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Technology's Effect on Firm Size: Manufacturing vs. Service

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TECHNOLOGY'S EFFECT ON FIRM SIZE: MANUFACTURING VS. SERVICE

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Abstract

We develop theory that describes how increased IT investment motivates different actions within different types of industries. We contend that manufacturing firms tend to have revenue that is firm dependent, regardless of the number of employees and thus use IT to reduce costs by reducing firm size, as stated in previous theory. However, retail and service firms tend to have revenue that is tied to the number of employees and use IT to increase firm size in order to allow greater revenue. Using 629 yearly observations from 37 industries from 1985 to 2005, we find that IT investment precedes size decreases with manufacturing firms and size increases with retail and service firms. Further, impulse response functions indicate that differences in firm size differences following IT investment eventually vanish, and non- IT-investing firms eventually achieve the same firm size after several years, indicating that IT allows firms to be more responsive.

L'EFFET DE LA TECHNOLOGIE SUR LA TAILLE DES ENTREPRISES: FABRICATION C. SERVICE

Nous soutenons que les prix de détail et les entreprises de services ont tendance à avoir des recettes qui est lié au nombre d'employés, mais ce n'est pas le cas pour les fabricants. Les deux utilisent la technologie de l'information afin d'optimiser la taille de l'entreprise. Nous examinons les 629 observations annuelles de 37 industries de 1985 à 2005, et de trouver que ce soit le cas.

Keywords: Electronic markets, Electronic hierarchies, Firm size, Firm growth, Impulse response functions

TECHNOLOGY'S EFFECT ON FIRM SIZE: MANUFACTURING VS. SERVICE

Researchers have long been interested in the effects of information technology (IT) on firm structure, stressing the importance of IT in driving organizational change and shaping company strategy (e.g., Malone et al., 1987). For example, outsourcing and off shoring can be viewed as organizational change facilitated by IT. While there has been an increasing interest in examining economic theories to understand how IT may shape the structure and size of the firm, researchers also note that empirical work on the relationship between IT and firm structure has produced few, if any, reliable generalizations (Brynjolfsson et al., 1994).

Malone et al. (1987) have developed the Electronic Market Hypothesis (EMH) and argue that IT used for communication will lead to a decrease in firm size. The rationale for this hypothesis stems from their reasoning that IT investment lowers the costs associated with information search and market transaction when compared to the cost of manufacturing goods within a firm hierarchy. There exists anecdotal and empirical evidence supporting the major points of the EMH and showing cases or time periods where technology leads to smaller firms. For example, Brynjolfsson et al. (1994) show empirical support for the EMH, in which economy-wide IT investment is coupled with economy-wide firm shrinkage in previous decades (1976-1989).

Since the introduction of the EMH in 1987, there have been revolutionary changes in communication technology. During the 1990s, investments in IT soared, and eventually became the largest proportion of capital expenditures in the U.S. companies, comprising more than $400 billion in 2000. Moreover, recent economic figures in general indicate that IT expenditures have increased, coupled with an increase in average firm size. Surprisingly, despite the incredible advances in information technology late last century and early this century, such as page formatting with HTML, the World Wide Web, proliferation of Internet-based exchanges, XML-facilitated data transfer, etc., there has been no research that we are aware of that examines the economy-wide effect of technology on firm structure, with the last economy-wide study done by Brynjolfsson et al. (1994).[1] Further, researchers that investigate firm size in relation to IT investment often caution that there are many influential factors on firm size (e.g., stock prices, regulations, interest rates, etc.). Brynjolfsson et al. (1994) cite this uncertainty and conclude that the inverse relationship between IT and firm size is a provocative finding and needs further investigation. We concur with Brynjolfsson et al. that there is a need to reinvestigate the relationship between firm size and IT investment. Especially with new data available, the present study will allow further theoretical contribution and extend the current knowledge about the effect of IT investment on firm size.

In this context, the primary objective of the current study is to address the following research questions:

- How is firm size affected by IT investment, and is that effect situationally dependent upon other factors?
- How can we theoretically reconcile the gap between the EMH, which predicts firm shrinkage resulting from IT expenditures, and a group of economic theories that predict firm growth with IT investment?
- How do firms in different industries restructure to profit from increases in efficiency driven by increased IT investment?

To address these research questions, we examine industry-level data for firm size and IT investment for 37 industries spanning 1985-2005. In addition, we employ empirical models consistent with the existing models in the literature to facilitate fair comparison between different datasets. This research results in several theoretical, empirical, and managerial contributions from this research.

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[1] While there has been little published formal and rigorous examination of how IT expenditures affect firm structure on an economy-wide scale during the two decades following the data used by Brynjolfsson et al. (1994), the topic of IT investment and firm size still resonates with IS researchers, including researchable questions investigating this relationship brought up by Hal Varian, the chief economist at Google the keynote speaker at the *2005 Workshop on Information Systems and Economics*, and a panel seminar dealing with this topic at the *2007 International Conference on Information Systems*.

From a theoretical perspective, no prior research has provided plausible explanations why firm growth occurred during the 1990s despite dramatic increases in IT investment. We theoretically explain and empirically show why the EMH does apply to the manufacturing sector but not as well to the retail and service sectors. Manufacturing firms tend to have firm-specific revenues (irrespective of firm size) and may not always require their size and employee base to grow to generate more revenue. Thus, manufacturing firms may be able to sustain revenues while reducing the number of employees. As IT investment improves efficiency, both internal transaction costs and market search costs for outsourcing are reduced, and thus, IT investment may help induce manufacturing firms to shrink in size. In contrast, retail and service firms tend to grow with firm size since more employees can generate more revenue or reduce overall costs (e.g. consider Wal-Mart or a consulting firm). For these firms, IT investment may be used to reduce the cost of growth to allow greater revenue, making firm growth more desirable. As the size of retail and service sectors increases faster than that of manufacturing, this insight can lead to a cautious prediction that overall, IT investment will lead to firm growth in the retail-oriented and service-oriented economies.

Empirically, we observe a sharp increase in IT investment in the 1990s concurrent with an increase in firm size, yet we also find that this relationship is not consistent across industrial sectors. We show that, with manufacturing industries, investment precedes a decrease in firm size, as predicted by the EMH. However, with the retail and service industries, investment precedes a increase in firm size.

We also use impulse response functions in conjunction with an autoregressive model to show that increases in IT investment do lead to changes in firm size, but that firms who do not increase their IT investment eventually catch up to the other firms. Consequently, the effect of IT investment on firm structure is temporary. This additional finding implies that the increased IT investment can help firms be more agile (e.g. Bharadwaj 2000; Jarvenpaa and Leidner 1998; Feeny and Ives 1990) in that firms utilize IT to identify and achieve firm structure goals more quickly than those firms that do not increase their IT investment. In other words, firms with increased IT investment may achieve an appropriate size more quickly than those without increased IT investment.

Literature Review

Some research suggests that firm size deceases as investments in technology increase (e.g., Malone et al. 1987) while other research contends that firms grow as technology increases (e.g., Chandler 1992; Penrose 1955). However, authors from both camps use Coase (1937) as a basis for their research. In his seminal work, "The Nature of the Firm," Coase (1937) attempts to discover why a firm emerges and grows while most other economic theories at that time concentrated on market transactions. According to Coase, firms emerge primarily to reduce the costs involved in market transactions, and a firm's size is a function of the number of transactions conducted by that firm.[2] As the firm grows, however, the coordination costs of internalizing additional transactions may rise due to "diminishing returns to management." Therefore, the firm will continue to grow as long as the costs of managing (or organizing) extra transactions within the firm is less than the costs of carrying out the transaction in the open market and less than the expected profit from the transaction.[3]

In this literature review, we examine both camps of research, paying particular attention to Coase's work and implicit and explicit assumptions made by both camps as we compare and contrast the theoretical basis for both streams. We summarize by juxtaposing the assumptions made by the two competing theories to develop a strategic firm size theory that is a generalization of both theories.

It is also worthy to note that a group of studies, deviating from the two conventional economic views of the firm, focus on firms' strategic behavior and its influence on firms' structure, size and performance. These studies help understand the procedural aspects of how increases in IT investment improve the agility of firms so that firms can anchor at a desired firm size. We define this particular domain of studies as firm agility. For instance, Zaheer and Zaheer (1997) use the resource based view of the firm and discuss the link between a firm's alertness and

[2] To quote Coase (1937, p. 393), "A firm becomes larger as additional transactions … are organized by the entrepreneur and becomes smaller as he abandons the organization of such transactions."

[3] Coase (1937, p. 395) clearly states this position: "[A] firm will tend to expand until the costs of organizing an extra transaction within the firm become equal to the costs of carrying out the same transaction by means of an exchange on the open market or the costs of organizing in another firm." In this research, we stress Coase's belief that firms wish to incorporate profitable transactions, but are limited by coordination costs.

responsiveness. Alertness can be defined as proactive attentiveness to information about the environment or as "having one's antenna out" (p. 1496), and responsiveness as the nimbleness and speed with which firms respond to environmental signals. Strategy and Information Systems (IS) researchers agree that IT facilitates the organization in undertaking strategic changes quickly and effectively (e.g., Bharadwaj 2000; Jarvenpaa and Leidner 1998; Powell and Dent-Micallef 1997; Feeny and Ives 1990). The present study supports this contention, indicating that increases in IT spending help a firm determine the proper firm size and quickly achieve that firm size.

Firm Shrinkage with Technology

Malone et al. (1987) introduced the EMH based upon Williamson's (1975) transaction cost economics (TCE) theory. They argue that, since communication technology reduces the costs of market transactions and reduces asset specificity, firms that invest in IT will be motivated toward buying goods in the market as opposed to producing goods within the firm's hierarchy. Later, Brynjolfsson et al. (1994) found empirical support for the EMH by analyzing industry data from the U.S. Census Bureau and the U.S Bureau of Economic Activity (BEA) for the time period 1976-1989, concluding that investment in IT indeed leads to smaller firms as predicted by the EMH.

EMH authors agree that IT leads to decreases in both internal coordination costs and external coordination costs, but IT investment will lead to overall relative decreases in the disadvantages of buying through market transactions. A contention of EMH is that the negative impact of both asset specificity and product complexity is reduced, leading to an overall increase in market transactions. Malone et al. (1987, p 496) claim that because of decreases in external communication costs, IT investment will ultimately lead to an overall decrease in firm size, as they state throughout their paper and in their conclusion. Brynjolffson et al. (1994, p. 1633) echoes this point and describes that if outsourcing occurs because of an increase of market transactions, we should expect to see a decrease in both the average establishment size (i.e. the number of employees per firm establishment) as well as the average amount of "value added" in the products sold by the firm. In fact, in their conclusion Brynjolfsson et al. (1994, p. 1641) relay their empirically findings that "There is substantial evidence of a relationship between increased levels of IT investment and smaller firm size."

We use Brynjolffson et al.'s (1994) empirical research as a starting template for our empirical examination of IT investment during the late 1980s, the 1990s, and the early 2000s. Because we wish to maintain consistency and a high level of comparability, we rely heavily upon their empirical model in this research, although we have added some changes that reflect recent advances in econometric analysis.[4]

Firm Growth with Technology

In this research, the term "firm growth research" refers to the theoretical position, held by a group of economics and strategy researchers, that firms tend to grow in order to incorporate profitable transactions within the firm hierarchy.

Coase (1937) is clearly interested in theorizing why a firm organizes and why markets are not the sole mechanism for economic transaction, and thus he concentrates on why a firm grows, not why the firm shrinks. Coase contends that firms grow until the cost of adding and managing one additional person exceeds the marginal profit contributed by that person. Zhu (2004) argues that IT reduces the costs of management, and thus technological advances and investment may encourage larger firms, conforming to Coase. This opinion is echoed by Baker and Hubbard (2004) who examine on board computers in the trucking industry and find that monitoring technology can reduce agency costs, thereby making firm growth more attractive. Lucas (1978) suggests that more capable managers allow for less costly management and thus larger firms. Through Lucas' theory, technology that enhances a manager's capabilities will motivate an increase in firm size. Baumol (1959, p. 37) hypothesizes that IT investment and firm size may correlate. His reasoning is that large firms may not only enjoy all the benefits of small firms, but also possess additional capability of investing in areas (including technology) that require economies of scale or are denied to smaller operations. Later, Hall and Weiss (1967) empirically support Baumol's hypothesis.

Chandler (1992) points out that it is often profitable for a firm to expand under competition. A firm that can capitalize on the existing resources would expand with less cost than a new entrant with no existing infrastructure.

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[4] Note that other literature may only partially support the EMH (e.g., Clemons, Reddi, and Row 1993; Hess and Kemerer 1994; Granados, Gupta, and Kauffman (2006); Choudhury et al. 1997).

This contention is supported by other research. Singh and Montgomery (1987) agree and point out that it is often profitable for an existing firm to enter into related industries since technologies and infrastructure of the firm can be adapted to manage the new firm with less cost than developing new infrastructure. Penrose (1955, 1959) echoes Chandler and describes how firm growth can be limited by the technological expertise of upper management. In particular, Penrose, who in general concurs with Coase, describes that administrative coordination abilities and "authoritative communication" abilities of the management may constrain further growth of the firm. Armour and Teece (1978) empirically support Penrose's and Chandler's view with an investigation of the oil industry, confirming that internal use of IT can enhance the communication within the firm and in turn motivate the firm to take on profitable ventures and grow.

In conclusion, many researchers have argued that managers wish to incorporate profitable transactions that increase the firm size, but that coordination costs limit firm growth. In their logic, technological advances in communication, technological investment, decision support, and knowledge management that reduce coordination costs will lead to an expansion in firm size.

Contrasts in the Literature

Despite some commonality, a fundamental difference exists between the two theoretical streams of research both in theory and in empirical analysis. EMH research describes how IT's effect on the reduction in external market search and coordination costs leads to smaller firms. Conversely, firm growth research focuses on technology's contribution to reduction in internal coordination cost which allows firms to take advantage of profitable opportunities, leading to firm expansion as firms incorporate more profitable transactions.

Development of the Strategic Firm Size Hypothesis

In the last section, we showed that EMH and firm growth theories make opposite predictions of the effect of IT investment on firm size. In this section, we examine the underlying implicit and explicit assumptions that may have caused contrary predictions of the two theories. This insight leads to our Strategic Firm Size Hypothesis that reconciles these competing predictions for the effect of IT investment on firm size.

We also acknowledge that the electronic market of the 1990s is vastly advanced from that of the 1970s and 1980s, when Brynjolfsson et al. (1994) gathered data to find empirical evidence to support the EMH. In the spirit of an investigation of the EMH called for by Hess and Kemerer (1994) and Brynjolfsson et al. (1994), we examine newer data in a much more advanced electronic market during the 1990s and early 2000s that were not available to prior researchers.

Rationale for the Strategic Firm Size Hypothesis

Both EMH and firm growth theories make consistent predictions about IT investment leading to a decrease in costs, yet each has different assumptions on how a firm's size affects its revenue. Proponents of the EMH implicitly assume that revenue is rather firm-specific and may be independent of firm size. Brynjolfsson et al., (1994, p. 1631-1632), for example, identify two major reasons why an increasing use of IT would lead to firm shrinkage. First, IT is substitutable for labor since it can enhance individuals' productivity. Second, IT reduces both external coordination and market search costs which may surpass the benefit of reduced internal coordination costs and thus motivates market transactions.

This implicit assumption in the EMH is often reasonable and valid in many industries. In particular, many firms in manufacturing industries can generate the same amount of revenue even after replacing some workers with less expensive technology. Thus, *ceteris paribus*, such firms are likely to reduce firm size in order to improve profits.[5]

In contrast, firm growth research suggests how a reduction in coordination costs can make transactions profitable

[5] In the manufacturing sector, 16 of the 19 industries in this study had no significant positive correlation between firm size and profitability, and thus we show evidence that firm size has little to do with profitability and that revenues are tied to the firm, rather than the individual, for manufacturing firms.

that previously were not profitable. Chandler (1992), Penrose (1959), and Teece (1988) contend that an organization can combine individual and organizational knowledge and capabilities to accomplish more profitable ventures. In this perspective, supporters of the firm growth research assume that addition of employees (thus increase in firm size) generates larger revenue to the firm, which is distinct from the implicit assumption of the EMH. In this traditional view of firm growth research, firm revenue corresponds to the number of transactions carried out by the firm, and the number of transactions corresponds to firm size. If a firm's revenue is tied to the number of employees (who provide valuable services to the firm), it is reasonable to infer that reduced management costs driven by IT investment will motivate the firm to hire more employees in an effort to increase the firm's revenue.[6]

Just as we contend the EMH implicit assumption of firm-specific revenue can be reasonable within certain industries, we also contend that the firm growth assumption of revenue as a function of firm size is also often reasonable and valid in other industries. For instance, many firms in service industries need billable hours or customer contact to generate revenue. Thus, *ceteris paribus*, such firms are likely to utilize IT to reduce internal coordination costs and increase the number of transactions and firm size in order to improve revenue.[7]

Based upon the evidence and theories in the literature, we propose that the effect of IT on firm size is dependent upon industry characteristics. In other words, in retail and service industries, firms can increase revenues by hiring more revenue-generating employees. These firms would use IT to reduce managerial costs in expanding their infrastructure and business territory, which is consistent with firm growth research. In other industries, as is often the case in manufacturing industries, revenue and firm size are not strongly tied together, and firm size reductions may still result in the same revenue with lower costs. Therefore, as enhanced IT reduces search costs and makes communicating with the market less costly, market transactions become more attractive, and firms are motivated to replace transactions conducted inside the firm hierarchy with market transactions, which is consistent with the EMH.

Note that we are not stating that the EMH argument does not hold. Instead, we contend that IT capabilities can motivate either firm growth or firm shrinkage depending on the nature of business. According to Coase, economic transactions can be organized either through a market or within a hierarchy. Given that IT affects the cost of management within a firm as well as the cost of coordination in the market, IT investment would lead to greater firm size only when the cost reduction effect of IT within the firm outweighs the effect of IT on external coordination cost across firms in the market. IT may not directly stimulate firm growth or firm shrinkage overall, but, rather, we contend that industry characteristics will determine whether IT is used for firm growth or firm shrinkage.

Research Hypotheses

As specified in the prior section, the underlying proposition in the present study is that the effect of IT on firm size is primarily dependent upon intrinsic industry-level differences associated with firms' revenue.

The implicit assumption in the EMH of firm-specific revenues seems reasonable with established manufacturing firms. Thus, the role of IT in substituting for labor and reducing market coordination (or search) costs could be evident in the manufacturing industries. Moreover, our conjecture that manufacturing firms are likely to reduce their size to become more profitable is consistent with many previous findings that examine manufacturing industries. For instance, as early as 1949, Alexander (1949) pointed out that we should expect higher frequencies of high profit rates among smaller manufacturing firms. Brynjolfsson et al. (1994) primarily investigate manufacturing firms in their sample and come to the conclusion that profitability results from a reduction in firm size among these firms. Samuels and Smyth (1968) analyze a United Kingdom dataset consisting of mainly manufacturing firms in the late 1950s and early 1960s and determine that profitability and firm size are inversely related. However, while commenting on Samuels and Smyth's research, Marcus (1969) shows that the negative relationship between size and profitability only exists in some industries, not all. We take a similar position in this research. Thus, we

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[6] This is not to say that every department is revenue-generating, but rather that services are needed inside a business, and each business faces a make-or-buy decision whether to pay for these services or to bring them within the firm boundaries. These theories would argue that bringing these people in the hierarchy of the firm offsets negative effects to revenue that would occur if market-based mechanisms were used.

[7] In the retail and service sectors, 15 of the 18 industries in this study showed a positive correlation between firm size and profitability, and thus we show evidence that firm size and firm profitability are closely tied together in retail and service firms. This differs from the results shown in manufacturing firms, as we theorized.

hypothesize that the effect of IT investment on firm growth will be negative within manufacturing industries as suggested by the EMH:

Manufacturing IT Effect Hypothesis (H1): *The effect of IT investment on firm size will be negative within manufacturing industries.*

As described in our discussion of theory, firm growth hypotheses imply that the addition of each employee has a positive influence on revenue and profits to a certain degree, especially in retail and service industries. Our rationale for relating a firm's revenue/profits to the size of the firm (measured as the number of employees) is associated with "customer contact" nature of service. For example, a retailer (e.g., Wal-Mart) or a third party logistics company (e.g., FedEx) may have to recruit more employees to enhance its revenue and profit, along with additional investments in new stores, vehicles, equipments, and information network. Accordingly, we hypothesize that the effect of IT investment on firm growth will be positive in retail and service industries:

Retail/Service IT Effect Hypothesis (H2): *The effect of IT investment on firm size will be positive for retail and service industries.*

Data and Empirical Methods

In our data collection and empirical model development, we attempt to maintain a level of consistency with Brynjolfsson et al. (1994), who also investigate how firm size is affected by IT investment. In this way, we hope to facilitate impartial comparison between the two sets of results. In this section we describe the data used for empirical investigation, propose the empirical models, and discuss methodological challenges (and resolutions) encountered during this research.

Data

Consistent with Brynjolfsson et al. (1994), we measure firm size as the average establishment size which is calculated by dividing the number of employees by the number of establishments in each industry, taken from U.S. Census Bureau Data. The average establishment size has been commonly used as a proxy for firm size in many studies for the following two reasons. First, Carlsson (1988) notes that the number of establishments (the denominator) of recorded by the U.S. Census Bureau and the actual number of firms correlate at over 97%. Second, many researchers authors (e.g., Glancey, 1998) agree that the number of employees (the numerator) is a superior measure of firm size, compared to measures based on sales or assets.

Brynjolfsson et al. (1994) also note that the average establishment size is an appropriate measure for this type of research because it treats firms properly which wholly-acquire profitable subsidiaries (so that multiple establishments would exist separately in a single firm), yet have each establishment make its own make-or-buy decisions. Note that both the EMH and TCE consider the firm an independent economic entity which makes its own make-or-buy decisions. We echo the choice in the previous studies, and use the same measurement for our primary indicator of firm size, which we also call SIZE1 (again consistent with Brynjolfsson et al).

In addition to the average establishment size (SIZE1) Brynjolfsson et al. include multiple measures of firm size. We also adopt an alternative measure of firm size, the value added per establishment, using the BEA data, which we call SIZE2, which is defined by the BEA to be a firm's gross output (e.g., sales receipts, other operating income, commodity taxes, and inventory change) less its intermediate inputs (e.g., energy, raw materials, semi-finished goods, and services that are purchased from domestic industries or from foreign sources).

Note that the EMH focus on the possibility that a firm's sales (revenue) can be maintained while removing some transactions within the firm's hierarchy, leveraged by IT investment. In other words, some of the internal transactions will be outsourced. Outsourcing should not reduce sales, but the value added by internal transactions within the firm will be reduced because much of the value will be added by market transactions. As such, value added is an excellent measure (superior to total sales) as a measure of firm size. Both of our measures for firm size are also used by Brynjolfsson et al. (1994).

Data examining IT investment and total private investment in each industry are also available from the BEA, available online at the time of this study. We define IT investment as the sum of all IT-related assets, including computers and peripheral equipment, software, and communication equipment. All other private investments, such

as machinery equipments, engines, trucks, and office buildings, are aggregated to measure all non-IT expenses.

The BEA classifies their value added inventory into 61 separate industries, based upon the North American Industry Classification System (NAICS), which was adopted in 1998 by all U.S. government agencies. (Previously, the Standard Industry Code (SIC) was used.) Our preliminary analysis indicates a considerable shift in the industry-level average establishment size in many industries from 1997 to 1998, most likely due to the change from SIC to NAICS at the Census Bureau. Further in-depth interviews with governmental officials from the U.S. Census Bureau and the BEA confirm that no straightforward method has been developed to bridge the pre-1998 to post-1997 data. The lack of perfect correspondence between SIC and NAICS is problematic because inconsistencies between the two data sets can generate a large amount of noise and complicate industry-level empirical analysis.

In order to convert from a 6-digit NAICS code to a 4-digit SIC code, the U.S. Census Bureau provides a NAICS-to-SIC "bridge" conversion tool. However, this tool does not always associate the SIC codes at 100% accuracy with the NAICS codes. For example, for the converted BEA industry code to be considered for this study, there has to be 19 years of data (1985-2005). Any industry that fails to map to both SIC codes and NAICS codes for this period is removed from this study.

The first differencing employed in this research reduces the number of years by one, and thus data from 1987 is used for first differencing in 1988. Furthermore, and we exclude 1998 due to extreme noise in the data that year which we believe is due to the SIC-to-NAICS conversion. The remaining 17 years of data from 1988 to 2005, excluding 1998, are used in our analysis. A total of 19 manufacturing industries and 18 retail and service industries survived, satisfying our criteria adopted in the data refinement procedure. This results in sample sizes of 323 observations for manufacturing industries (19 manufacturing industries x 17 yearly observations) and 306 observations for the retail and service industries (18 retail and service industries x 17 yearly observations).

Scaling and First Differencing.

During the period of 1985-2005, IT investment in most industries was highly correlated with time (t), indicating that the amount of IT investment continually increased in most industries. This can lead to serial correlation, which may cause multicollinearity, inflated regression coefficients, and possible violation of the normality assumption. These technical problems associated with serial correlation may also lead to spurious conclusions when using time-dependent variables. Moreover, since technology prices tend to decrease over time, nominal prices become suspect as the length of the study increases. Wooldridge (2003, p. 440) points out that first differencing can be used to estimate the effects of time-varying independent variables in the presence of time-constant omitted variables. Our scaled, first differenced percentage variables are defined as follows:

$$\Delta SIZE_{it} = SIZE_{it} / SIZE_{it-1} - 1$$

$$\Delta IT_{it} = IT_{it} / IT_{it-1} - 1$$

$$\Delta TOT_{it} = \Delta TOT_{it} / \Delta TOT_{it-1} - 1$$

where:

i ≡ an industry at the NAICS two digit level.

$\Delta SIZE1_{it}$ ≡ the percentage change in **the average establishment size** for industry i in year t when compared to year t-1

$\Delta SIZE2_{it}$ ≡ the percentage change in average **value added** per establishment for industry i in year t when compared to year t-1

ΔIT_{it} ≡ the percentage change in IT investment for industry i in year t when compared to year t-1

ΔTOT_{it} ≡ the percentage change in other private investment (non-IT) for industry i in year t when compared to year t-1

$BOND_{t-1}$ ≡ the interest rate on AAA corporate bonds in year t-1

$\ln(EXPORT_{t-1})$ ≡ the log level of United States exports to other countries in year t-1

One of the remedies to resolve trending and time-dependent data is to use first differencing based upon ratio changes in variables ($\Delta SIZE_{it}$, ΔIT_{it}, and ΔTOT_{it}) rather than directly use nominal values ($SIZE_{it}$, IT_{it}, and TOT_{it}). The first-differencing used in this study is differs from that of Brynjolfsson et al., who used nominal values of data in their analysis. First differencing also can drastically reduce the effect of decreasing IT prices, limiting such decreases to a single year in effect, rather than assuming IT investment purchases roughly the same amount of IT throughout the entire study.

First differencing can result in fewer significant results. Thus, significance and relationships that result from this analysis can be viewed as conservative, and first differencing will lead to lower R^2 values than reported in Brynjolfsson et al. (1994). However, this method resolves many limitations and biases associated with time series data, which can be encountered in other methodologies.

Empirical Model

Since we investigate whether or not the negative association between IT investment and firm size found in earlier information systems research is also sustained during the decade of the 1990s, it is important to develop an empirical model which is consistent with those in the literature. By doing so, we can be assured that any disparity in statistical results is driven by the data rather than caused by the empirical models' structural differences. Since the basic framework of proposed empirical models is adopted from that of Brynjolfsson et al. (1994), we also incorporate their notation for consistency and clarity in comparison.

$$\begin{matrix}\Delta SIZE1_{it} \\ \Delta SIZE2_{it}\end{matrix} = \begin{matrix}\alpha_{it} + \beta_1 \Delta IT_{it-1} + \beta_2 \Delta IT_{it-2} + \beta_3 \Delta IT_{it-3} + \beta_4 \Delta IT_{it-4} \\ + \beta_5 \Delta TOT_{it-1} + \beta_6 \Delta TOT_{it-2} + \beta_7 \Delta TOT_{it-3} + \beta_8 \Delta TOT_{it-8} \\ + \beta_9 BOND_{t-1} + \beta_{10} \ln\left(EXPORT_{t-1}\right) + \varepsilon_{it}\end{matrix}$$

Our empirical model does not claim that only IT investment and total investment affects firm size, but rather uses an empirical model based on previously-established models to ascertain the effect of IT investment on firm size, similar to previous research done by Bryjolfsson et al. (1994). We feel that this consistency is important, in that consistency facilitates ease of comparison with this prior research.

Econometric Issues

We address several econometric issues before beginning empirical analysis. Brynjolfsson et al. found four lags (*t*-4) to be appropriate. Similarly, we also run Akaike information criteria and show that little or no additional information can be added in our model with our data after the fourth (*t-4*) lag. In this regard, we also include four lagged terms for IT investment in our empirical models. Also, variance inflation factor (VIF) tests for multicollinearity show no significant signs of multicollinearity are detected in the proposed empirical analyses.

Results from a Durbin-Watson test showed a high risk of our data being spuriously driven by trends, and so to reduce autocorrelation and detrend the data, we transform the variables into percentage changes (i.e., we use $\Delta SIZE1_{it}$ rather than $SIZE1_{it}$). Since trends may still exist that would allow previous percentage increases or decreases in firm size to predict future values in firm size, we employ another Durbin-Watson test for autocorrelation. The Durbin-Watson statistic used in this test is approximately equal to $2(1 - \rho)$, where ρ is the correlation between successive independent variables. As the Durbin-Watson statistic approaches 2, it is more likely that the residuals are independent of each other and that no autocorrelation exists. Our statistic, 1.85, is not significantly different than 2, supporting an argument that autocorrelation trends does not affect our results.

A Breusch and Pagan (1979) test reveals that heteroskedasticity affects our empirical analysis. To reduce the impact of heteroskedasticity, we employ a technique called robust regression. Mosteller and Tukey (1977, p. 203-209) describe how robust regression is resilient to violations of OLS assumptions so that with robust regression, variance in a small part of the data varies, even by a large amount, does not cause a large change in the estimators. *Stata 9.0,* used in this research, incorporates two types of robust weighting in their robust regression analysis: *M-Estimation* (Huber 1981) that uses maximum likelihood estimation to minimize the effects of heteroskedasticity, and a *biweight* (or *bisquare) estimator* (Mosteller and Tukey 1977) – a form of robust regression that adjusts for extreme residuals. After robust weighting, a further the Breusch and Pagan (1979) did not detect any heteroskedasticity, and

coefficients remained relatively stable even if outliers are removed. Thus, robust regression ensures that heteroskedasticity will not adversely impact our results. [8]

Robust Regression Results and Impulse Response Function Charts

In Table 1, we show the results of the proposed empirical models analyzed using data from the manufacturing industries to test the *Manufacturing IT Effect Hypothesis* (**H1**).

Table 1. Robust Regression Analysis of Change in Manufacturing Industries (1985-2005)

	Dependent Variable is *SIZE1* *(Average Establishment Size)*			**Dependent Variable is *SIZE2* *(Value Added per Establishment)***		
Variable	Coefficient	Std. Error	t-stat	Coefficient	Std. Error	t-stat
Constant	0.071	0.029	2.42*	0.200	0.047	4.30***
ΔIT_{it-1}	-0.064	0.030	-2.12*	-0.032	0.048	-0.66
ΔIT_{it-2}	-0.061	0.025	-2.44*	-0.093	0.040	-2.35*
ΔIT_{it-3}	-0.013	0.025	-0.54	-0.095	0.039	-2.44*
ΔIT_{it-4}	0.102	0.021	4.83***	0.083	0.033	2.49*
ΔTOT_{it-1}	0.165	0.029	5.63***	0.034	0.046	0.73
ΔTOT_{it-2}	0.045	0.027	1.71$^{\tau}$	0.017	0.042	0.40
ΔTOT_{it-3}	-0.038	0.027	-1.42	-0.024	0.042	-0.58
ΔTOT_{it-4}	-0.038	0.027	-1.43	-0.083	0.042	-1.97*
$BOND_{t-1}$	-0.010	0.003	-2.98**	-0.018	0.005	-3.46**
$LN(Export_{t-1})$	0.000	0.000	-2.34*	0.000	0.000	-3.22**
R^2	29.8%			16.4%		
N	323			323		

$^{\tau}$ = p-value < .10; * = p-value < .05; ** = p-value < .01; *** = p-value < .001;
These results are from analyses of **19 manufacturing industries** evaluated for 17 yearly periods (excluding 1998) for a total sample size of 323 observations.

For both firm size measures, Table 1 shows a significant decrease in SIZE1 (the average establishment size) in the first and second years following an increase in IT expenditures. In the fourth year following an increase in IT spending, we show firms growing, but not up to their original loss in firm size. For SIZE2 (value added), the second and third years are significantly negatively related to firm size with, again, the fourth year showing that value added starts to return to the firm, though with still a negative net effect. This is true for firm size measured as the average establishment size as well as value added per enterprise. This result is consistent with Brynjolfsson et al. (1994) although it is not as strong as they report.

[8] Thus, there are three ways that this model differs from Brynjolfsson et al. (1994). First, we apply first differencing to detrend the data, as suggested by Wooldridge (2003). Second, to avoid issues of causality, we only consider *past* IT investment's effect on the current period. Brynjolfsson et al. considered both past and current IT investment. We did not feel that we could include the current period's IT investment as an independent variable due to issues of causality. At any rate, we examined the current period effect with actual and instrumented variables outside of this study, and found no significant relationship. Third, we employ a robust regression combining the methods suggested by Huber (1981) and Mosteller and Tukey (1977) that employs a weighting technique in order to eliminate the effects of outliers, so that any single point or a group of influential points can be removed with little effect on the coefficient estimates.

Overall, the *Manufacturing IT Effect Hypothesis* (**H1**) appears to be supported. However, since there are both positive and negative coefficients in our lagged results, we must examine the overall effect of IT investment over time. For this analysis, we use an impulse response function chart. Impulse response functions take the results of an autoregression to develop a vector moving average. The purpose of using impulse response functions is to identify the effect of "shock" (e.g. increase in IT investment) on a dependent variable (e.g. change in firm size). For a more detailed explanation, interested readers may refer to Kauffman and Wood (2007), Sims (1980) and Enders (1995).[9]

The impulse response function charts in Figure 1 and Figure 2 show how a 10% increase in IT spending affects firm size over four years, using the coefficient results from Table 1.[10] Figures 1 and 2 show that the overall effect is a net decrease in firm size due to IT expenditures, lending overall support to the *Manufacturing IT Effect Hypothesis* (**H1**) – that an inverse relationship exists between IT expenditures and firm size in the manufacturing industries.

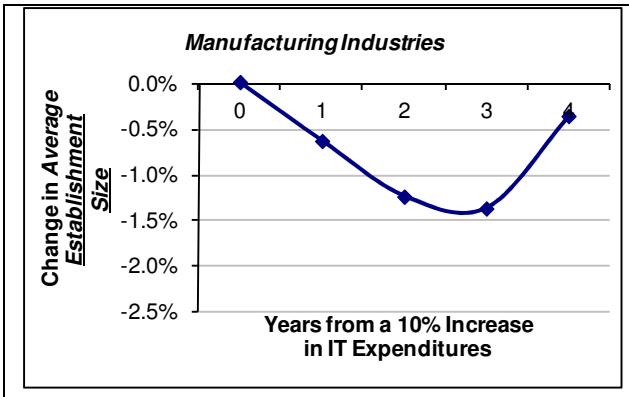

Figure 1. Impulse Response Function Chart – How a 10% Change in IT Spending Affects SIZE1 (Average Establishment Size) Over Time in Manufacturing Industries

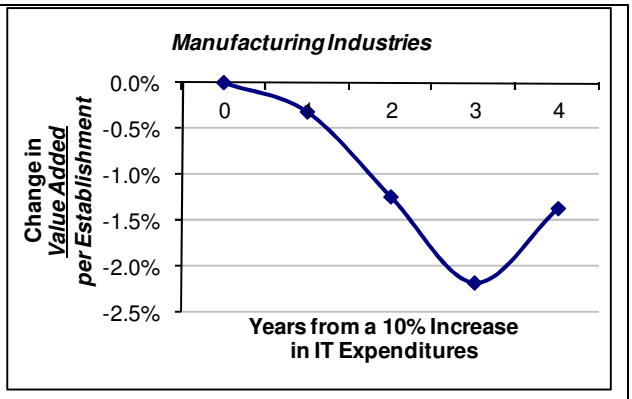

Figure 2. Impulse Response Function Chart – How a 10% Change in IT Spending Affects SIZE2 (Value Added Over Time) in Manufacturing Industries

However, Figure 1 and Figure 2 also provide another interesting insight. These charts should be interpreted to indicate that eventually (after four years or so) firms which do not increase investment in IT will be roughly at the same employment level as those that do invest. In other words, we support the contention that the EMH is valid for the manufacturing industry, but that firms that do not increase IT investment will eventually decrease to the same firm size levels as the firms that do increase IT investment after about four years (according the results in this study).

Table 2 shows the robust regression results if the effect of IT investment on firm size in the retail and service industries. In this table, we show a significantly positive relationship between the IT investment and SIZE1 – the average establishment size, after a one year lag, with no other lagged terms that are statistically significant. The result implies that the current years' IT investment has contributed to firm size growth, thus supporting our *Service/Retail IT Effect Hypothesis* (**H2**). The results with SIZE2 are weaker than with SIZE1.

The impulse response functions for the retail and service industries are shown in Figures 3 and 4. The significant support for the *Service/Retail IT Effect Hypothesis* is a new finding which was not observed by Brynjolfsson et al. (1994). Table 2 and Figures 3 and 4 collectively show that the relationship between IT expenditures and the average establishment size is opposite for the retail and service industries than it is for manufacturing. Just as with manufacturing, however, the impulse response function in Figure 3 shows that increases in the number of employees

[9] Sims (1980) describes how impulse response functions charts (in conjunction with a technique known as vector autoregression, or VAR) allow the "data to speak for itself" without "heroic" assumptions and *a priori* conditions.

[10] Ordinarily, impulse response functions track a single unit change. In this research, a single unit change would translate to a large 100% increase in IT spending, since 100% is a single unit. We think 10% change is more realistic. In our dataset, the average yearly increase in IT expenditures across all years and industries is 5.5%.

fades within three to four years. [11]

Table 2. Robust Regression Analysis of Change in Retail and Service Industries (1985-2005)

	Dependent Variable is *SIZE1* *(Average Establishment Size)*			**Dependent Variable is *SIZE2* *(Value Added per Establishment)***		
Variable	Coefficient	Std. Error	t-stat	Coefficient	Std. Error	t-stat
Constant	0.015	0.033	0.44	0.048	0.046	1.06
ΔIT_{it-1}	0.032	0.015	2.13*	-0.009	0.021	-0.42
ΔIT_{it-2}	-0.004	0.015	-0.29	0.038	0.021	1.82$^{\tau}$
ΔIT_{it-3}	-0.024	0.015	-1.64	-0.015	0.020	-0.75
ΔIT_{it-4}	-0.004	0.016	-0.26	-0.043	0.022	-1.96$^{\tau}$
ΔTOT_{it-1}	-0.004	0.020	-0.19	0.011	0.027	0.41
ΔTOT_{it-2}	0.034	0.021	1.67$^{\tau}$	-0.034	0.028	-1.21
ΔTOT_{it-3}	-0.017	0.021	-0.81	-0.003	0.029	-0.10
ΔTOT_{it-4}	0.013	0.023	0.58	0.043	0.032	1.36
$BOND_{t-1}$	0.000	0.004	0.09	-0.001	0.005	-0.21
$LN(Export_{t-1})$	0.000	0.000	-1.11	0.000	0.000	-0.49
R^2	8.5%			3.4%		
N	306			306		

$^{\tau}$ = p-value < .10; * = p-value < .05; ** = p-value < .01; *** = p-value < .001;
These results are from analyses of **18 retail and service industries** evaluated for 17 yearly periods (excluding 1998) for a total sample size of 306 observations

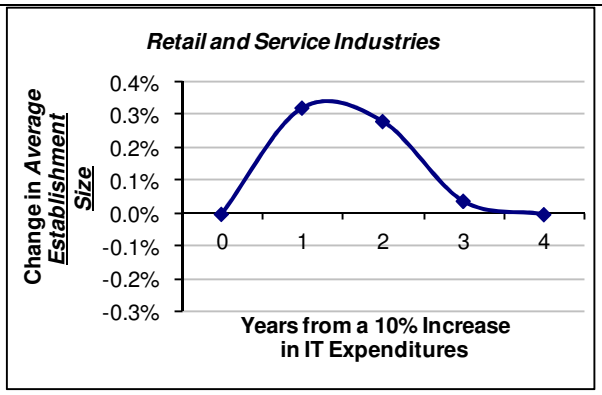

Figure 3. Impulse Response Function Chart – How a 10% Change in IT Spending Affects SIZE1 (the Average Establishment Size) over Time in Retail and Service Industries

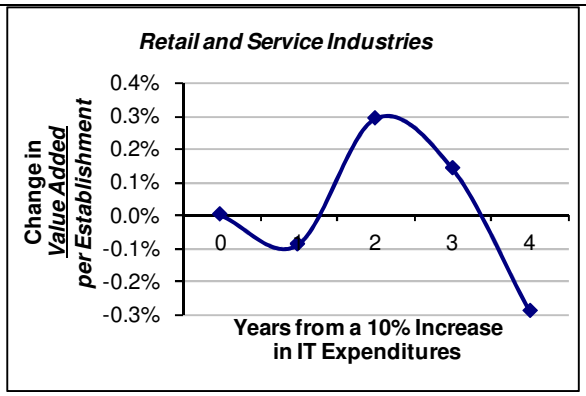

Figure 4. Impulse Response Function Chart – How a 10% Change in IT Spending Affects SIZE2 (Value Added) over Time in Retail and Service Industries

Figure 4 shows value added analysis, SIZE2, to be contrasted with SIZE1 in Figure 3. Figure 4 shows an overall increase in value added for service industries, followed by a long-term reversion back to the same firm size of those that did not increase investment. The results imply that increasing IT expenditures will increase the value added per

[11] Brynjolfsson et al. (1994, p. 1630) graphically show that service industries do not appear to have the same *overall* shrinkage as manufacturing firms in their Figures 1 and 2. Despite this, they find a *significantly negative* relationship between IT investment and firm size in their Table B (p. 1641). We show *the opposite results* for this period.

firm when compared to firms that do not increase IT investment for a period of several years. Given that the value added coefficients are only weakly significant for two years (*p-value* < .10), the actual strength of this relationship could be questionable. Thus, we must reiterate that the average establishment size is a better measure overall to define the relationship between IT and firm size.

Tables 1 and 2 show that the effect sizes (R^2) of both proposed models (for the dependent variables SIZE1 and SIZE2) are relatively low, especially for the retail and service industries. Although the strength of the relationship between IT investment and firm size is not hypothesized, this is a valuable finding. The only other statistical test of the economy-wide EMH (Brynjolfsson et al., 1994) provides an R^2 above 95% for both manufacturing and service industries. Despite this large effect size, Brynjolfsson et al. (1994) warn that such a strong relationship may change and that many other factors can affect firm size. Our findings show a possibility that Brynjolfsson et al.'s cautions (that there are many influential factors on firm size) maybe accurate. Indeed, although our use of first differences to detrend the data can result in a lower R^2 measures than with nominal models as was used in Brynjolfsson et al., the effects of IT on firm size in our proposed models are not nearly as dramatic as previously indicated.

Discussion

In this section, we further examine firm size in these two major industry sectors, and we discuss some broader implications on IT investment and responsiveness that are hinted at in this research.

A Further Examination of Firm Size

The County Business Patterns Census data show that during the electronic communication technology boom in the 1990s, the average firm size has grown steadily throughout the United States. To illustrate, consider the average establishment size (the Census Bureau data) given in Figure 5 and the economy-wide IT expenditures (the BEA data) in Figure 6. These figures both show a significant economy-wide trend of increasing firm sizes, coupled with a concurrent trend of increasing expenditures in IT.

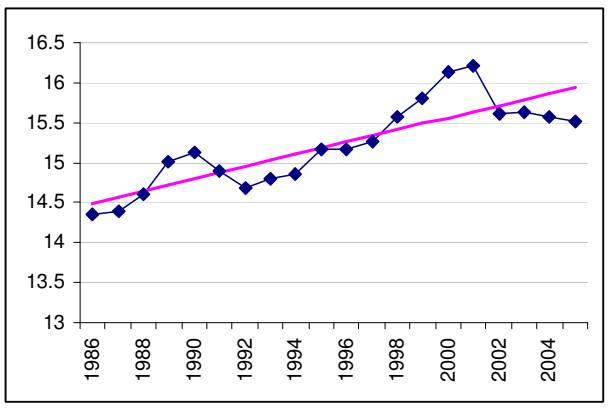

Figure 5. Census of the Average Establishment Size

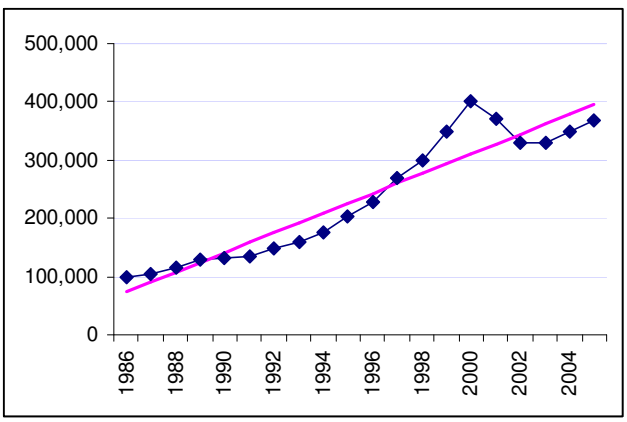

Figure 6. BEA Economy-wide IT Expenditures (in mil.)

When the empirical results in Table 1 and Table 2 are combined, the results in Figure 5, showing an overall increase in the average establishment size during the period of increased IT expenditures, can be further explored. In the U.S. economy, the retail and service industries have shown considerable growth, commensurate with IT investment. As the U.S. economy moves toward service and away from manufacturing, it is feasible that continuous increases in IT investment will result in economy-wide firm growth. Figure 6 shows a recent ubiquitous increase in IT investment during the period of this dataset.

Further analysis shows a significant decreasing trend of average establishment size exists in the durable manufacturing industries with firms employing roughly 52.8% of their employment levels in 1986. The non-durable goods manufacturing industries show an even greater decrease, with firms in 2005 employing, on average, only 47.1% of the number of employees that they had in 1986. Thus, we see significant downward trends in firm size in both durable and non-durable goods manufacturing. (The charts are omitted due to space considerations.)

By contrast, BEA and U.S. Census Bureau data show an overall increasing trend in the average establishment size for both the retail and service industries. On average, retails firms in 2005 employed approximately 121% of their employment levels in 1986. Average establishment size of service industries increased 119% from 1986 to 2005. (Again, the charts are omitted due to space considerations.)

These further observations support our contention that a growth in IT investment correlates to a decrease in firm size in the manufacturing industries while IT investment correlates with an increase in firm size in the retail and service industries for the period investigated in this study. Currently, the retail trade and service industries encompass larger employers, with economy-wide indicators showing that these two industries account for an increasing and substantial proportion of the overall economy. In contrast, the scale of manufacturing industries and their contribution to the U.S. economy have decreased over the last three decades. Thus, the trend of firm size decrease in the manufacturing industry could be overshadowed by the trend of firm size increase in the retail and service sector. With an assumption that the retail and service industries will continue to grow in the U.S., we propose a cautious prediction that IT investment overall consistently leads to firm size increases in the future economy.

That is, service firms that do not increase IT investment will eventually increase to the same firm size as the firms that do increase investments in IT after about four years. This finding also confirms our conjecture that firms that invest in IT are better able to determine and move to the correct level of firm size more quickly. However, the other firms will catch up the level of size in the end.

A Discussion of Alertness and Responsiveness

Although not formally hypothesized or tested, the results shown in the impulse response functions in Figures 1 through 4 hint at a contention that firms that increase investment in IT are better able to determine and move to the correct level of employees more quickly than those that do not, but firms that do not increase investment in IT will catch up, albeit more slowly than those that invest in IT. These results collectively imply that increased IT investment tends to make firms become more agile and respond to conditions more quickly, although more testing is suggested to test these implications.

Our impulse response function charts also give an indication as to the marginal effect of IT investment. A 10% increase in IT expenses results in a 0.3% increase in firm size in the first year for service industries, while the same 10% increase in IT expenses results in a 1.5% decrease in firm size for manufacturing industries, although not until year 3. Both these changes in firm size are, by-and-large, erased over time unless additional IT investments are made.

Conclusion

Census data show that the period after 1988 was a period of growth in firm size with concurrent expansive technological growth. This growth in firm size during the period of increasing IT investments seems to challenge some current research and provides a strong motivation to reevaluate the effect of IT investment on firm size. We show that the retail and service industries' trend in firm size differs from that of the manufacturing industries, and we find empirical support consistent with our Strategic Firm Size Hypothesis that retail and service firms are motivated to use IT to increase firm size whereas manufacturing firms are motivated to use IT to reduce firm size. During the 1980s, the retail and service sectors eclipsed manufacturing in employment for the first time. Since then, the Bureau of Labor Statistics shows that employment in the retail and service sectors has grown steadily to comprise about 80% of workforce while the manufacturing workforce has declined to 15% of the total private workforce. This growing trend of service sector could be epitomized by Wal-Mart becoming the country's largest employer, followed by McDonalds, and UPS. Under these changing times, the prescriptions and conclusions of previous research supported in earlier studies may no longer be universally true.

In this research, we develop the Strategic Firm Size Hypothesis to theoretically explain why firm growth exists during advances in communication technology and increased investment, despite predictions of smaller firm size in the face of increasing technology expense (e.g., Malone et al., 1987; Brynjolfsson et al., 1994). We develop our hypothesis by examining the implicit and explicit assumptions of theories that predict firm growth and firm shrinkage with technology. The Strategic Firm Size Hypothesis can be used to reconcile these opposing theoretical perspectives. Our hypothesis predicts that manufacturing firms will behave much in the same manner as predicted by the EMH, since manufacturing revenue is not typically tied to firm size. Thus, we contend that efforts to reduce

firm size of manufacturing firms will increase productivity and profit, and IT can be used to make market transactions more attractive without having a negative impact on revenue. In this light, earlier results that support the EMH (economy-wide firm shrinkage with IT investment) can be explained in that in earlier studies, employment in manufacturing sectors was greater than in retail and manufacturing sectors. In the mid-1980s, however, the average establishment size of the manufacturing sector was surpassed by the retail and service sectors, and thus we show the opposite in the overall economy (firm growth with IT investment).

Another contribution is that this is the first study to point out that differences in firm sizes attributed to the amounts of IT investment (both increases and decreases) appear to be short-lived, in that after a period of four years, the average establishment size of IT investors seems to approach the average establishment size of non-IT investors. Other firms lacking increased IT investment show an isomorphic pattern and achieve the same firm size changes after about four years with no increase in IT investment. However, using impulse response functions, we support the contention that increased IT investment will allow firms to detect the appropriate firm size and/or achieve the appropriate firm size at a much quicker rate, indicating that firms that increase IT investment are more alert and/or responsive to achieving that appropriate firm size.

In terms of empirical analysis, the present study builds upon the work of Brynjolfsson et al., (1994) who demonstrate that the prescriptions of the EMH hold true for manufacturing firms and that, as investment in IT increases, firms did become smaller. They employed aggregated industry-level statistics to demonstrate such an effect, and we follow their lead by utilizing similar models with similar data. We contribute to the literature by showing that the EMH does not hold as well for service and retail firms, and that the effect of IT expenditures on firm size varies due to industry characteristics. In the case of service or retail firms – those that often increase revenues by increasing firm size – there is a positive relationship between IT and firm size. In the case of manufacturing firms – those that often use IT to reduce employee costs – there is an inverse relationship between IT and firm size. These effects are robust to alternate forms of analyses and different sample sets, adding credibility to our results. If it is accepted that developed economies trend toward service-oriented products, as suggested by some economics researchers (e.g., Baumol 1989), implications from our Strategic Firm Size Hypothesis predict that IT investment will lead to firm growth as economies develop.

This study offers several implications. Implications from EMH indicate that firms should use IT to reduce firm size in a move to the market, while firm growth theories state or imply that firms should use IT to grow until the marginal revenue added by a single employee is exceeded by the cost of managing that employee. In light of this research, managers should examine how revenues are tied to the firm, either at the employee level (where IT would be used for growth) or the firm level (where IT would be used to reduce the size of the firm.) Our results corroborate earlier work on the relationship between IT and firm size to suggest that downsizing, increasing firm size, outsourcing, and other structural changes within organizations are driven by technological progress to a certain degree. In addition, the specific form of organizational change – firm growth or firm shrinkage – is related to the type of industry where the firm operates. Managers can use these results to give insight as to the best practices for investing in newer communication technology within their firms, with an understanding that industry dynamics and products may play a role in determining how IT investment will change firm size.

Our study has some limitations that are often shared for economy-wide studies of this type. Managers often avoid limiting firm growth in order to satisfy their own self-interest, rather than the interests of their employers (Jensen 1986). However, we argue that such behavior is unlikely because such actions would place these firms at a distinct competitive disadvantage. Also, we only consider 629 industry/year points, categorized by industry, as was done in Brynjolfsson et al. (1994). Some industries are excluded from our study since it is impossible to make a transition from SIC codes to NAICS codes in certain industry, making comparative analysis impossible over this period. Finally, many researchers (e.g., Malone et al. 1987; Hess and Kemerer 1994; Brynjolfsson et al., 1994) caution researchers that there are, of course, many other important forces (e.g., stock prices, regulations, interest rates, etc.) that might affect firm and market structures. We agree. As an economy-wide study, we focus on broad industrial analysis, yet the relationship between IT investment and firm size can also be influenced by some firm-level factors. Future firm-level research is called for that regards the various impacts of IT on firms.

We hope that our study sparks interest among MIS researchers to address such research issues as well as the relationship between IT and other organizational factors, and that other researchers continue to validate or expand our findings using more time periods, other explanatory variables, or other explanations for the IT-firm size relationship.

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