efficiency), rare (i.e., exclusive to the focal firm, providing a competitive advantage), and should not be imitable by competitors (Barney, 1991).

There exists a variety of approaches to categorize resources, but only a few fit to our research objective. Barney (1991) classifies resources into physical capital, human capital and organizational capital. Physical capital resources include all physical assets used in firms, e.g., plants and equipment. Physical capital therefore also includes the technological IT resource, which consists of IT infrastructures such as servers and networks and IT applications for business processes such as ERP systems or analytics software solutions. As noted above, we adopt the capital dimension of the proxy view of IT, which in turn means that we will focus on the impact of physical capital. Of course, the impact of physical capital will strongly rely on the availability of the other resources. As Melville et al. (2004), Mata et al. (1995) and others have shown, the IT management’s capabilities to utilize information technology – and thus also to be able to react to new market requirements and opportunities in the sense of the dynamic capabilities perspective (Teece et al., 1997) – is crucial for achieving competitive value from IT.

While the consideration of the RBV has given birth to manifold organization-centric studies on the business value of IT, there are also studies that consider or even focus on external factors such as industry dynamics and the given macro environment; in their integrative model of IT business value, Melville et al. (2004) start from a firm-level RBV model, but do also take collective-level dynamics into account. In their model, just as in the RBV itself, the center of IT business value generation is the focal firm that employs the IT resources. But this firm is now embedded into two other, embracing, domains: the competitive environment and the macro environment. The macro environment includes factors that influence the way IT can be utilized, for example, the level of development and basic infrastructure of a country.

In the focal firm, much of the value generated due to IT resource employment is the ability to improve business processes and workplace practices. These improvements may eventually lead to increased productivity and organizational performance (Brynjolfsson and Hitt, 2000). Although some IT implementations can be made with few organizational changes (McAfee, 2002), most IT employment entails significant organizational changes (Brynjolfsson and Hitt, 2000, 2002). Business processes include all work activities with specific “ordering of across time and place, with a beginning, an end, and clearly identified inputs and outputs” (Davenport 1993, p. 5). Performance in this context may refer to both individual business process performance and overall organizational performance. However, performance in our study refers to organizational performance only since the aim is to investigate how aggregate IT-enabled performance may lead to competitive advantages, hence we are not studying individual business processes.
The second domain in the integrative model, the competitive environment, captures industry characteristics. Industry characteristics, e.g., in the form of competitiveness, regulation or technological change, influence the mode of IT employment in the firm (Melville et al., 2004). McAfee and Brynjolfsson (2008) indicate that some industries can reap higher benefits than others reap and therefore pull away from other competitors. These findings imply heterogeneous responses to IT employment, which have to be considered when comparing the impacts of IT across multiple industries.

2.3 Prior Research and Research Hypotheses

Most of the IT business value studies using a proxy view of IT applied aggregate firm-level metrics. The majority of the studies have found a positive relationship between IT and organizational performance, especially for productivity metrics. Even with varying parameters regarding, for example, the utilized metrics, time frames, or macro environments, there seems to be strong evidence that IT enables improved performance (Brynjolfsson and Hitt, 1995, Lichtenberg, 1995, Siegel, 1997). In addition to increased productivity, there is strong evidence that IT investments also yield excess returns compared to other forms of capital (Lehr and Lichtenberg, 1999, Brynjolfsson 1993, Siegel, 1997), especially in the long-run (Brynjolfsson and Yang, 1996). While the previously mentioned literature employed accounting-based measures of firm-performance, Bharadwaj et al. (1999) also found a positive relationship between IT and firms’ market valuation utilizing Tobin’s q.

While most research focuses predominantly on physical resources, Brynjolfsson and Hitt (1995) observed productivity gains from IT when implementing a combined metric of computer capital and labor, thus accounting for human capital resources, too. Dewan and Min (1997) showed that IT capital is increasingly substituting labor and other forms of capital thus providing evidence that business processes are being replicated using IT resources to increase productivity and reach a higher overall organizational performance. Correspondingly, studies on more recent IT trends – such as big data (Müller et al., 2018) – found that investments in big data and analytics increased firm-level productivity significantly, and particularly in information intensive and competitive industries.

Concluding, there is a wide body of research that provides evidence for a strong positive relationship between IT and organizational performance on the firm level. However, the amount of available studies thins out when searching for research that pays particular attention to the relationship between IT resources and the competitive environment.

A major study that systematically investigated the link between IT spending and competitiveness in U.S. industries between 1960 and 2005 was performed by McAfee and Brynjolfsson (2008). Their findings suggest that industries spending relatively more in IT than other industries (in the following labelled as “high-IT industries” vs. “low-IT industries”) display accelerated competition after 1995, which correlates with the drastic increase in IT investments across all industries in the mid-1990s. Moreover, productivity growth in the U.S. economy accelerated sharply within the same period (Stiroh, 2002).

In their HBR article, McAfee and Brynjolfsson (2008) employ three distinct metrics to measure industry-level competition: turbulence, performance spread, and concentration. Turbulence is the absolute average rank change of sales compared to the previous year. Performance spread is the interquartile range of gross profit margin in an industry. In other words, it represents the difference between the company performing at the 25th percentile and the 75th percentile in its industry. Market concentration is represented by the Herfindahl-Hirschman Index (HHI).

McAfee and Brynjolfsson’s HBR article is based on the quantitative study published in Brynjolfsson et al. (2008) – here, we learn that the authors use the industry-level IT share of capital services from (Stiroh, 2002) as a metric for measuring how IT intensive a certain industry is. This measure is used in (McAfee and Brynjolfsson 2008) to distinguish between high-IT and low-IT industries.

The results presented by McAfee and Brynjolfsson (2008) indicate that the turbulence in high-IT industries was much higher than in low-IT industries after 1995. Furthermore, the performance spread between the highest and lowest performers has grown, meaning that the industry leaders have increased
their lead while laggards have increasingly been left behind. The findings also suggest that high-IT industries tend to display a slightly higher increase in concentration compared to low-IT industries. Overall, the findings suggest that the trend of decreasing industry concentration has reversed in the mid-1990s for both high-IT and low-IT industries.

The regression models on industry concentration and turbulence in (Brynjolfsson et al., 2008) generally underpin the propositions of McAfee and Brynjolfsson (2008). They provide evidence for a strong link between IT investments and accelerated competition at the industry level. However, they only examined industry concentration and sales turbulence in that paper. In both papers, the authors argue that the driver behind these changes to the competitive landscape is not merely due to IT resources becoming a catalyst for business process innovations but they also become an enabler to propagate those processes quicker and more efficiently across the firm. The ability to replicate these processes consistently stems from the integrative nature of IT resources. They argue that when IT is used to embed and replicate business processes well, it can enforce standardized and more consistent processes almost instantly and facilitate the interaction with complementary resources, thus increasing organizational performance. As a consequence, firms that diffuse innovation successfully can grow more rapidly "at the expense of other firms, leading to winner-take-all dynamics and hence greater concentration" (Brynjolfsson et al., 2008, p. 2). This implies that the best performers pull away from the rest and widen the gap between leaders and laggards in their industry (McAfee and Brynjolfsson, 2008). Additionally, they argue that the successful adoption of IT-enabled business processes does not guarantee sustained advantage over competitors. Competitors and new entrants can copy the first mover and further innovate their business model to quickly supersede the current industry leaders, thus creating a turbulent competitive environment.

These arguments generally align with the RBV, but they also draw from theories of hypercompetition and Schumpeterian creative destruction (Schumpeter, 1947), which support the proposition that in such turbulent environments no sustained (long-term) advantages can be achieved because technological changes (e.g. IT solutions) can be imitated or replaced increasingly effortlessly by competitors (D’Aveni et al., 2010). Those who gain a temporary competitive advantage through strong innovation can pull away and create a concentrated "winner-take-all" environment. This reduces the applicability of the RBV by ruling out sustained competitive advantages in turbulent environments.

Brynjolfsson et al. (2008) suggest that the increased availability of Enterprise IT, such as ERP systems, in the mid-1990s acted as the main catalyst for the drastic acceleration in competition. Software vendors made it possible to conveniently buy and deploy IT solutions (relatively) quickly instead of developing them internally. Besides, the deployment of generic Enterprise IT to improve processes was amplified with the expansion of the Internet that made most of the private networks redundant.

Implementing a similar methodological approach, Stiroh (2002) quantified the impact of IT on industry-level productivity using a bottom-up approach by drawing on firm-level data. He used “labor productivity acceleration” as dependent variable and different measures for IT intensity as predictors, such as the previously mentioned IT share of capital services. A split variable was applied to study the difference between the time before and after 1995. This method was later adapted by Brynjolfsson et al. (2008) with the difference that the dependent variables were, as introduced above, turbulence and concentration, instead of productivity measures. Stiroh (2002) illustrated that those industries that made the largest IT investments showed larger productivity gains especially after 1995. These results are consistent with the findings of Brynjolfsson and McAfee and provide further evidence for significant changes to the competitive environment due to information technology investments.

We were able to find two replications of McAfee and Brynjolfsson’s work: Neirotti and Pesce (2019) and Neirotti et al. (2016) investigated the competitive environment in Italy. Although, due to different macro environment, their results are not directly comparable to the competitive landscape in the U.S., they provide evidence for accelerated competition in an overall less IT-intensive country like Italy and that spendings on IT may have still influenced the competitive nature of industries in more recent years. Since our first aim is to replicate the findings of McAfee and Brynjolfsson (2008) and extend their study with current data, we hypothesize that IT investments are associated with higher industry turbulence,
concentration, and performance spread. In addition, according to their findings and the fact that firms’ investments into IT have strongly increase since 1995, we propose that the competition has accelerated significantly after 1995. Therefore, our hypotheses are as follows:

H1a: High IT intensity in an industry is associated with higher turbulence.
H1b: High IT intensity in an industry is associated with higher performance spread.
H1c: High IT intensity in an industry is associated with higher concentration.

H2a: The relationship between IT intensity and turbulence is stronger after 1995.
H2c: The relationship between IT intensity and concentration is stronger after 1995.

This concludes the replication part of our study. For more recent years, since McAfee and Brynjolfsson have conducted their study, there will be two contradicting arguments. On one hand, we might simply extrapolate their view and argue that the positive relationship between IT intensity and competition has proceeded since then:

H3+a: The relationship between IT intensity and turbulence has further increased after 2005.
H3+b: The relationship between IT intensity and performance spread has further increased after 2005.
H3+c: The relationship between IT intensity and concentration has further increased after 2005.

On the other hand, we can also come up with a contradicting proposition to their argument of sustained hypercompetition, as argued in the following.

In 2003, Carr published the controversial article "IT doesn’t matter", which sparked a fierce debate on the strategic importance of IT investments. He argued that a resource is only of strategic importance and can therefore be used to gain an edge over competitors, if the resource is scarce. But, as the core functions of IT have become available and affordable to anyone, the capacity to sustain a competitive advantage has diminished. Carr differentiates between proprietary and infrastructural technologies. While proprietary technologies can be owned by a single company that allows it to reap higher profits than its competitors for as long as the technology remains protected, infrastructural technologies are much more valuable to a company when the technology is shared with other companies. However, in the early stages of its build-out, an infrastructural technology may behave like a proprietary technology because accessibility is restricted through e.g. high adoption costs, intellectual property rights or even a lack of standards. But as the build-out of an infrastructural technology progresses, its strategic value for a company to differentiate itself from its competitors declines as the technology will become accessible and affordable to all. Carr argues that once a technology has become ubiquitous, the influence it has will be on the macroeconomic level rather than at the firm level. Carr further maintains that IT possesses all the characteristics of an infrastructural technology that is near its commoditization. This suggests that the strategic advantage due to the implementation of generic information systems is diminishing over time and only a few firms have the capabilities to gain and maintain competitive advantages through highly specialized proprietary information systems that are not easy to replicate by others (Carr, 2003).

This proposition aligns with the RBV and seems to be supported by others (e.g. Davenport, 2005). To investigate this proposition of commoditized IT, we hypothesize that the impact of IT resources on the competitive environment in industries has not further increased but instead decreased after the investigation by McAfee and Brynjolfsson (2008), thus:

H3-a: The relationship between IT intensity and turbulence has declined after 2005.
H3-b: The relationship between IT intensity and performance spread has declined after 2005.
H3-c: The relationship between IT intensity and concentration has declined after 2005.

In the following, we describe how we have tested our hypotheses.
3 Methodology

To establish whether there is a relationship between IT intensity and industry dynamics, a secondary analysis of quantitative data gathered and combined from different sources was performed. The analysis follows the established "Knowledge Discovery in Databases" (KDD) process model by Fayyad et al. (1996) which is "the process of using the database along with any required selection, pre-processing, subsampling, and transformations of it; to apply data mining methods (algorithms) to enumerate patterns from it" (p. 83). The section below describes our approach for each step of the KDD process.

3.1 Data Collection

Company-level data were obtained from COMPUSTAT. To assign firms to an industry, we classified them according to the North American Industry Classification System (NAICS). NAICS codes group companies that use similar processes to produce goods or services together, whereas other industry classification systems often group companies based on either demand or production. As the argumentation underlying our hypotheses builds on the effects that IT investments have on business processes that change the competitive landscape within industries, using the NAICS seems to be most appropriate. Another advantage of using NAICS codes is that aggregate industry-level data that were obtained from the BEA (Bureau of Economic Analysis) and the BLS (Bureau of Labor Statistics) do also use the NAICS. This allows for a reliable mapping between firm data from COMPUSTAT and industry-level data obtained from government authorities.

The Multifactor Productivity data from the BLS contains detailed measures of capital services of 61 NAICS industries comprising the private business sector. As pointed out by McAfee and Brynjolfsson (2008), there are various factors other than IT that may confound the competitive nature within industries. In congruence with them, we controlled for R&D spendings as well as for M&A activity. These measures were also obtained from COMPUSTAT.

3.2 Data Pre-processing and Transformation

To derive the final metrics for the statistical models, all data needed to be transformed: The turbulence metric for each industry is represented by the average absolute rank change in sales for a given industry for each year. The turbulence of an individual company for the year \( t \) is computed as the absolute difference in rank compared to the previous year \( t-1 \). To model industry concentration, we calculated the Herfindahl-Hirschman Index (HHI), which is computed from the sum of squares of firms’ market shares within each industry\(^2\). The performance spread is represented by the interquartile range (IQR) of gross profit margins within an industry as described in (McAfee and Brynjolfsson, 2008).

All previously described competition metrics for a given year \( t \) have been smoothed by calculating a rolling average value over three years (\( t, t-1, t-2 \)) to account for the volatile nature of firm-level data from COMPUSTAT. This approach was adopted from (Brynjolfsson et al., 2008).

As pointed out by Stiroh (2002), a good indicator for IT intensity is the IT share of capital services “because it identifies industries spending tangible investment on IT and relocating inputs towards high tech assets” (Stiroh, 2002, p. 1567). Because capital service figures are estimated based on age-efficiency profiles for each type of asset, they can represent the actual productivity of assets over time more accurately. The “age-efficiency pattern describes the change in an asset’s productive efficiency as the asset ages. Typically, the age-efficiency profile is expressed relative to the productive efficiency of

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\(^2\) While the HHI was also used in Brynjolfsson et al. (2008), McAfee and Brynjolfsson (2008) utilized the 20-firm concentration ratio (CR) for sales, instead. We did nevertheless decide to use the HHI as our main concentration metric because it is more robust to variance in industry size as individual market shares are squared before being summarized.
a new asset” (OECD, 2009, p. 60). In contrast, capital stock measures are based on geometric depreciation profiles which rather represent the current market value of old assets as a percentage of new assets (OECD, 2009).

To illustrate, one can of course express the value of an old computer by comparing its computing power to a new generation computer, but often newer hardware also allows the user to install new software that leads to improved processes that increase productivity organizational performance. If the new software cannot be run on older hardware, then the old computer loses much more of its value than the capital stock measure would indicate through geometric depreciation models.

IT intensity is thus defined as the ratio of ICT to the total capital service flow. ICT is composed of hardware, communication technologies, and software. Since our aim is to show how IT resources play a crucial role for a firm’s competitiveness, the measure of IT intensity should reflect the resulting dematerialization. Therefore, we aggregated all asset categories such as intellectual property products (IPP) and equipment, because if the IT ratio of each asset were to be calculated first and the mean overall asset categories IT ratio would be used to measure IT intensity, asset categories with a low total volume would have a big impact on the intensity3. As final step of data pre-processing, extreme outliers (lower than \( \text{first quartile} - 3 \times IQR \) or larger than \( \text{third quartile} + 3 \times IQR \)) were removed.

The following table provides the descriptive statistics and correlations among the variables used.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Skewness</th>
<th># of firms</th>
<th>M&amp;A</th>
<th>R&amp;D</th>
<th>Turbulence</th>
<th>Perf. spread</th>
<th>HHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT intensity</td>
<td>.04</td>
<td>.07</td>
<td>3.54</td>
<td>.25</td>
<td>.22</td>
<td>-.07</td>
<td>.29</td>
<td>.23</td>
<td>-.11</td>
</tr>
<tr>
<td># of firms</td>
<td>113.25</td>
<td>110.97</td>
<td>2.12</td>
<td>.32</td>
<td>-.12</td>
<td>.87</td>
<td>.10</td>
<td>-.45</td>
<td></td>
</tr>
<tr>
<td>M&amp;A</td>
<td>3486.03</td>
<td>11915.96</td>
<td>6.32</td>
<td>-.16</td>
<td>.27</td>
<td>-.02</td>
<td>-.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D</td>
<td>-75.84</td>
<td>693.86</td>
<td>7.56</td>
<td>-.11</td>
<td>.02</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbulence</td>
<td>4.51</td>
<td>4.02</td>
<td>1.63</td>
<td>.24</td>
<td>.12</td>
<td>1.22</td>
<td>.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perf. Spread</td>
<td>.12</td>
<td>.10</td>
<td>1.93</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>HHI</td>
<td></td>
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</table>

Table 1. Descriptive measures (left) and correlations between variables (right)

### 3.3 Statistical Analysis

As we aimed at replicating the study of McAfee and Brynjolfsson, we also used their main statistical method (OLS regressions) with robust standard errors to analyze the changes in competition over time. The R software environment was used to perform statistical analysis4. To conceptually replicate the findings of (McAfee and Brynjolfsson, 2008) and investigate whether there was a significant acceleration in the competition after 1995, we introduced a post-1995 dummy, where the value of the dummy equals one if the year is 1996 or higher. The interaction between the post-1995 dummy and the IT intensity predictor will be used to assess possible differences. In a similar vein, to study the changes that occurred after the period of investigation of (McAfee and Brynjolfsson, 2008) (1987-2005), we introduced a post-2005 dummy, which equals 1 for data from 2006 to 2018 and 0 for data from 1987 to 2005. The interaction term between the IT intensity and the dummy will then be examined to study possible differences.

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3 The Forestry and Fishing Sector in 1987 illustrates this point clearly. The total productive capital value for software assets was .022, which is 100% of all IPP assets. But, computers and hardware, on the other hand, made up 0% of all the equipment assets. The measure for IT intensity would then be 0.5, which does not adequately represent dematerialization triggered by process innovations through ICT as described in (Brynjolfsson et al. 2008).

4 Brynjolfsson et al. (2008) did also use GLS as a second approach of analysis but did not find any structural differences compared to the OLS-based results. Therefore and because of limited space, we restricted our analysis to the use of OLS.
changes in trend. Furthermore, we do also run a separate analysis of the data from 2006-2018 to specifically examine the more recent relationship between IT intensity and the competition metrics.

4 Results

In this section, our results are presented. Table 2 provides the regression models for turbulence. The results suggest a strong link between IT intensity and industry turbulence (H1a). Furthermore, the strongly significant 1995-dummy variable suggests that turbulence has increased significantly after 1995. The significant interaction effect between the 1995-dummy and IT intensity indicates that IT intensity yields even higher industry turbulence after 1995 (H2a).

Interestingly, the regression models fitted on the entire data for 1987 to 2018 (Models 5 to 7) reveal a significant trend reversal. Despite IT intensity remaining a significant predictor for industry turbulence, the interaction between the post-2005 dummy and IT intensity reveals that, although higher IT intensities are related to higher turbulence, the relationship has weakened after 2005. This finding is further supported by Model 4, which uses only the data from 2006 to 2018 and shows a still significant (H1a) but much lower path coefficient for IT intensity (H3-a).

Next, we tested the models for performance spread (Table 3). In general, the results indicate a positive relationship between performance spread and IT intensity (H1b). The negative interaction effect in Model 7 indicates a change in trend as the influence of IT intensity on the performance spread is lower in more recent years (H3-b). This is also consistent with the lower coefficient of IT intensity in Model 4. It is important to note that, while the IT intensity predictors are highly significant, the R²'s are quite low. This is due to the high volatility of the performance spread metric.

Finally, we tested the effect of IT intensity on market concentration (Table 4). Between 1987 and 2005, in most cases, the results show a significant positive relationship between IT intensity and concentration (H1c); here, the post-1995 dummy as well as the interaction between IT intensity and the post-1995 dummy, are not significant. Thus, the model does not suggest that industry concentration has increased after 1995 (H2c). When examining the data of the overall timeframe to examine changes in IT-induced industry concentration after 2005, Model 7 displays a negative interaction between the post-2005 dummy and IT intensity (H3-c). An additional slope analysis showed that the effect of IT intensity on market concentration has not only weakened but even reversed in more recent years. Model 4, which uses only the data from 2006-2018, supports this finding as there is a significant negative relationship between IT intensity and industry concentration (H1c).
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<td>2.80*** (.76)</td>
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Table 2. Industry Turbulence OLS models (regression coefficients, robust standard errors, levels of significance (***: p < .001, **: p < .01, *: p < .05), R², and # of observations)

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<thead>
<tr>
<th>Model</th>
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Table 3. Performance Spread OLS models (regression coefficients, robust standard errors, levels of significance (***: p < .001, **: p < .01, *: p < .05), R², and # of observations)
Table 4. Industry Concentration OLS models (regression coefficients, robust standard errors, levels of significance (***, p < .001, **, p < .01, *, p < .05), R^2, and # observations)

To increase the reliability of our results, we conducted a couple of post-hoc analyses. First, we note that IT value studies are sometimes criticized for ignoring time lag effects. Therefore, we repeated the tests above by regressing the same predictors on time-lagged outcome variables (t+3, t+4); we could not find any differences to our original calculations – therefore, we stuck to the original models and remained methodologically consistent with Brynjolfsson et al. (2008). Second, we might argue that the amount of hardware capital is much higher in most industries than software capital is – which weakens the influence of software capital when combining both into one metric. Fortunately, the available data allowed for splitting IT capital services into hardware, software, and telecommunications. We repeated the analyses above with ‘IT intensity’ being separately replaced by ‘hardware intensity’, ‘software intensity’, and ‘telecommunications intensity’, accordingly. Again, we did not find any structural differences compared to the results in Tables 2 to 4 above. In the following, we discuss the implications of our findings.

5 Discussion

The reported results provide an updated perspective on the link between IT intensity and the competitive nature of industries. The scope of prior research was limited to data of the last century and early 2000s, and little is known about recent developments regarding the impact of IT investments on the competitive nature of U.S. industries. Our first objective has been to replicate the findings of McAfee and Brynjolfsson (2008). The tests support the hypothesis that, in general, higher industry-level IT intensity is associated with higher market turbulence (H1a), with larger performance spreads between leaders and laggards within an industry (H1b), and with higher industry concentration (H1c). Further, the models also illustrate that the link between IT intensity and competition with regard to turbulence has become stronger after 1995 (H2a). Surprisingly, our models do not suggest that industry concentration has risen after 1995 (H2c). This finding contradicts the earlier studies (McAfee and Brynjolfsson, 2008, Brynjolfsson et al., 2008), which suggested that industry concentration had at least slightly increased after 1995. As noted above, we have used another concentration measure than McAfee and Brynjolfsson, which might be the cause for this deviating result. We did however also run the calculation with their original concentration measure and still found our results to remain stable. Moreover, they did also
remain consistent when moving the breakpoint for the dummy variable to 1994 or 1996 instead of 1995. One possible explanation for this discrepancy may be due to different databases used. In particular, the underlying NAICS classification has been revised several times since 2008. While COMPUSTAT data is still based on 1997 NAICS codes, the BLS and BEA databases have updated their classification systems in accordance with the NAICS industry code revisions. As a consequence, some firms might have been mapped to other industries compared to the earlier studies. Since data based on old classification systems are not available, this assumption cannot be empirically validated.

The second objective of this paper was to test whether the hypotheses of McAfee and Brynjolfsson (2008) still hold true for more recent data since 2006. Our tests suggest that IT investments are still significantly related with higher industry-level turbulence and performance spread (H1a,b). By contrast, higher IT intensity is not related with higher industry concentration anymore (H1c). Instead, the effect becomes even negative, hence displaying a clear trend reversal compared to the previous studies.

While the influence of IT investments on industry concentration has vanished, the relationship between IT and the other competition metrics has changed considerably as well. The results show that the impact of IT investments on turbulence has decreased substantially after 2005 (H3-a), suggesting even a trend reversal. Moreover, the link between performance spread and IT has declined in recent years (H3-b).

At first glance, these findings appear rather contradictory, as we observe a trend change regarding turbulence and concentration, yet the performance gap between industry leaders and laggards remains much larger in high-IT industries. However, the underlying theory of Schumpeterian creative destruction and hypercompetition is able to explain the turbulent nature in highly competitive industries while at the same time allowing for the development of concentrated “winner-take-all” industries. There is no extensive literature on how the performance spread of industries is linked to competitive dynamics. McAfee and Brynjolfsson (2008) infer that those firms with the most successful IT-based innovations will invest even more in successive competitive moves and therefore pull away from a group of competitors, which thus will not be able to keep up. This contradicts the notion of hypercompetition and Schumpeterian creative destruction, where the central assumption is that leaders can always be leapfrogged by new entrants or existing competitors. Therefore, the IT-induced hypercompetition may not correlate with the IT-induced widening of the gap between industry leaders and laggards. This can be nicely seen even in the early years of the growth of Amazon, which started with a very simple e-commerce business model that was easy to copy – however, as Bezos managed to establish a continuous series of innovation moves that complemented and extended Amazon’s value proposition further and further, no one has been able to catch up.

So, while IT may lead to a sustained performance spread, the data suggest that the level of hypercompetition has decreased, hinting at a potential shift to IT resources turning into commodities. These suggestions may be biased towards physical infrastructure technologies as they generally make up most of the IT asset stock, hence they also affect the findings the most. So, consistent with the idea that infrastructural IT will lose its strategic value once the technology has become widely accessible, only proprietary software solutions have the potential to yield competitive advantages (Carr 2003). However, as exemplified using Amazon above, the sustained performance spread despite declining market dynamics is also an indication that the majority of IT innovations is of a combinatorial rather than of a disruptive nature; top performers in industries have developed capabilities to continuously build out their superior market position by adding new, complementary, innovations on what they have already in place. This, in turn, maps very well with the dynamic capabilities perspective: Firms that have established the managerial capabilities to utilize new technologies and have established an IT architecture which allows them to do this quickly and effectively in a business-consistent manner, can stay ahead of the competitors over time and achieve a consistently higher performance.

In summary, this study shows a significant slowdown in the Schumpeterian competition. The trend reversal may be a hint that the strategic (i.e., differential) value of IT may decrease as the bulk of IT assets has become increasingly commoditized, while top performers can still stay at the top by continuous digital innovation, drawn from their dynamic capabilities. Table 5 summarizes our findings.
Hypothesis Earlier study by Our study
Brynjolfsson and McAfee

H1: High IT intensity → higher competitive dynamics Confirmed for turbulence, performance spread, and market concentration Confirmed for turbulence and performance spread. Confirmed for market concentration until 2005 only. Then, the relationship reversed.

H2: The relationship between IT intensity and market dynamics is stronger after 1995 Confirmed for turbulence, performance spread, and market concentration Confirmed for turbulence only

H3+: The relationship between IT intensity and market dynamics has further increased after 2005. (N/A) Falsified

H3-: The relationship between IT intensity and market dynamics has declined after 2005. (N/A) Confirmed for turbulence, performance spread, and market concentration

| Table 5. Summary of this study’s findings, compared to (Brynjolfsson et al. 2008; McAfee and Brynjolfsson 2008) |

Our study is of course not free from limitations: A general weakness that arises from the nature of the data is the potential for measurement errors in the metrics used for market dynamics. Since COMPUTSTAT only provides data of public firms, this may lead to further biases. Further, as already noted above, changes of databases (possible re-assignment of firms to other industry groups over time) and the even more fundamental problem that it gets increasingly problematic to assign a company to a specific industry at all, given that industry boundaries are blurring due to digitalization (Nicholls-Nixon and Dale, 1995), are making industry-level comparisons difficult. Moreover, our analysis was limited to physical (IT) capital (hardware and software) while the bigger part of IT spending (> 60 %) goes into IT workforce and external services, ranging from consulting to outsourcing and cloud (Kappelman et al., 2021), – which might have a larger or smaller effect on the different industry-level variables.

The generalizability of our results is subject to certain limitations, too. While we covered all industries in our study, Melville et al. (2004) introduced the macro environment as another moderating factor for IT employment. Particularly, the telco infrastructure shapes the way industries can deploy IT resources (Melville et al., 2004). Hence, our findings on competitive dynamics can only be reliably applied to U.S. industries and will maybe not hold for countries with a less or more mature digital infrastructure.

6 Conclusion

This paper set out to reevaluate the findings of McAfee and Brynjolfsson (2008) on IT induced changes to the competitive environment and to investigate recent developments. The results provide evidence for a slowdown in competitive dynamics in terms of turbulence, performance spread and concentration, supporting the proposition that (parts of) the IT resource will eventually become a commodity. On the other side, the spread between high and low performers within an industry remains larger in industries with comparatively high IT intensity, which refers to the combinatorial rather than disruptive nature of the majority of digital innovations.

This paper has been among the first attempts to identify trend changes with regard to the link between information technology and the competitive nature of industries. Despite the study being limited to U.S. industries, the study certainly adds to our understanding of the recent trends in IT business value research. Future research should both widen the perspective by, e.g., conducting similar studies in other economies and deepen the analyses by tapping into more granular categories of IT spending, also trying to take firms’ and their providers’ non-technical IT resources, such as the IT workforce, into account. Consequently, our findings can be put into a meaningful context and further provide a solid foundation for identifying the economic role of IT and digitalization at the industry level.
References


