Scale without Mass: Business Process Replication and Industry Dynamics

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Since the mid-1990s, productivity growth has accelerated in the U.S. economy. In this paper, we identify several other changes in the economy that have occurred during the same time and argue that they are consistent with an increased use of information technology (IT) in general and enterprise information technology in particular. In a series of case studies, we find that IT can enable firms to more rapidly replicate improved business processes throughout an organization, thereby not only increasing productivity but also market share and market value. We develop a simple model that shows how this process will increase both turbulence and concentration in affected industries. We then document a substantial increase in firm-level turbulence starting in the 1990s, as measured by the average intra-industry rank change in sales, enterprise value, and other metrics. Furthermore, we find that IT-intensive industries account for most of this increase in turbulence, especially after 1996. Before 1996, IT-intensive industries were becoming less concentrated than non IT-intensive industries; this situation reversed in the late 1990s. The combination of increased turbulence and concentration, especially among IT-intensive industries, is consistent with an increasingly Schumpeterian style of competition. We conclude that the improved ability of firms to replicate business innovations has affected not only productivity, but also the nature of business competition itself.

Key words: Business Process Replication; Creative Destruction; Information Technology; Industry Concentration

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1 Introduction: IT Heterogeneity and its Implications

The real, quality-adjusted quantity of computing power used by American companies increased by several orders of magnitude between 1986 and 2006. Because one of the key roles of both firms and markets is information processing (see, for example, Hayek 1945 and Galbraith 1973), it would be surprising if this radical increase in information technology (IT) stocks did not have large effects on business performance and industry dynamics.

A stream of economics research has focused on articulating the consequences of the rapid penetration of IT into the U.S. economy. A key finding has been the linkage between IT investment and the surge in U.S. economic productivity, especially since 1995 (Brynjolfsson and Hitt 2000, Oliner and Sichel 2000, Stiroh 2002, Brynjolfsson and Hitt 2003, Dedrick et al. 2003). The research also suggests that nothing about IT appears to be evenly distributed. IT investment levels themselves vary greatly across firms and industries, as do the organizational forms and practices accompanying these investments (Bresnahan et al. 2002) and the outcomes linked to them, including productivity and revenue gains (Brynjolfsson and Hitt 1996, Dedrick et al. 2003, Brunner et al. 2006), stock market valuations (Brynjolfsson and Yang 1997, Brynjolffson et al. 2002), and share-price volatility (Chun et al. 2005). Research has also repeatedly demonstrated that the correlation between IT investment and positive outcomes is far from perfect; it is possible to spend heavily on IT and realize few or no benefits (see, for example, Brynjolfsson and Hitt 2000).

This paper extends research on the consequences of IT heterogeneity by considering outcomes related to competition, namely concentration and turbulence. We find that a positive relationship has existed since the mid-1990s between an industry's IT intensity and its levels of turbulence and concentration growth. We hypothesize that this is the case because IT has become a means of embedding business innovations, then replicating them across an increasingly large intra-firm "footprint." Today, managers can scale up their process innovations rapidly via technology without the degree of inertia historically associated with larger firms. In other words, they can achieve scale without mass.

However, these innovations do not diffuse equally across all firms in an industry. Firms that successfully use IT to embed and diffuse innovations grow relatively rapidly at the expense of other firms, leading to greater concentration at the industry level. Because firms operate in dynamic environments, however, successful adoption of a set of IT-enabled business innovations at one point in time does not guarantee sustained dominance. Competitors and new entrants can also innovate and replicate with IT over time, leading to high levels of turbulence within an industry. These phenomena are more salient in IT-intensive industries than in non-IT-intensive ones.

This paper is organized as follows. Section 2, which makes use of several short case studies, describes how contemporary IT is used to embed and deploy business innovations, and why this work could be expected to lead to competitive heterogeneity across firms in an industry. Section 3 presents a more formal model of competition which shows how, over time, both concentration and turbulence will increase as IT-enabled replication becomes more prevalent. Section 4 describes our data sources and variables, and Section 5 gives results of empirical analyses that make use of industry-level IT endowment and firm-level performance data. These analyses indicate that, since the mid-1990s, IT-intensive industries have experienced higher levels of turbulence and concentration growth than have non-IT-intensive ones and that these differences were not as strong when IT was less pervasive. Section 6 presents a brief summary and conclusion.

2 IT and Business Process Replication

2.1 Volatility and Technology

In recent years, the U.S. economy has been characterized by increased levels of firm-specific volatility even as the economy as a whole became less volatile (Comin and Mulani 2004, Irvine and Schuh 2005). Campbell et al. (2001) find that while market- and industry-level stock variance remained largely stable between 1962 and 1997, firm-specific variance more than doubled over the same period. Campbell et al. also document a decrease over time in correlations among individual stocks. Chun et al. (2005) document similar patterns in firm-specific and systematic volatility between 1971 and 2000, and also find a positive relationship between firm-specific volatility and the IT intensity (as measured by IT's percentage of total capital stock) of the industry in which a firm resides.

IT has been identified as a source of industrial disruption and shifts in market value since the early 1970s (Hobijn and Jovanovic 2001). Stiroh (2002), however, finds clear evidence of a positive association between IT intensity and productivity growth in many U.S. industries only since the mid-1990s. Oliner and Sichel (2000) note that, until recently, IT represented only a relatively small portion of the capital stock of U.S. firms, and thus could not be expected to have a significant impact on high-level outcomes.

2.2 IT and Business Process Replication

Information technology enables the replication of certain types of innovations at almost no cost. Bits, for example, can be copied much more easily than atoms. This ease of replication is especially evident in the computer software and hardware industries themselves. When a software engineer improves a sorting algorithm in a database management program, a digital copy of that improved process can be instantly copied and included in thousands or even millions of copies of the next release of that program. The Internet has broadened the set of activities subject to this phenomenon to include an increasing share of commerce (Blinder 2000). Today, for example, when a marketing expert at Amazon.com develops a better sequence of images, words, and data requests for reducing abandoned “shopping carts” on the site’s checkout page, a digital copy of that algorithm can instantly be made available in millions of virtual storefronts on customer desktop PCs worldwide.

It is easy to see the power of replication in these purely digital domains. But economic impacts also derive from business process changes that involve technology, people, and physical products. An early example was Mrs. Fields Cookies (Cash and Ostrofsky 1986). Randy Fields sought to replicate not only his wife’s cookie recipes throughout thousands of small stores, but also the daily, minute-by-minute routine that made her initial Palo Alto store so successful, including when to mix each cookie batch, when to dispose of unsold cookies, when to offer more free samples, what questions to ask of job applicants, and so on. As better business processes were developed, they were embedded in store management software that guided each employee worldwide based on a set of algorithms combined with local data and parameters. Other franchisors and chain stores have adopted similar technologies to address processes ranging from inventory management to pricing.

2.3 Enterprise Information Technology

In the 1990s, the use of technology to embed and replicate business processes became more sophisticated and pervasive, addressing industries far more complex than cookie baking. In 1992, the German IT vendor SAP released R/3, an enterprise system with client-server architecture. R/3 quickly proved popular with large corporations, and other software vendors soon released enterprise information technology

(EIT) aimed at different types of firms (e.g., large vs. medium-sized, discrete vs. continuous manufacturing) and different business processes (e.g. customer-facing vs. supplier-facing, administrative vs. operational). Previously, firms that wanted integrated information systems had to develop them internally. The availability of commercial EIT meant that firms now could purchase systems that interlinked their functions.

The geographic "reach" of EIT was greatly increased by the Internet, which freed companies from having to construct private networks when extending their systems to remote locations. The "Internet era" that began in the mid-1990s can also be thought of as the era of enterprise computing. By one estimate, up to three-quarters of U.S. corporate IT spending is now devoted to EIT (McAfee 2003). With EIT, insights about better ways to work need not remain localized or diffuse slowly; instead, they can be replicated widely and with complete technical fidelity. Just as a digital copy of a photograph or song can be endlessly copied and distributed with no degradation of quality, so too can copies of EIT-embedded business processes. Enterprise technologies thereby give firms the capability to "copy exactly" the IT-based elements of their business processes. Exact copying of interdependent processes has been shown to be optimal when initial knowledge is low, learning is difficult, and innovation lifecycles are short (Terwiesch and Wu 2004). EIT allows firms to propagate a wide range of operational and administrative processes across all appropriate units. It is possible, of course, for people within the units to work around, game, or even sabotage these processes, but these behaviors are often at least somewhat observable since transactions are recorded in databases.

Case Study: In 2002, the retail pharmacy firm CVS became concerned about high customer turnover and formed a team to determine root causes and implement solutions. The team found that an initial step in the process of filling prescriptions was a computer-based drug safety check, performed approximately one hour before the desired pick-up time. Immediately after the safety check, the firm's enterprise system for pharmacy operations performed a check of the customer's insurance status. If the prescription passed both of these steps, fulfillment was rarely problematic and could be completed in less than five minutes. However, 17% of prescriptions encountered problems during the insurance check, the majority of which could not be resolved without involving the customer.

The team decided to switch the order of the two computerized checks and to perform the insurance check at the time of prescription drop-off while the customer was still present. Both of these changes were embedded in the firm's EIT. Most insurance problems had simple sources, such as an incorrect date of birth or a change of employer, which were resolved immediately. The new process led to significant increases in customer retention and satisfaction. Once developed, the changes did not simply improve performance at one CVS location. On the contrary, using the IT platform, the process changes were replicated across CVS's more than 4000 retail pharmacies within a year (McAfee 2005).

Other documented examples of business process replication via EIT include:

- European distributors of midrange computers linking their internal information systems to IBM's to standardize and automate order placement (McAfee and Otten 2005).
- The Port Authority of Dubai's success in convincing both large and small shipping agents to submit and clear cargo documents electronically rather than with paper (McAfee et al. 2002).
- The Spanish clothing retailer Zara's ability to let local managers at over 750 stores worldwide place individualized orders using uniform technologies, templates, and deadlines (McAfee et al. 2004).

In each of these cases, the advance took the form of a new business process embedded and deployed by the use of enterprise IT.

IT can also assist with the propagation of other types of innovation; technologies such as email, instant messaging, groupware, information portals, blogs, and wikis let employees share information and ideas widely and, in many cases, generate them collaboratively (McAfee 2006). Like EIT, these technologies are also tools for replicating valuable business innovations, albeit ones that are less formal or structured than entire processes.

It is important to note that business process replication is perfectly consistent with decentralized decision rights, and with local innovation. In many cases, the myriad small innovations and improvements generated by line employees are collectively more important that any centrally conceived business process changes. Zara's technology, for example, is explicitly designed to facilitate the rapid response to local tastes as perceived by store managers around the world. Similarly, the many information technologies that explicitly or implicitly facilitate collaboration and the propagation of ideas will amplify and accelerate productivity improvements which might have remained localized in earlier decades.

2.4 Difficulty of Intra-firm Propagation

Of course, replicating business innovations throughout organizations is nothing new. The rise of multi-establishment firms in general and the M-form Corporation in particular reflect efforts to replicate key business processes throughout an organization (Chandler 1990). However, replication has historically been costly, slow, and imperfect. While training programs, oral and written instructions, and other tools and techniques can help, human communication is inevitably imperfect, and much information is garbled or remains tacit (Hayek 1945, Leonard-Barton 1989, Ancori et al. 2000).

Even with EIT, process replication can be difficult. Commercial EIT and the Internet have lowered many technical barriers, but other impediments exist. Business process design and deployment is organizationally challenging, as is the imposition of greater monitoring. Numerous case studies document the failure of large-scale IT adoption efforts, some so harmful that they led to firm failure (e.g., Rose and MacDonald 1998). Surveys of EIT adoption efforts report failure rates of 30-75%, depending on the technology studied and the definition of failure used (McAfee 2003). Across these investigations, a consensus emerges that the observed failures have organizational root causes, not technical or budgetary ones. As one review of the literature concluded, "…extant empirical research supports the assertion that economic and technical considerations are unlikely to feature prominently when IT fails to deliver" (McDonagh 2001).

2.5 Difficulty of Inter-firm Propagation

As difficult as intra-firm propagation of novel business processes can be, propagating them across firms is typically far more challenging. The process configuration that works well in one firm might not transfer well to one with a different culture, set of pre-existing routines, mix of incentives, asset base, and approach to human resources. Empirical research shows that many beneficial managerial practices are not universally diffused across firms (Bloom and Van Reenen 2005) and highlights the importance of complementarities in explaining the difficulty of diffusion (Ichniowski et al. 1997).

This work suggests that the boundary of the firm is a significant barrier to the diffusion of IT-enabled work changes. This conclusion is supported by research on the heterogeneity of workplace reorganizations in the presence of IT (Bresnahan et al. 2002) and by research that reveals large differences in firm-level outcomes such as productivity growth even after controlling for IT investment (Brynjolfsson and Hitt 2000).

Case Study: It became evident in the late 1990s that the discount retailer Kmart operated less efficiently than did competitor Wal-Mart. Specifically, Kmart suffered from poor inventory availability in its stores due to inadequate forecasting and fulfillment processes. Wal-Mart's operational excellence was due in part to an integrated IT infrastructure that rapidly transmitted sales and inventory data from all stores to headquarters.

In October 2000, Kmart, whose previous large-scale IT initiatives had stumbled, announced a $1.7 billion effort to improve both its physical and IT infrastructures. This process adoption effort, which reflected a conscious strategy to adopt many of the processes of market-leading Wal-Mart, did not succeed. In fall 2001, Kmart wrote off two distribution centers and IT assets related to the effort worth $130 million while announcing a redirected $600 million IT strategy. In January 2002, Kmart declared bankruptcy. The firm had had four chief information officers in the previous five years (Konicki 2002).

2.6 New Growth Theory and Creative Destruction

As the case studies throughout this section illustrate, firms are using information technologies to embed and diffuse new knowledge. Although the "new growth theory" (Romer 1990, Romer 1994) has typically focused on the national economy, rather than the firm, as the primary unit of analysis, its insistence that knowledge, technology, and innovation be treated endogenously make it applicable to our work.

At least three of new growth theory's stylized facts seem applicable when considering the competitive impact of IT on firms in an industry. First, the theory asserts that while knowledge is non-rival, it is at least somewhat excludable (Romer 1990). That is, trade secrets, path dependence, intellectual property protection, and other mechanisms combine to give the generator of new knowledge the ability to at least partially exclude others from its benefits. Second, new growth theory maintains that knowledge-based competition tends to become monopolistic over time (Romer 1992). Increasing returns to knowledge, a cornerstone of new growth theory, implies that leading firms will build up significant advantages over their rivals such that they become monopolies. This idea is consistent with the insight that information itself can create economies of scale because of its relative ease of replication (Wilson 1975).

Monopolies are not eternal, however, because of a third stylized fact labeled "creative destruction" by Joseph Schumpeter. Competitive equilibria are repeatedly disturbed by innovation and new knowledge; consequently, new ways of working displace old ones. Outcomes and end states, as a result, become very difficult to predict (Romer 1994, Arthur 1996). One result that *can* be anticipated is that, as competition revolves increasingly around knowledge, Schumpeterian creative destruction becomes increasingly pronounced.

Case Study: In January 1998, brokerage Charles Schwab offered Internet-based stock trades to all of its customers for $29.95 per trade, ending the previous tiered pricing structure. By December 1998, Schwab's market capitalization surpassed that of Merrill Lynch, a firm with nearly three times as many client assets under management. Many analysts expected Merrill Lynch to also offer discounted online trading, but Schwab's CEO remarked, "I don't think Merrill will ever have two things that have been critical to our success. First, they will never embrace technology as the core of their business the way we do. Second, they will never have as low a cost structure as we do, which will make it hard for them to offer superior value" (McFarlan and Tempest 2001).

Merrill Lynch unveiled its "Integrated Choice" program in June 1999. Integrated Choice offered a range of trading support and investment advisory options; its most basic option was similar to Schwab's, offering online trades for $29.95. In tandem with the launch of Integrated Choice, Merrill Lynch made significant IT investments and changed the inventive structure of many of its employees (McFarlan and Weber 2001). Unlike the first generation of Web-based trading platforms, Merrill's system focused not simply on low costs and simple execution of trades, but on a richer flow of information and advice that leveraged some of the unique assets, including a research staff, possessed by Merrill Lynch. The new offerings were well-received by customers, and Merrill began to acquire new client assets more rapidly than Schwab. By October 2005, Merrill Lynch's market capitalization was almost four times that of Charles Schwab.

2.7 Hypotheses

We hypothesize that, since the mid-1990s, when the adoption of commercial EIT and business use of the Internet both began in earnest, an industry's IT intensity has been positively associated with its level of turbulence, defined here as the average yearly rank change among firms in measures such as sales and enterprise value. While turbulence differs from firm-specific volatility, our hypothesis is consistent with the claims of Chun et al. (2005) related to IT's impact on volatility.

Chun et al. also argue that because general purpose technologies benefit newer firms more than incumbents and because newer firms are likely to be smaller than incumbents, IT should benefit smaller firms more than larger ones. If this is true, IT intensity should be associated with lower aggregate concentration and lower levels of measures such as the Herfindahl index. We argue, however, that IT-based capabilities such as business process replication and standardization, monitoring, and remote collaboration are just as likely to be beneficial to larger firms. These capabilities help overcome the losses of control, visibility, and personal connection that often accompany a larger scale, where high fidelity replication of business processes is especially relevant to competitive success. IT intensity should therefore be positively related to concentration growth at the industry level. This hypothesis is consistent with White's speculation that "Improved technologies of managing and monitoring may have helped overcome the inherent difficulties of managing larger organizations (Williamson 1967) and thus encouraged larger enterprises" (White 2002).

Our broad hypothesis is that because the capabilities IT delivers are valuable, difficult to acquire, and often transient, IT in recent years has become the opposite of a competitive leveler, or a "cost of business that must be paid by all but provides distinction to none" (Carr 2003). Indeed, Brynjolffson and Smith (2003) find that IT was not a "great equalizer" even in purely online markets. We posit instead that, since the mid-1990s, the dual innovations of commercial EIT and business use of the Internet have heightened both turbulence and concentration in industries where IT is intensively used. The following section formalizes these hypotheses.

3 Model

We use a simple dynamic model to illustrate the impact of information technology on firm performance and industry structure. Consider an industry with two competing firms, A and B. Assume the economy has n cities and each firm has one branch in every city. Let the branches be $A_1, A_2, ..., A_n$ for firm A and $B_1, B_2, ..., B_n$ for firm B. Assume A_i and B_i are competing in city i. Further, assume customers in each city are uniformly distributed on a line with density one. Each period consists of two stages. In the first stage, the branches of the two firms decide their locations in each city simultaneously. In the second stage, they select their technologies and announce their prices simultaneously.

We assume quadratic transportation cost tx^2, where t is the transportation cost per unit of length and x is the distance between a consumer's location to a branch. The marginal costs of the two branches, c_i^A and c_i^B, have the same expected value, but their variances are determined by the technologies selected. In each period, $c_i^A = \bar{c} + k_i^A$ and $c_i^B = \bar{c} + k_i^B$, where $\bar{c}$ is a constant and k_i^A, k_i^B are independently drawn from the same uniform distribution U(- $f(IT_{ind})$, $f(IT_{ind})$), where $f(IT_{ind})$ is a function of total IT stock in the industry and is greater than zero. We assume $f'(IT_{ind}) > 0$ to capture the fact that more IT stock used in the production processes often lead to greater potential to affect costs. We also assume the performance of a branch in the current period to be uncorrelated to its past performance, as modern innovations tend to make old competence obsolete.[1]

In equilibrium, the two branches will choose to locate at the two ends of the linear city (see Tirole 1988 or D'Aspremont et al. 1979 for detailed derivations). The equilibrium prices are:

[1] The results do not change if we assume weak correlation.

$p_i^A = t + \frac{2}{3}c_i^A + \frac{1}{3}c_i^B$ and $p_i^B = t + \frac{1}{3}c_i^A + \frac{2}{3}c_i^B$ and market shares are: $MS_i^A = \frac{1}{2} + \frac{c_i^B - c_i^A}{6t}$ and $MS_i^B = \frac{1}{2} + \frac{c_i^A - c_i^B}{6t}$.

Assume that c_A and c_B are the lowest marginal costs among all branches of firm A and firm B respectively. Without loss of generality, assume $c_A < c_B$. The new growth theory suggests that knowledge is partially excludable (Romer 1990, Romer 1994). A natural implication of this theory in our setting is that IT processes can be replicated within the same firm but not beyond the firm boundary. As a result, it can be shown (see Appendix A) that the variances of market shares for both firms, MS_A and MS_B, are positively correlated to IT_{ind}. That is, the volatility of market shares increase as the total IT stock in the industry increases. In addition, if we assume that the ability to replicate is positively associated with IT_{ind}, we can similarly show that the gap between MS_A and MS_B increases with IT_{ind}; i.e., the industry becomes more concentrated with the increased use of IT.

This gives us two formal propositions:

P1: The variance of market share is an increasing function of IT intensity: $\frac{dVar(MS)}{d(IT_{ind})} > 0$

P2: The concentration of market share is an increasing function of IT intensity: $\frac{dVar(Conc)}{d(IT_{ind})} > 0$

4 Data Sources and Variables

To test our hypotheses, we gather data on industry-level concentration, turbulence, and IT intensity from multiple sources. In our study, we classify industries using the North American Industry Classification System (NAICS).

4.1 Industry Turbulence and Concentration

We evaluate industry-level turbulence and concentration for two outcomes of interest: revenue (sales) and enterprise value (EV). For each measure, the turbulence of an industry of year t is calculated as the average rank change of all firms in that industry from year t-1 to t. We use rank change instead of actual change because we do not want to include events that affect all firms in an industry uniformly, such as a sudden change in input prices. Rank change has been used in many papers to measure volatility (see, for example, Comin and Phillipon 2005).

We measure the concentration at the industry level with the Herfindahl index (HI), which is calculated by squaring the market share of each firm in the industry and then summing the squares. As EV can sometimes be negative, we standardize the lowest negative value in each industry to zero to properly calculate HI.

Hou and Robinson (2004), note that yearly HI data might be subject to high volatility. To correct for this possibility, we follow their approach and average the data over three years. We report the results of the average in this paper. (The results are slightly weaker but substantively unchanged when unaveraged year-by-year data are used.).

Panel A of Table 1 provides a detailed description of the above variables and our construction of them.

4.2 IT Intensity

We obtained data on industry-level IT and non-IT capital from the Bureau of Economic Analysis's (BEA) "Tangible Wealth Survey." These data are available for 63 industry sectors at roughly the three-digit NAICS level from 1987 to 2004. IT capital comprises computer hardware (mainframes, personal computers, storage devices, printers, terminals, tape drives, and integrated systems) and computer software (prepackaged, custom, and own-account). A more appropriate measure than IT capital stock levels is the service flow of IT stock (Jorgenson and Stiroh 2000, Stiroh 2002). Following the approach outlined in Jorgenson and Stiroh, we calculate the service flow for IT and other forms of capital. Throughout the remainder of this paper, we use the phrase "IT capital" as shorthand for "IT capital service flows"; the same is true for "total capital."

Following Stiroh (2002), we use three different measures of IT intensity: IT capital as the percentage of total tangible wealth (i.e., capital stock), IT capital per full-time employee (FTE),[2] and IT capital as the percentage of nominal industry output. Like Stiroh, we use IT capital as a percentage of tangible wealth (ITTW) as our primary measure of IT intensity.

After calculating ITTW for each industry and year in our dataset, we use these figures to calculate each industry's z-value for each year from 1987-2004. We then calculate each industry's mean z-value over this time period. We use these 1987-2004 mean z-values as a continuous measure of each industry's IT intensity. In our analyses below, therefore, each industry has a single IT intensity value.[3] To arrive at a discrete categorization of industries as either IT-intensive or non IT-intensive, we took as the threshold the median of these 1987-2004 mean z-values.

We summarize the variables for IT intensity and construction method in Panel B of Table 1.

4.3 Combining Data

While the BEA reports capital stock information for the Federal Reserve and credit intermediation industries separately, it combines these two industries when reporting the FTE data. In addition, no firms in CompuStat are classified into the Federal Reserve industry. Therefore, we drop the Federal Reserve industry from our capital stock dataset and use the combined FTE data for the credit intermediation industry only. CompuStat also does not contain any firms in the industry 51, "Management of Companies." We therefore drop this industry as well.[4] Our final dataset thus consists of 61 industries. For each industry, we present data on different IT-intensity measures from 1987-2004 and data on industry concentration and turbulence from 1971-2004.

[2] Data on the number of full-time employees (FTE) from 1998 to 2004 are from Section 6 of the BEA "National Income and Product Accounts Tables." Earlier data on FTEs from BEA are based on SIC. We generate values for NAICS-based industries by taking the percentage change in the employment from the SIC data. Data on industry output are also from BEA and are detailed at Bureau of Economic Analysis (2004).

[3] We also conduct analyses in which each industry's IT intensity varied from year to year based on its z-value for the year. Results are substantively unchanged from those reported here.

[4] In addition, BEA combines the hospital and nursing industries when reporting the industry-level GDP. To address this problem, we allocate their total GDP evenly to each industry.

5 Empirical Results

This section empirically investigates the effects of rapid IT adoption on the competitive dynamics of US industries. As Figures 1a and 1b show, the U.S. economy became substantially more IT intensive from 1987-2004. Figure 1a plots corporate IT stock (at historical cost) per FTE by year; the graph shows accelerating IT intensity from 1987-2000, followed by two years of decline corresponding to recession. IT per FTE resumed its upward trend in 2003. By 2004, at more than $2,600, it was the highest it had ever been and was more than three times higher than it had been in 1987, even before adjusting for the large increase in real computing power delivered per dollar of expenditure. Figure 1b plots IT's percentage of total investment in tangible wealth each year, together with the equivalent percentages for equipment and plant (the three values for each year sum to 100). IT's share of the total increased more than 10% during this period to almost 23% of total tangible wealth.

We present two sets of regression results tying IT to industry-level turbulence and concentration growth. We first examine whether IT-intensive industries in general are more turbulent and are concentrating faster than non IT-intensive industries during 1987-2004. We find that IT-intensive industries are consistently more turbulent than non IT-intensive ones during this period, but not concentrating at significantly higher rates. We then take a difference-in-differences approach that relates industries' IT intensities to their pre- vs. post-1996 changes in turbulence and concentration growth. We show that IT intensity is a significant factor in post-1996 changes to industry dynamics captured by these measures. Finally, we discuss robustness checks to evaluate whether our key findings are artifacts of our particular measures, operationalizations, and model specifications.

5.1 Turbulence and Concentration Growth in IT-intensive and non IT-intensive Industries

To examine the difference in the turbulence levels and concentration growth rates between IT-intensive and non IT-intensive industries from 1987-2004, we consider the following model:

$$(1) \quad y = \beta_0 + \beta_1 \mathrm{IT} + \beta_2 \#\text{ of firms} + \varepsilon$$

where *y* is the dependent variable. When the outcome of interest is the turbulence, *y* is measured as the average rank change of sales or enterprise value. When the outcome of interest is the concentration growth, *y* is measured as the percentage change of the Herfindahl Index for sales or enterprise value. For discrete operationalization of IT intensity, *IT* is 1 if an industry is IT intensive, 0 otherwise. For continuous operationalization, *IT* is measured as the logarithm of mean value of IT as a percentage of total wealth over the sample period. We also include the number of firms for each industry in each period as a control variable. In the case of turbulence, as the number of firms in an industry increases, firms in the industry will have greater potential to change their ranks. Similarly, in the case of concentration, the number of firms indicates the level of competition and may affect the change of the Herfindahl index. Removing this control variable gives stronger results in all models.

As the continuous measure captures the actual magnitude of difference in IT intensities, we focus our discussion on the continuous measure of IT and use the discrete operationalization of IT as a robustness check.

Table 2 reports the regression results where the average rank change of sales and enterprise value are used as the dependent variable respectively. We also consider some specifications in which we drop low-density industries, or outliers for dependent and independent variables. An industry is considered to be low-density if CompuStat has data for 5 or fewer firms for this industry in at least one year from 1987 to 2004. We consider an industry as an outlier if its value for the dependent or independent variable in any year is more than four standard deviations away from the population mean. Panel C of Table 1 lists low-density and outlier industries. In all models shown in Table 2, the coefficients for IT intensity and the number of firms are significant at 1% level. The results indicate that IT intensive industries are more turbulent than non IT-intensive ones during 1987-2004.

We then run a similar set of regressions using the percentage change in concentration (as measured by the Herfindahl index) as the dependent variable and report the results in Table 3. None of the specifications shows significantly growth in concentration among IT-intensive industries over the period 1987-2004. In fact, in all cases, the coefficient of the IT variable is negative, albeit often statistically in-significant. This result indicates that industry-level IT intensity was *not* positively associated with concentration growth during the years 1987-2004. We now proceed to divide these years into two periods, and compare the turbulence and concentration growth in these two periods.

5.2 Turbulence and Concentration Growth Pre- and Post-1996 for IT-intensive and Non IT-intensive Industries

We first consider the appropriate year to use to divide our sample period (1987-2004) into two periods. Chow test results suggest that 1995, 1996, or 1997 could be used as the break year. In particular, we find that the year 1996 gives the most notable and economically significant accelerations in both turbulence and concentration growth rates. Thus, in the following analyses, we use 1996 as the break year. (Results are very similar if we use 1995 or 1997 as the break year.)

Visual inspection of data indicates differences in turbulence and concentration growth before and after 1996. Figure 2a plots each industry's average yearly sales turbulence levels over the period 1987-1996 against the same average for the period 1997-2004. In these graphs, data points above the 45-degree line represent industries in which turbulence was higher in the more recent period. This figure shows that the increase in turbulence is widespread rather than limited to one or two industries. Figure 2b is a parallel graph of the average percentage change in the Herfindahl index of sales during the two time periods. In both graphs, we observe a similar pattern: the majority of the data points fall above the 45-degree line. This suggests that industries in general are becoming more turbulent and are concentrating faster post-1996.

We next turn to examining these patterns in a regression framework, taking a difference-in-difference approach:

$$\text{(2)}\quad y = \beta_0 + \beta_1 \text{D96} + \beta_2 \text{IT} + \beta_3 \text{D96} \cdot \text{IT} + \beta_4 \#\text{ of firms} + \varepsilon$$

where D96 equals 1 if the year is higher than 1996 and 0 otherwise. This model extends equation (1) with an additional dummy for the post-break year period and its interaction with the IT intensity measure.

We first consider turbulence. Table 4 reports the results for sales and enterprise value in Panel A and B respectively. We first estimate models without the IT variable to determine whether there is a general increase in turbulence after 1996. Models 1-4 in the two panels suggest that the post-1996 period is significantly more turbulent for sales but not for EV. We then introduce the IT variable without the interaction term. The results from Models 5-8 suggest that even when we control for the time period, IT-intensive industries are still significantly more turbulent than are non-IT-intensive industries. Finally, we include the interaction term. Consistent with patterns evident in Figure 2a, results from the last three models show that the increase in turbulence after 1996 is more pronounced for IT-intensive industries.

We then conduct a similar analysis for the concentration growth rates and report the results in Table 5. Similar to the turbulence results, industries on average concentrate faster after 1996. Controlling for the time period, the IT variable does not show any significance. The coefficient for the IT variable is negative in all cases. After we add the interaction term, in several instances, the negative coefficient for IT variable becomes significant. This suggests that before 1996, the concentration growth rate for IT-intensive industries was actually below that of non-IT-intensive industries. The coefficient for the interaction term in the weighted models is positive and significant. This indicates that IT-intensive industries concentrated more quickly than did non-IT-intensive ones after 1996.

5.3 Robustness Checks

A natural concern is whether our results are a consequence of our choice of metrics and parameters. In unreported regressions, we modify our analyses in several ways to explore the robustness of our findings.

We first discretely categorize industries as IT-intensive or non-IT-intensive based on their relation to the median intensity and repeat the analysis. We obtain similar results.

We also look at other outcomes of interest in addition to sales and enterprise value, such as earnings before interest, taxes, depreciation, and amortization (EBITDA) and total assets. We also employ other operationalizations of the dependent variables for concentration, such as the first difference in the logarithm of the Herfindahl index and the percentage change in the four-firm concentration ratio (C4). Results are again similar. In addition, as there is no standard definition of IT intensity, we also repeat the analysis for two other measures of IT intensity: IT capital per FTE and IT capital per industry output. The results are broadly consistent with those presented here. In fact, we obtain higher significance for the IT-intensity variable in a number of cases.

6 Conclusion

Enterprise information technology is increasingly pervasive in American businesses. As a result, firms are able to more rapidly and completely replicate their innovations in business processes, achieving scale without mass. Other types of IT, such as email, knowledge management systems, wikis, and instant messaging allow firms to propagate innovations that are less structured than entire business processes (McAfee 2006). IT makes it possible for better techniques and processes to become rapidly known and adopted throughout the organization.

We show through a formal model how this process can lead to increased turbulence and concentration. In particular, competition becomes increasingly Schumpeterian as innovators are able to leverage their best practices to rapidly gain market share. At the same time, competitors and new entrants have the opportunity to more rapidly leap-frog and displace leading firms. Our model is consistent not only with the increase in productivity growth since the mid-1990s, but also with the higher levels of turbulence. Furthermore, as predicted by our model, concentration levels have also increased in IT-intensive industries, an outcome that is not consistent with other explanations for higher turbulence.

Our research cannot conclusively establish that causality flows unidirectionally from IT investments to changes in industry dynamics, but our analyses of economy-wide data do present evidence of discontinuities in these dynamics beginning at approximately the same time that investments in IT, and particularly enterprise IT, accelerated. It is particularly reassuring that our qualitative case studies of individual firms and competitive dyads provide clear examples of the phenomena we model and illustrate the causal mechanism.

We believe that a great deal of fruitful ground exists between the case studies and the economy-wide analyses. In particular, future research detailing the competitive impact of IT within a single industry could help clarify the impetus for technology investments, their timing, and their effects.

Further research could also help determine the duration of IT's competitive impact. Recent U.S. productivity growth remains strong, indicating that IT continues to contribute positively to productivity acceleration even though IT itself is no longer novel. If IT is in fact a means to embed and replicate business innovations within a firm, if the boundary of the firm remains high, and if the stock of valuable business innovations is not yet depleted, then one might expect to observe a permanent positive relationship between IT intensity and levels of turbulence and concentration growth rather than a transient one. However, our model does not necessarily predict that these trends will persist indefinitely. Investments in IT and especially EIT are the key drivers in our story; if they tail off, then, all else being equal, so would productivity, turbulence, and concentration growth. Furthermore, the nature of IT itself is multi-faceted and evolving. If innovations in business processes become easier to translate across firm boundaries, the variance in returns might decrease rather than increase.

Acknowledgements

We are grateful to Warren McFarlan and to workshop participants at Harvard University, Carnegie Mellon University, and the National Bureau of Economic Research for insightful comments on this research. We are also grateful to the Harvard Business School Division of Research, the MIT Center for eBusiness, and the National Science Foundation (IIS- 0085725) for generous funding.

Appendix A

By definition, we know that $c_A = \min(c_1^A, c_2^A, ..., c_n^A)$. Without loss of generality, we normalize the expected value of c_i^A, $\bar{c}$, to be zero. We have:

$$\Pr(c_A \geq y) = \Pr(\min(c_1^A, c_2^A, \ldots, c_n^A) \geq y) = \Pr((c_1^A \geq y) \cap (c_2^A \geq y) \ldots \cap (c_n^A \geq y))$$

$$= \prod_{i=1}^{n} \Pr(c_i^A \geq y) = (\frac{1}{2} - \frac{y}{2f(IT_{ind})})^n$$

Therefore, $F(y) = 1 - (\frac{1}{2} - \frac{y}{2f(IT_{ind})})^n$.

The density function of c_A is $f(y) = \frac{n}{2f(IT_{ind})}(\frac{1}{2} - \frac{y}{2f(IT_{ind})})^{n-1}$. We then have:

$$E(c_A) = \int_{y=-f(IT_{ind})}^{f(IT_{ind})} \frac{ny}{2f(IT_{ind})}(\frac{1}{2} - \frac{y}{2f(IT_{ind})})^{n-1} dy = -\frac{n-1}{n+1} f(IT_{ind})$$

Similarly,

$$E(c_A^2) = \int_{y=-f(IT_{ind})}^{f(IT_{ind})} \frac{ny^2}{2f(IT_{ind})}(\frac{1}{2} - \frac{y}{2f(IT_{ind})})^{n-1} dy = \frac{f^2(IT_{ind})n(2+n(n-1))}{n(n+1)(n+2)}$$

Therefore,

$$Var(c_A) = E(c_A^2) - E(c_A)^2 = f^2(IT_{ind})(\frac{4n}{(n+1)^2(n+2)})$$

$Var(c_A) = Var(c_B)$. Since c_A and c_B are independent, $Cov(c_A, c_B) = 0$.

Therefore, the variance of the market shares of firm A and B, MS_A and MS_B, are:

$$Var(MS_A) = Var(\frac{1}{2} + \frac{c_B - c_A}{6t}) = \frac{1}{36t^2}(Var(c_B) + Var(c_A)) = \frac{f^2(IT_{ind})}{9t^2}(\frac{2n}{(n+1)^2(n+2)})$$

Hence, $\frac{dVar(MS_A)}{d(IT_{ind})} > 0$. $Var(MS_B)$ has the same expression.

Table 1

Variable definitions and definitions of outliers. In Panel A, we report data sources used to compute industry concentration and turbulence. In Panel B, we report data sources used to compute IT intensity for each industry. Panel C reports definitions of low-density industries, outliers for dependent and independent variables. The data on IT and non-IT capital are available for 63 industries from BEA. Federal Reserve banks and Management of Companies are dropped in all analyses because CompuStat does not have any data on these industries. An industry is considered a low-density industry if CompuStat has data for only five or fewer firms for this industry in at least one year during 1987-2004. The independent variable used in our regressions is the continuous operationalization of IT capital share of tangible wealth (ITTW). The dependent variables for turbulence analyses are average rank change for sales and enterprise value (EV); for concentration growth analyses they are the percentage change in the Herfindahl Index for sales and enterprise value (EV). We consider an industry an outlier if its value is more than four standard deviations away from the industry mean.

Panel A: Industry Concentration and Turbulence

Variable	Source	Computation
Enterprise Value (EV)	CompuStat	Enterprise Value = Market Value (data25 * data199) + Total Debt (data9 + data34) + Preferred Stock (data130) - Cash and Equivalents (data1) (For two financial industries (Credit intermediation and related activities, and Securities, commodity contracts, investments), enterprise value is calculated without cash and equivalents because of savings accounts.)
Revenue (sasles)	CompuStat	Data 12

Panel B: IT Intensity

Variable	Source	Computation
IT Capital	BEA	Created from the BEA “Tangible Wealth Survey” following the approach outlined in Stiroh (2002)
Non-IT Capital	BEA	Created from the BEA “Tangible Wealth Survey” following the approach outlined in Stiroh (2002)
Total Capital	BEA	IT Capital + Non-IT Capital
Full-time Employees (FTE)	BEA	From Section 6 of the BEA “National Income and Product Accounts Tables”
Industry Output	BEA	From “Survey of Current Business” detailed at Bureau of Economic Analysis (2004)

Panel C: Definitions of Low-density Industries and Outliers

Low-density industries: Forestry & Fishing; Transit; Warehousing; Broadcasting; Information Processing; Legal Services

		Outliers
Independent Variable	ITTW	Computer Systems Design and Related Services
Dependent Variables	Average Rank Change for Sales	Computer and Electronic Product Manufacturing Credit Intermediation and Related Activities
	Average Rank Change for EV	Computer and Electronic Product Manufacturing Credit Intermediation and Related Activities
	Percentage Change in Herfindahl Index for Sales	Miscellaneous Health Care
	Percentage Change in Herfindahl Index for EV	None

Table 2

Comparing turbulence levels of IT intensive industries with non IT-intensive industries using continuous operationalization of IT intensity. The sample period is 1987-2004. The dependent variables are average rank change of sales and enterprise value (EV) of industry *i* from year *t-1* to year *t* respectively. Here IT intensity is a continuous variable. We first calculate IT capital share as a percentage of tangible wealth (ITTW) for each industry in each year, and calculate z-values of these figures for each industry by year. We then calculate each industry's mean z-value over this time period. The logarithms of these mean z-values are used as continuous measures for each industry's IT intensity. Model 1 and Model 2 are OLS and other models are weighted least squares using the square root of FTE in each industry in each year as weights. Standard errors are in parenthesis. All regressions allow errors to be correlated across industries and are corrected for heteroskedasticity.

	Average Rank Change for Sales				**Average Rank Change for EV**			
Model	1	2	3	4	1	2	3	4
IT-intensity	0.55***	0.30***	0.87***	0.92***	0.75***	0.34***	1.02***	0.90***
	(0.17)	(0.08)	(0.19)	(0.15)	(0.22)	(0.13)	(0.23)	(0.20)
# of firms	0.041***	0.041***	0.037***	0.033***	0.07***	0.074***	0.064***	0.066***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Weights			yes	yes			yes	yes
Industry fixed effects								
Drop Outliers		yes		yes		yes		yes
Drop low-density industries		yes		yes		yes		yes
Observations	1096	936	1096	936	1095	936	1095	936
Number of industries	61	52	61	52	61	52	61	52
R-squared	0.74	0.77	0.83	0.9	0.83	0.84	0.89	0.93

* Significant at the 10-percent level; ** Significant at the 5-percent level; *** Significant at the 1-percent level

Table 3

Comparing concentration growth rate of IT intensive industries with non IT-intensive industries using continuous operationalization of IT intensity. The sample period is 1987-2004. The dependent variables are percentage changes in Herfindahl Index (HI) of sales and enterprise value (EV) of industry *i* from year *t-1* to year *t* respectively. Following Hou and Robinson (2004), we average the HI over 3 years. We first calculate IT capital share as a percentage of tangible wealth (ITTW) for each industry in each year, and calculate z-values of these figures for each industry by year. We then calculate each industry's mean z-value over this time period. The logarithms of these mean z-values are used as continuous measures for each industry's IT intensity. Model 1 and Model 2 are OLS and other models are weighted least squares using the square root of FTE in each industry in each year as weights. Standard errors are in parenthesis. All regressions allow errors to be correlated across industries and are corrected for heteroskedasticity.

	Percentage Change in Herfindahl Sales				**Percentage Change in Herfindahl Enterprise Value**			
Model	1	2	3	4	1	2	3	4
IT-intensity	-0.179	-0.221	-0.849*	-0.944*	-0.23	-0.256	-1.238	-1.341
	(0.32)	(0.31)	(0.47)	(0.51)	(0.33)	(0.30)	(0.90)	(0.95)
# of firms	0.001	0.003*	0.007***	0.009***	0.004	0.006**	0.012	0.014
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Weights			yes	yes			yes	yes
Drop Outliers		yes				yes		
Drop low-density industries	no	yes	no	yes	no	yes	no	yes
Observations	1098	954	1098	990	1098	972	1098	990
Number of industries	61	53	61	55	61	54	61	55
R-squared	0	0.001	0.014	0.021	0.002	0.005	0.024	0.026

* Significant at the 10-percent level; ** Significant at the 5-percent level; *** Significant at the 1-percent level

Table 4

Comparing turbulence levels of IT-intensive industries with non-IT-intensive industries pre- and post-1996 using continuous operationalization of IT intensity. The sample period is 1987-2004. In Panel A, the dependent variable is the average rank change of sales of industry *i* from year *t-1* to year *t*. In Panel B, the dependent variable is average rank change of enterprise value (EV) of industry *i* from year *t-1* to year *t*. Post-1996 dummy equals 1 if t > 1996, 0 otherwise. We first calculate 1) IT capital share as a percentage of tangible wealth (ITTW) for each industry in each year and 2) z-values of these figures for each industry by year. We then calculate each industry's mean z-value over this time period. The logarithms of these mean z-values are used as continuous measures for each industry's IT intensity. Model 1, 2, 5, 6, 9 and 10 are OLS, and other models are weighted least squares using the square root of FTE in each industry in each year as weights. Standard errors are in parentheses. All regressions allow errors to be correlated across industries and are corrected for heteroskedasticity.

Panel A: Average Rank Change of Sales

Model	1	2	3	4	5	6	7	8	9	10	11
IT-intensity					0.56***	0.30***	0.93***		0.28	0.23	0.68***
					(0.17)	(0.08)	(0.15)		(0.24)	(0.18)	(0.25)
Post-1996 dummy	0.97**	0.68***	1.19***	1.13***	0.99**	0.68***	1.20***	1.13***	1.02**	0.81***	1.16***
	(0.41)	(0.24)	(0.41)	(0.31)	(0.42)	(0.24)	(0.42)	(0.31)	(0.43)	(0.28)	(0.40)
Post-1996 dummy * IT-intensity									0.66*	0.57**	0.787**
									(0.38)	(0.27)	(0.36)
# of firms	0.042***	0.041***	0.034***	0.055***	0.041***	0.04***	0.033***	0.055***	0.041***	0.04***	0.032***
	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.002)
Weights			yes	yes			yes	yes			yes
Industry fixed effects				yes				yes			
Drop Outliers		yes	yes	yes		yes	yes	yes		yes	yes
Drop low-density industries		yes	yes	yes		yes	yes	yes		yes	yes
Observations	1096	936	936	936	1096	936	936	936	1096	936	936
Number of industries	61	52	52	52	61	52	52	52	61	52	52
R-squared	0.74	0.77	0.9	0.94	0.74	0.77	0.91	0.94	0.74	0.77	0.90

Panel B: Average Rank Change of EV

Model	1	2	3	4	5	6	7	8	9	10	11
IT-intensity					0.76***	0.35***	0.903***		0.35	0.25	0.57*
					(0.22)	(0.128)	(0.20)		(0.28)	(0.25)	(0.29)
Post-1996 dummy	0.55	0.20	.022	-0.38	0.60	0.22	0.25	-0.38	0.64	.041	.021
	(0.42)	(0.30)	(0.56)	(0.51)	(0.42)	(0.30)	(0.57)	(0.511)	(0.44)	(0.36)	(0.55)
Post-1996 dummy * IT-intensity									0.98**	0.83**	1.12**
									(0.44)	(0.39)	(0.44)
# of firms	0.072***	0.075***	0.068***	0.103***	0.07***	0.074***	0.066***	0.103***	0.07***	0.07***	0.07***
	(0.002)	(0.003)	(0.003)	(0.01)	(0.002)	(0.003)	(0.003)	(0.01)	(0.002)	(0.003)	(0.003)
Weights			yes	yes			yes	yes			yes
Industry fixed effects				yes				yes			
Drop Outliers		yes	yes	yes		yes	yes	yes		yes	yes
Drop low-density industries		yes	yes	yes		yes	yes	yes		yes	yes
Observations	1096	936	936	936	1096	936	936	936	1096	936	936
Number of industries	61	52	52	52	61	52	52	52	61	52	52
R-squared	0.83	0.83	0.93	0.96	0.83	0.84	.0.93	0.96	0.74	0.77	0.93

* Significant at the 10-percent level; ** Significant at the 5-percent level; *** Significant at the 1-percent level

Table 5

Comparing concentration growth rate of IT-intensive industries with non-IT-intensive industries pre- and post-1996 using continuous operationalization of IT intensity. The sample period is 1987-2004. In Panel A, the dependent variable is the percentage change in the Herfindahl Index (HI) of sales of industry *i* from year *t-1* to year *t*. In Panel B, the dependent variable is the percentage change in Herfindahl Index (HI) of enterprise value (EV) of industry *i* from year *t-1* to year *t*. Following Hou and Robinson (2004), we average the HI over three years. We first calculate 1) IT capital share as a percentage of tangible wealth (ITTW) for each industry in each year and 2) z-values of these figures for each industry by year. We then calculate each industry's mean z-value over this time period. The logarithms of these mean z-values are used as continuous measures for each industry's IT intensity. Model 1, 2, 5, 6, 9 and 10 are OLS and other models are weighted least squares using the square root of FTE in each industry in each year as weights. Standard errors are in parentheses. All regressions allow errors to be correlated across industries and are corrected for heteroskedasticity.

Panel A: Concentration growth rate of Sales

Model	1	2	3	4	5	6	7	8	9	10	11
IT-intensity					-0.165	-0.207	-0.843		-0.142	-0.576	-1.853***
					(0.32)	(0.31)	(0.52)		(0.42)	(0.40)	(0.72)
Post-1996 dummy	4.687***	3.536***	4.347***	4.408***	4.685***	3.534***	4.335***	4.408***	3.938***	3.172***	3.601***
	(0.80)	(0.82)	(0.89)	(0.85)	(0.81)	(0.82)	(0.90)	(0.85)	(1.00)	(0.92)	(0.92)
Post-1996 dummy * IT-intensity									-0.025	0.833	2.066**
									(0.60)	(0.57)	(1.02)
# of firms	0.001	0.002	0.006***	-0.003	0.001	0.002*	0.058***	-0.003	0.00	0.00	0.007***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)
Weights			yes	yes			yes	yes			yes
Industry fixed effects				yes				yes			
Drop Outliers		yes	yes	yes		yes	yes	yes		yes	yes
Drop low-density industries		yes	yes	yes		yes	yes	yes		yes	yes
Observations	1098	954	954	954	1098	954	954	954	1098	954	954
Number of industries	61	53	53	53	61	53	53	53	61	53	53
R-squared	0.039	0.026	0.058	0.136	0.039	0.027	0.008	0.136	0.028	0.023	0.062

Panel B: Concentration growth rate of EV

Model	1	2	3	4	5	6	7	8	9	10	11
IT-intensity					-0.214	-0.238	-1.272		-0.413	-0.422	-2.499**
					(0.33)	(0.30)	(0.98)		(0.28)	(0.41)	(1.08)
Post-1996 dummy	5.570***	4.686**	6.228*	6.180*	5.567***	4.683**	6.210*	6.180*		4.710**	5.772*
	(1.85)	(1.90)	(3.33)	(3.33)	(1.86)	(1.90)	(3.33)	(3.33)		(1.92)	(3.29)
Post-1996 dummy * IT-intensity										0.452	2.743**
										(0.68)	(1.28)
# of firms	0.003	0.005*	0.011	0.015	0.004	0.005**	0.091	0.015	0.006**	0.005**	0.01
	(0.00)	(0.00)	(0.01)	(0.02)	(0.00)	(0.00)	(0.10)	(0.02)	(0.00)	(0.00)	(0.01)
Weights			yes	yes			yes	yes			yes
Industry fixed effects				yes				yes			
Drop Outliers		yes	yes	yes		yes	yes	yes		yes	yes
Drop low-density industries		yes	yes	yes		yes	yes	yes		yes	yes
Observations	1098	972	972	972	1098	972	972	972	990	972	972
Number of industries	61	54	54	54	61	54	54	54	55	54	54
R-squared	0.042	0.036	0.049	0.081	0.042	0.037	0.005	0.081	0.005	0.037	0.056

* Significant at the 10-percent level; ** Significant at the 5-percent level; *** Significant at the 1-percent level

Figure 1

Figure 1a shows U.S. Corporate IT stocks and flows per full-time employee (FTE), and Figure 1b shows annual US corporate investment in Equipment, Plant, and IT as percentages of total , 1987-2004. In Figure 1a, each year's value is calculated by taking total IT stock (at historical cost) and dividing by total FTEs. In Figure 1b, The three values for each year sum to 100% (Data source: Bureau of Economic Analysis (BEA) Tangible Wealth Survey.)

Figure 1a

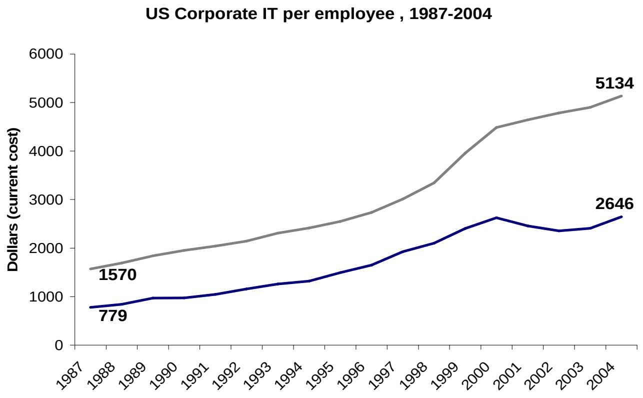


Figure 1b

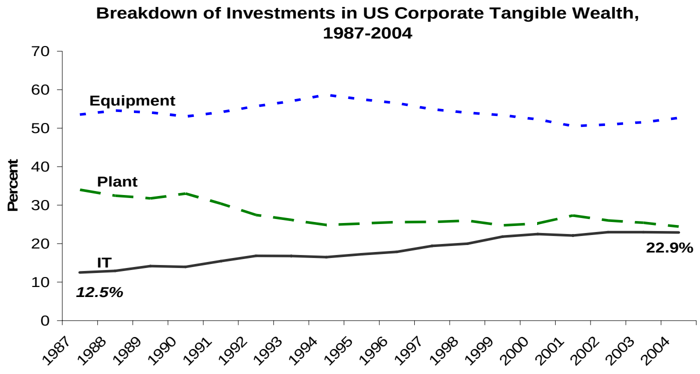


Figure 2

Scatterplot of average yearly changes in sales turbulence and average yearly changes in the Herfindahl Index of sales, 1987-1996 vs. 1997-2004. These graphs contain 55 data points, one for each industry. In Figure 2a, one industry, Computer and electronic product manufacturing, is not shown because plotting its data point – x = 36.99, y = 49.28 – would compress the rest of the graph. (Data source: CompuStat.)

Figure 2a

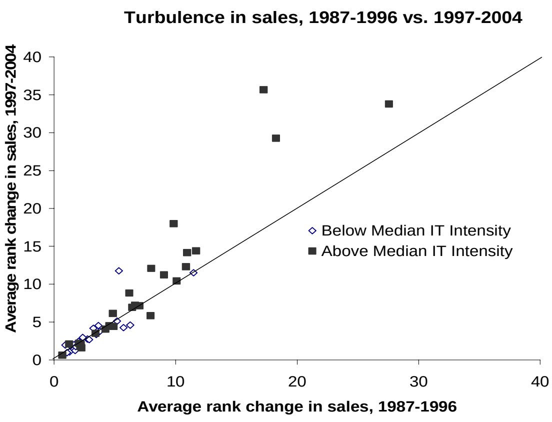
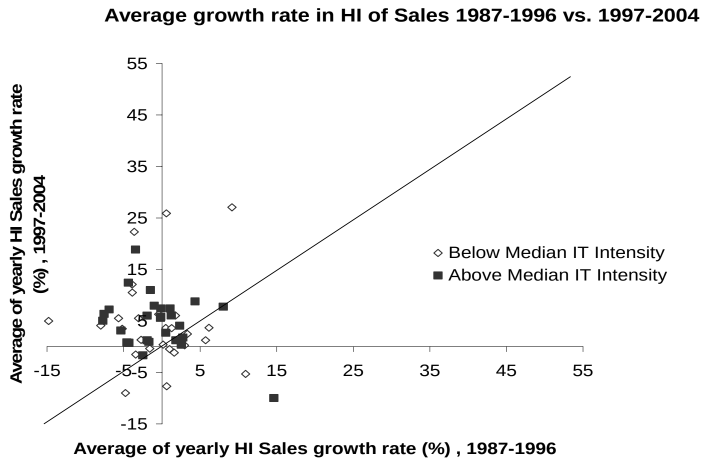


Figure 2b



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