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Understanding Cross-Level Interactions of Firm-Level Information Technology and Industry Environment:
A Multilevel Model of Business Value

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ABSTRACT

This article contends that although much research on the business value of IT focuses on firm-level impacts, studies have begun incorporating industry-level variables as explanatory factors of interest to offer better contextualized explanations for the differences in value firms obtained from their IT across different industries. The authors present a multi-level model of IT value where industry-level and firm-level factors jointly determine the value a firm obtains from its IT. By using a nested model to examine industry to firm interactions, they are able to control for problematic violations of statistical assumptions that are likely to bias estimates from conventional methods. Their analysis shows that all of the industry factors we examined had significant interaction effects. Specifically, industry concentration, industry growth, industry capital intensity, industry outsourcing, and presence in service sector significantly impact firm-level IT value. More interestingly, the authors find these impacts manifest not as mean differences between industries, but rather as interactions with firm-level effects.

KEYWORDS

Business Value of Information Technology, Hierarchical Linear Modelling, HLM, Industry Effects, Information Technology and Firm Performance

INTRODUCTION

Information technology (IT) is the single largest category of capital investment in the United States (Stiroh, 2002). Much research has examined the impact of this investment on various measures of firm performance, such as labor productivity, and market valuation, (e.g. Jorgenson, 2001; Triplett and Bosworth, 2002; Bharadwaj et al., 1999; Brynjolfsson and Hitt, 1996; Hitt and Brynjolfsson, 1996; Morrison, 1997; Anderson, Banker and Ravindran, 2006; Aral & Weill, 2007; Stiroh, 2002; Pilat, 2004). Most investigation of IT impacts have, understandably, focused at the locus of decision-making: the firm-level (Rai et al., 2006; Barua et al., 2004; Banker et al., 2006; Paulo and Sawy, 2006).

However, more recently, information systems (IS) researchers have pointed out the importance of the investigatory context (Luke, 2004; Hong et al., 2013). In the context of firm-level investigations, contextual understanding connotes firm decisions within an industry (Chiasson and Davidson, 2005). Despite seemingly widespread acknowledgement of the importance of industry context, such investigations are largely under-explored.

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While IT value research has begun to take notice of this issue, it has not been adequately addressed in the extant literature. Melville et al. (2004) conducted an extensive review of the field and proposed a number of potentially fruitful avenues for future research on IT value. We attempt to answer their call by addressing one of the questions they propose: "What is the role of industry characteristics in shaping IT business value?" They also specifically mentioned that the use of industry controls was not a viable means of answering that question because the use of such controls ultimately ignores the investigatory context. Despite this, researchers, while moving away from using simpler industry dummies to control for industry heterogeneity, have persisted in using industry attributes as controls to measure industry impacts. For example, Chari, et al. (2008) controlled for industry capital intensity, uncertainty, concentration, and growth in their study of the impact of firm diversification on the returns from IT investments. Similarly, Melville, et al. (2007) inserted industry dynamism and competitiveness into their firm-level production functions. Also, Xue et al. (2012) demonstrated how industry environments moderate the type of performance gains firms are likely to realize through IT. Nevertheless, none of these studies used an explicitly contextualized modelling approach such as multilevel modelling. Multilevel or hierarchical models allow firm-level effects to vary across industries. This approach enables researchers to assess both the impact and magnitude of a variety of contextual factors and is a major source of this paper's expected contribution. Since most phenomena that scholars study is fundamentally multilevel in nature, the use of multilevel analytic techniques becomes extremely important (Luke, 2004).

The critical role of industry characteristics is beginning to be recognized, and a burgeoning number of studies in the IS and strategy literature suggest that industries do differ in the extent of IT use and adoption (e.g. Farrell, 2003; Forman et al. 2003). Nevertheless, no formal analysis has been conducted to identify either how these differences interact with industry-specific attributes to affect firm performance, or by how much. If this was known, researchers would be better able to ascribe reasons for the differences in IT value found across firms. Without this knowledge, the measurement and establishment of performance-related goals from IT investments may be biased. Thus, our research question is:

How do the characteristics of the industry environment impact firm IT value?

The inability of existing research to provide a basis to differentiate firm-level IT impacts according to the nature and types of industry characteristics hinders improvements in the efficient management of IT resources, as well as the achievement of greater accuracy in the measurement of IT impacts, as various questions remain unanswered. This research study explores some of these issues using hierarchical linear modelling (Raudenbush & Bryk, 2002), a robust analytic method that is expressly designed to estimate models with nested data structures. We then present the details of our model, followed by the description of the data, the analysis procedures and the results. The paper concludes after a discussion of the implications of the initial results.

LITERATURE REVIEW

The purpose of this study is to conduct an initial analysis to examine the role industry factors play in the link between IT and firm performance, and to determine if a multilevel model can prove a useful lens through which to examine this link. The strategy literature informs us that a firm's industry has a significant and sustained impact on its performance (Brush et al., 1999; Chang and Singh, 2000; McGahan and Porter, 2003). Building on prior studies of firm performance in the IS and strategy literature (e.g. Chang and Singh, 2000; McGahan and Porter, 2003), a range of both firm and industry-level factors were selected for inclusion in our model. Anecdotal evidence and practitioner studies indicate that industries do differ in the extent to which they adopt and use information technology

(IT) as well as the effectiveness with which they leverage IT functionalities and capabilities (e.g. Farrell, 2003; Forman, et al., 2003). The firm-level factors that we study are: advertising expenditure, research and development (R&D) expenditure, market share, and IT expenditure. These variables are regularly used in IT value studies, in addition to IT investment studies, and their utility as important covariates that impact firm performance has been frequently demonstrated (e.g. Bharadwaj et al, 1999, Melville et al., 2007; Chari et al., 2008; Kobelsky, et al. 2008).

Table 1 lists the variables and their measures, including the dependent variable used in the study, Tobin's q, which is essentially the ratio between a firm's market value and its replacement value (Brainard & Tobin, 1968; Tobin, 1969). It is important to note that, while James Tobin developed the measure a long time ago, it is not an IT-specific measure of firm value. Tobin's q has been adopted in several IT business value studies because it is particularly well suited to measure the value that IT investments tend to produce (Bharadwaj et al., 1999). It has been commonly used in IT business value studies for two reasons: a) unlike conventional accounting measures, it is not prone to manipulation, and b) it captures the contribution of IT to a firm's intangible value by improving its product quality, customer and supplier relationships, knowledge capture, reputation and goodwill, intellectual capital, and other intangible assets (Bharadwaj et al., 1999; Zafar et al., 2011; Bardhan et al., 2013). These aspects are part of a firm's competitive advantage, which is considered to be the ultimate measure of the impact of IT on a firm, not operational efficiency (Melville et al., 2004).

Industry attributes can influence a firm's performance both directly (for example, by affecting access to valued resources or possible competitors) and indirectly (for example, by modifying the relationship between firm-level variables and firm performance). For example, the link between IT investments and firm profitability could be stronger (i.e. have a more positive slope) in less competitive industries, but weaker (i.e. have a flatter slope) in more competitive industries. Thus, in addition to including industry-level covariates as direct influences on firm performance, as suggested by prior strategy research, we could also take into account findings regarding cross-industry differences in IT use and effectiveness by interacting them with firm-level variables to capture relationships such as the one in the example above.

Information technology is associated with the formation of intangible resources, such as new work processes or simply the build-up of data (Hitt and Brynjolfsson, 1996). A long line of research has pointed out that many modern IT systems deliver little value when they simply automate existing processes; instead, changes in how work is done are required to deliver substantial value (Melville et al., 2004). These changes in how work gets done are represented as new processes and procedures, which represent an intangible asset for the firm. Additionally, other researchers have pointed out that IT is not simply a faster machine, but is also a form of organizational memory (Simon, 1973). This memory can be viewed as a capital stock. As it is a memory, the capital stock builds over time; however, it is intangible in that it does not register on the balance sheet as an asset (Brynjolfsson, and Yang, 1996).

Intangible resources are inherently difficult to measure (Conner and Prahalad, 1996). Tobin's q, introduced by James Tobin in 1969 as a forecast of a firm's future prospects (Tobin 1969), has been commonly used as a measure of a firm's intangible value (Hall 1993, Megna and Klock 1993). In line with this, Tobin's q has proved to be a good way to measure the business value of IT because it provides a way to capture the intangible capital formed by a firm's investments in modern IT systems (Bharadwaj et al., 1999; Tanriverdi, 2005; Bardhan et al., 2013).

CONCEPTUAL MODEL AND RESEARCH HYPOTHESES

Industrial organization theory suggests that an industry's environment directly impact firm-level actions and that firm performance is contingent upon industry conditions (Porter, 1985). This is mirrored in IS research, where firm-level studies of IT value have consistently found strong industry effects, both as binary indicators and with industry measures such as industry concentration and industry growth (Bharadwaj, 2000; Dedrick et al., 2003; Melville et al., 2007). Evidence from cross-industry studies suggests substantial differences in the performance impacts of IT (Strioh, 2002; Cheng and Nault, 2007; Wimble et al., 2007). This is reflected in managerial practice, with companies often benchmarking their IT practices using within-industry comparisons, making cross-industry comparisons more useful (Cullen, 2007). The challenge is that prior research has mainly examined the firm and industry-level impacts of IT independently, or that the methods used have not accounted for industry effects meaningfully. Figure 1 presents our research model. This model proposes that the value realized from IT will be shaped by the environment in which it is deployed.

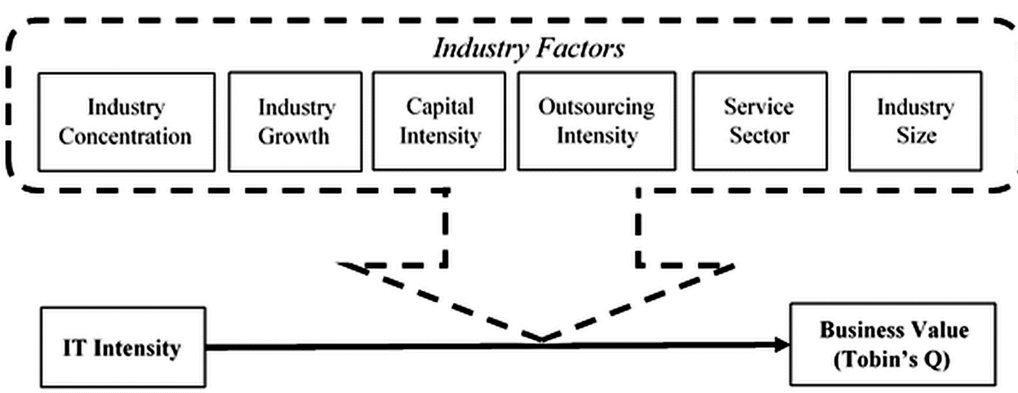
The following industry-level covariates were used in our model: industry concentration, industry capital intensity, industry growth rate, industry outsourcing intensity, industry size, and whether or not the firm is in the service sector. These five covariates were selected from a list of explanatory variables generated by Capon, Farley, and Hoenig (1990) who, in their meta-analysis of 320 published studies, identified several different causal variables impacting financial performance. The meta-analysis examined the determinants of financial performance across a wide range of journals and was unique in that it looked across levels of aggregation, including the macroeconomic level, and at the industry, firm, and business unit levels. Since the focus of this study is to examine to what degree industry factors plan a role in differences in the firm-level business value of IT, we used Capon et al.'s (1990) study as a starting point and chose the five most commonly cited factors.

Industry Concentration

Industry concentration indicates the level of competition in an industry, and firms in more concentrated industries are generally able to obtain higher profit margins. This is central to notions of monopoly and competition. According to Capon, et. al. (1990), industry concentration is the most commonly cited determinant of financial performance. Industrial concentration measures the number and market-share of major competitors in a given industry and has been the most widely studied factor in industrial organization literature (Peltzman, 1977). Industry concentration is commonly viewed as a proxy for competitiveness, with more concentrated industries being view as less competitive. Greater concentration results in an increased ability to control prices, thereby insulating firms in the industry from the 'invisible hand' of competition and allows firms to have the slack resources necessary to successfully complete higher-risk projects, such as large-scale transformative IT projects.

On the one hand, prior work has found that increased industry concentration leads to lower marginal product for firm-level IT capital (Melville et al., 2007). On the other hand, increased industry

Figure 1. Conceptual Model



concentration means it is easier for individual firms to capture the revenue benefits of IT because they have fewer competitors (Kobelsky et al., 2008; Besanko et al., 2001; Zhao and Zou, 2002). Additionally, more concentrated industries by definition have relatively larger firms due larger optimal plant sizes (Curry and George, 1983). Investments in transformative, process-changing technologies (such as enterprise resource planning and supply chain management) involve a high degree of fixed costs, which become more feasible at larger scales of operation. In a more concentrated industry, the nature of competition is less complex and performance comes through incremental innovation and operational efficiencies. IT systems can improve control and facilitate incremental improvements. While it is possible that increased industry concentration can make individual firms less efficient in their use of IT, it is also likely that increased industry concentration makes it easier to capture the revenue-side advantages of IT use, rather than have those advantages competed away. Therefore, it is argued that:

Hypothesis 1: *Increased industry concentration positively moderates the association between IT intensity and business value.*

Industry Growth Rate

An industry's growth rate affects economies of scale (Kobelsky et al., 2008), and may influence the intensity of competitive rivalry by reducing barriers to entry, as newer firms access the newest technologies, while avoiding the transaction costs associated with legacy technologies (Atkeson and Kehoe, 2007). According to Capon et al. (1990), industry growth is the second most commonly cited industry determinant of financial performance and is positively associated with performance when measured across a range of studies. Additional studies argue that a higher industry growth rate makes it easier to take advantage of the benefits that IT provides. High growth industries provide comparatively more opportunities for firms to expand their business, and IT helps firms capture this additional business by increasing firm agility (Xue et al., 2012). Specifically, IT can be used to leverage customers as a source of gaining market intelligence and building new opportunities (Holstrom, 2001; Xue, et al., 2012; Ray et al., 2005; Pavlou and El Sawy, 2006). Also, growing markets are easier for new firms to enter. Newer firms are more likely to have more up-to-date technology since they do not have to shoulder the switching costs associated with transitions out of less efficient legacy technology (Akeson and Kehoe, 2007). These reasons lead to the following:

Hypothesis 2: *Increased industry growth rate positively moderates the association between IT intensity and business value.*

Capital Intensity

Capital-intensive industries have several characteristics related to firm-level performance effects of IT. First, increased capital intensity raises the barrier to entry for new firms, which in turn results in lower competition (Capon et al., 1990; Bharadwaj et al., 1999). Also, increased capital investment is also likely to take resources away from investments that complement IT investments (Bharadwaj, et. al., 1999). However, because IT has been shown to be a complement to ordinary capital investment, the impact of IT could be greater in capital-intensive industries because there is a greater potential for superadditive gains.

Capital intensity leads to strategic rigidity because fixed costs are high and changes can be costly (Datta and Rajagopalan, 1998; Hambrick and Lei, 1985). As a result of this, competition in capital-intensive industries tends to be based upon cost leadership and operational efficiency (Datta, et. al., 2005). As has been noted by other IS researchers, IT used for a cost reduction strategy often results from tighter integration with suppliers and intangible asset-stock accumulation (Mithas et al., 2012). These approaches can be competitively sustainable because they can represent a barrier to erosion of competitive advantage. The accumulation of intangible capital stock, such as databases used to forecast demand or standardized processes, are often path-dependent and thus difficult to replicate (Mithas et al., 2012). These reasons lead to the following:

Hypothesis 3: *Increased industry capital intensity positively moderates the association between IT intensity and business value.*

Outsourcing Intensity

The outsourcing intensity of an industry can influence its operational efficiency and the extent of supplier management (Malone, Yates, and Benjamin, 1987). This idea is also related to the older concept of vertical integration. Outsourcing intensity is the degree to which firms in an industry "buy" rather than "make", whereas vertical integration represents the degree to which firms in an industry "make" rather than "buy". This is a widely studied industry attribute and one which the IS literature has predicted will be especially related to IT. Buyer/supplier relations are a central subject of research in transaction cost economics (TCE) and have a very long history of both empirical and theoretic work (Shelanski and Klein, 1995). IT has been shown to reduce external coordination costs by improving the monitoring of suppliers (Bakos and Brynjolfsson, 1993). IT has also been shown to reduce agency costs by reducing the cost of monitoring employees, which could result in IT efficiency being greater in industries where a greater share of production is internalized. Prior research has shown that while IT does decrease internal coordination costs, it reduces external coordination costs to a greater degree (Brynjolfsson, et. al., 1994). Consistent with TCE, by reducing external coordination cost through IT, firms are better able to manage suppliers and externalize inefficient internal operations (Malone, Yates, and Benjamin, 1987). Additionally, greater integration with suppliers also leads to greater social complexity, and such social complexity requires significant organizational learning to develop repeatable processes across the organization (Mithas et al., 2012). Such an environment is one where IT becomes more valuable because it can facilitate the organizational learning required. Given that prior research has shown that a major benefit of IT for firms is that makes it easier for them to externalize, or outsource, inefficient operations, thereby making them more efficient, this leads to the following:

Hypothesis 4: *Increased industry outsourcing intensity (decreased vertical integration) positively moderates the association between IT intensity and business value.*

Industry Size

IT investments have a larger impact on firms when they are accompanied by process innovations, as the latter complement IT investments. Process innovations, in turn, are more likely to be found in larger markets (Acemoglu and Linn, 2004; Cohen, 1995). Since firms in larger industries are more driven to develop process innovations (Ceccagnoli et al., 2012), this implies that industry size may influence a firm's ability to obtain benefits from its IT investments.

Since IT investments often have a high level of fixed costs (Shapiro and Varian, 2013), it is easier to find a niche of sufficient size in larger industries to justify IT investments. While research shows that larger industries are more competitive, research also shows that larger industries are associated with larger firms and establishments (Campbell and Hopenhayn, 2005). In most cases, this increased competition would dilute the potential gains from increased market size. However, with IT, this increased average firm size has an advantage: IT is a net substitute for labor (i.e. variable costs) and this substitution of variable costs for fixed costs becomes relatively more advantageous in industries where firms are larger. Additionally, research shows that in larger industries, competition is inherently more intense than in smaller industries, resulting in lower profit margins on average. This squeezes out inefficient firms faster than in smaller markets, resulting in more turnover, which favors younger firms (Asplund and Nocke, 2006). Younger firms are not faced with the switching costs associated with legacy technology and can more easily adopt up-to-date technology (Akeson and Kehoe, 2007). This leads us to the following:

Hypothesis 5: *Increased industry size positively moderates the association between IT intensity and business value.*

Service Sector

The service sector is distinctive from other industries for a number of reasons. In an ideal sense, services are intangible, involve co-production, and involve a high degree of heterogeneity (Zeithaml and Bitner, 2000; Bowen and Ford, 2002). Intangibility refers to the fact that services cannot be inventoried, are not easily measured, and do not consume physical space (Shostack, 1977). Co-production is the idea that the consumption and the production of a service often occur simultaneously (Carmen and Langeard, 1980). Production is often inseparable from consumption in services to such a degree that the consumer becomes integral to the production process (Parasuraman et al., 1985; Brown et al. 2002). Heterogeneity is the idea that services often vary from customer to customer and from day-to-day (Parasuraman, et. al., 1985). Heterogeneity is in part the result of co-production, whereby the production process is highly contingent upon the specific interactions of consumers and producers, which implies far greater uncertainty *a priori* as to the sequence of events necessary for production (Argote, 1982; Jones, 1987). It is important to note that this represents an ideal case. No service is purely intangible, nor purely coproduced, nor completely heterogeneous. Manufacturing firms typically provide some services. Likewise, service sector firms have aspects which do not fit the ideal case definition. For example, a patient might note how the comfort of a couch in a psychiatrist office made them feel comfortable discussing their feelings (Bowen and Ford, 2002).

These inherent differences in the service sector have several implications for the likely impacts of IT. Due to the intangible nature of services, measuring quality becomes more difficult since objective measures based upon physical properties are not available. As a result, managers must use latent and subjective measures based upon satisfaction and loyalty to determine quality (Bowen and Shoemaker; Paulin et. al., 2000; Bowen and Ford, 2002). In such an environment, IT should become more valuable because it can be used to measure and record such subjective measures using systems such as customer relationship management (CRM) systems (Peppard, 2000; Verhoef, 2003; Payne and Frow, 2005). In addition to difficulties in measuring output, the differences inherent in services make production planning difficult. The heterogeneity in services means that demand is more volatile (Bowen and Ford, 2002). Compounding this difficulty is intangibility, which means that inventory cannot be used to dampen demand volatility. A hotel room which goes unused cannot be stored and used the next day. In such an environment, demand forecasting is at a premium. Information technology can be used to improve demand forecasts in service environments (Ansel and Dyer, 1999; Lee and Whang, 2000; Wu et al., 2006).

The heterogeneity inherent in services is manifested as 'variety', which can be seen as a sign of the flexibility required for high quality outcomes (Feldman, 2000). Empirical work has observed a high degree of sequential variety in service settings (Pentland, 2003). Increasingly, IT involves the use of workflow management systems to define work processes in service industries (Fletcher et al., 2003). The ability to deal with a wide variety of situations is a mark of good customer service (Zeithaml et al., 1990) and important for retaining customers in service environments (Keaveney, 1995). Service workers must be capable of developing novel solutions to the unique situations they often face in real time because services cannot be inventoried and involve coproduction. This need for real-time adjustment puts a premium on coordination, where IT can help as it reduces coordination costs (Malone, Yates, and Benjamin, 1987). These reasons collectively lead to the following:

Hypothesis 6: *The association between IT intensity and business value is greater for service firms.*

METHODOLOGY

As is often recommended for analyzing nested data, we used hierarchical linear modelling (HLM) (Raudenbush & Bryk, 2002). Nested data leads to several problems such as: a) aggregation bias, when a variable has different meanings at different levels, b) misestimation of errors, which occur because observations at different levels are not independent, and c) heterogeneity of regression, where relationships between Level 1 units differ across Level 2 units (Mithas et al., 2006-7). These problems can be addressed using HLM. In addition to empirical problems arising from nested data, there is also a problem of inference. An explicitly nested modelling approach avoids logical problems of ecological or individualistic fallacy by expressly modelling the phenomenon in question as having multiple levels of aggregation.

In this context, firms (Level 1 units) are aggregated (i.e. nested) within industries (Level 2 units); the implication here is that within-industry (i.e. across-firm) variation in performance must take into account industry membership. Standard regression, ordinary least squares (OLS) or otherwise, typically assumes that the association between IT and performance is identical across industries. HLM does not make this assumption; in fact, it assumes the association varies. HLM provides an estimate of the variance in firm performance connected with between-industry differences in attributes such as industry concentration. Such analysis is not possible when industry summary statistics of these attributes are used as outcomes in standard ANOVA or regression models.

Additionally, from a conceptual point of view, utilizing a single-level model to study phenomena which are multilevel in nature is inherently problematic (Luke, 2004). The failure to provide contextualized explanations in such contexts can lead to problems of both the ecological fallacy and the individualistic fallacy. The ecological fallacy refers to the situation where relationships observed at the group-level are assumed to hold for individuals (Freedman, 2001). For example, research into the association between fat intake and breast cancer has shown to be very weak at the individual-level, despite high correlations at the group-level (Holmes at al., 1999). This can also work the other way, whereby individual-level characteristics are assumed to provide insight into group-level phenomenon, which is the individualistic fallacy. Both of these are problems of inference or theory, not simply measurement. Hierarchical modeling addresses both the measurement and theory concerns of conducting contextualized research, such as what we are attempting to do in this paper.

Additionally, using a conventional single-level approach results in overweighting groups which have higher representation in the sample. For example, consider the case where one was interested in the effect of industry growth rate on firm performance, and the sample being examined for this effect consisted of 10 firms across 3 industries. However, 5 of the firms in the sample were from one industry, 2 firms were from a second industry, and 3 firms were from a third industry. In such a situation, the measure for industry growth from the industry with the most firms would account for half the sample. This inherently alters variance in a way, usually by reducing it. A nested approach deals with this by having an error term for each industry, which in effect measures each industry only once, thereby preserving variance and making measurement of cross-level effects easier.

Data

Firm-level data on the IT investments of 1,413 firms from 1998 to 2004, together with accounting data from Compustat, is used to test our hypotheses. The firms were part of 290 industry-years. The IT investment data is obtained from a survey of IT executives carried out by the trade periodical *Information Week*. The *Information Week* data has been used extensively in other studies (e.g. Kobelsky et al., 2008; Chari, et al., 2008; Liu & Ravichandran, 2008). Industry-level data was obtained from the U.S. Bureau of Economic Analysis (BEA) and U.S. Bureau of Labor Statistics (BLS), with the exception of the industry concentration measures. Industry concentration measures were estimated from Compustat in order to provide annual estimates and estimates for services industries. Industry concentration measures are not available from the U.S. Census Bureau on an annual basis, nor in

Herfindahl-Hirschman Index (HHI) form for service industries. It is important to note that the time period for this data allows us to field-test a phenomenon which is discussed often, the role of industry effects on firm performance. The use of data in other time periods is common in archival studies on the business value of IT. In fact, several recent studies in prominent journals use data much older than what we use in this study (Tambe and Hitt 2013; Dewan and Ren, 2011). What is of importance is if the research question is enduring and if the data allows one to test the research question at hand. While the data is not as recent as what would be found in survey or experimental research, the important issue is that the theoretical question is of continued interest.

Analysis

We used full maximum likelihood and an empirical Bayes procedure to estimate the model in HLM v. 6.05a (Raudenbush et al., 2002). The model was estimated in an incremental approach, which allows for model testing. First, a fully unconditional model was tested where there were no covariates at either level (Model 1). This helped evaluate whether sufficient variation existed in firm performance across the two levels. Partitioning the variance in this way allowed for the computation of the intra-class correlation (ICC), which is a measure of the relatedness or dependence of nested data. ICC is equal to $\sigma 2/ \sigma 2 + \tau$, where $\sigma 2$ represents between-industry variation and τ represents within-industry variation.

Next, we estimate a random coefficients model, where we add firm-level covariates (Model 2). The significance of random or fixed effects can be assessed by comparing the deviance (-2 log likelihood criterion) between the two nested models, using a $\chi 2$ distribution. The degrees of freedom for this test will be the difference in the number of parameters between the two models. In the next step, we include industry-level covariates (Model 3), which means that we are allowing slopes and intercepts to vary across industries. Thus, in this Level 2 model, the intercepts and slopes of the Level 1 model are estimated using industry-level covariates. It is worth noting that because this study is focused on estimating the impact of industry-level factors on the IT-firm performance relationship, we will be introducing industry-level covariates to explain the IT slope only.

where TOBINS is the outcome variable, subscript *i* indexes firms, subscript *j* indexes industries, and subscript *k* indexes years; π_{ojk} is the conditional mean performance of all firms in industry *j* (the

Table 1. Variable Descriptions

Variable	Measure	Source
IT	*IT intensity* = IT expenses/Revenue	Information Week 500 & Compustat
TOBINS	*Tobin's Q* = [(Fiscal year-end market value of equity) + (liquidating value of company's outstanding preferred stock) + (current liabilities) – (current assets) + (book value of inventories) + (long term debt)] / book value of total assets	Compustat
HHI	Herfindahl-Hirschman Index. A measure of industry concentration. where n is the number of firms in the industry and is the marketshare of the ith firm in the jth industry.	Compustat
GROWTH	*Industry growth* = Mean percentage sales growth for previous and current year	BEA
KINT	*Industry capital intensity* = Total assets/sales revenue	BEA & US Bureau of Labor Statistics (BLS)
SERVICE	*Industry type* = Dummy variable: Services =1, Other = 0	BEA
OINT	*Outsourcing intensity* = Total intermediate goods/sales revenue	BEA
SIZE	*Industry Size* = Total sales	BEA

intercept) in year k; $\pi_{1\text{-}4jk}$ are the conditional effects (the slopes) of market share, advertising intensity, R&D intensity and IT intensity respectively for firms in industry *j* (the slope) in year *k*; {$MKTSHR_{ijk}$, ADI_{ijk}, RDI_{ijk} and IT_{ijk}} denote the market share, advertising intensity, R&D intensity, and IT intensity respectively of the *i*th firm in industry *j* in year *k*;{,,, } denote the mean market share, advertising intensity, R&D intensity and IT intensity respectively of the firms in industry *j* in year *k*.

In the next step, we include industry-level covariates (Model 3), which means that we are allowing slopes and intercepts to vary across industries. Thus, in this level 2 model, the intercepts and slopes of the level 1 model are estimated using industry-level covariates. It is worth noting that, because this paper is focused on estimating the impact of industry-level factors on the IT-firm performance relationship, we will be introducing industry-level covariates to explain the IT slope only. The between-industry (level 2) model is as follows:

where β_{00k} is the mean performance for firms in all industries in year k; r_{0jk} is the deviation of the mean performance of firms in industry j from π_{ojk}; $SERV_{jk}$ is a dummy variable indicating membership in a service industry $GROWTH_{jk}$, HHI_{jk}, $KINT_{jk}$ and $OINT_{jk}$ are between-industry covariates: growth rate, concentration, capital intensity, and outsourcing intensity respectively) β_{10k}, β_{20k}, β_{30k}, and β_{40k} are the mean effect of market share, advertising intensity, R&D intensity and IT intensity respectively on performance for industries in year *k*; β_{41k}, β_{42k}, β_{43k} and β_{44k} are the conditional effects of membership in a service industry, industry growth rate, industry concentration, and outsourcing intensity respectively on the impact of IT intensity on the mean performance of firms in industry *j* in year *k*.

RESULTS

Table 2 depicts the correlation matrix at the firm-level, with industry covariates included. Table 3 shows the industry-level covariates. Note that the correlations between the industry covariates are different between the two tables due to the inherent nesting of industry-level measures when viewed from the firm-level. The impact of the nesting on the correlations is why HLM is needed to conduct cross-level studies. To reduce multicollinearity, the industry-level variables were centered using group mean centering, while the year-level variables were centered using grand mean centering. Grand mean centering is appropriate for assessing whether industry-level predictors provide incremental prediction of firm performance over and above firm-level predictors (p. 634: Hofman & Gavin, 1998).

Table 4 lists the HLM results. The largest percentage of variation in firm performance lies within industries (89.29%), while a smaller but substantial proportion lies across industries (10.71%). The significance of the deviance difference statistic between the models indicates that the additional variables significantly improved the model compared to the original one. The significance of the industry-level random effect (χ^2 =410.559, $p<0.05$) indicates that there is significant variation between industries in both average IT impacts and the rates at which performance improves.

This hierarchical analysis offers a more complete and accurate estimation of the impact of IT intensity. For example, while IT intensity is found to have a substantial impact on firm performance (Model 2, Table 4), the hierarchical analysis (Model 3, Table 4) reveals how these impacts are decomposed into the various industry factors. The results of Model 3 indicate that IT enhances firm performance on average, but the effect is stronger when the industry is: a) growing, b) more concentrated (i.e. less competitive), c) uses outsourcing heavily, and d) a service firm.

While a large portion of the variance in impacts of IT occur at the firm-level, all cross-level interaction effects with firm-level IT are significant. This suggests that much of the performance effects from IT occur as a result of the interaction with the industry environment conditions the IT investment occurs in. The model illustrates that industry-level effects of IT are likely to manifest through interaction with firm-level impacts. It is possible that firms that engage in higher levels of outsourcing are able to use their IT investments more efficiently. Thus, this study could possibly be a test of the claim that IT use and adoption lowers transaction costs (Gurbaxani and Whang, 1991).

Table 2. Firm-Level Correlation Matrix

	tobins	mktshr	ADI	RDI	IT	Serv	Growth	HHI	KINT	Ind. Size	OINT
tobins	1										
mktshr	-0.015	1									
ADI	0.121	0.001	1								
RDI	-0.010	-0.015	-0.005	1							
IT	0.180	-0.049	-0.006	-0.013	1						
Serv	-0.018	-0.083	-0.029	-0.029	0.172	1					
Growth	-0.014	0.029	0.007	-0.009	-0.019	0.244	1				
HHI	-0.023	0.327	-0.074	-0.005	-0.029	-0.131	0.122	1			
KINT	0.003	0.167	-0.015	0.004	-0.089	-0.334	0.004	0.223	1		
Ind. Size	-0.007	-0.236	0.079	-0.003	-0.022	0.334	0.190	-0.146	-0.266	1	
OINT	0.047	0.165	0.116	0.025	-0.147	-0.693	-0.166	0.294	0.127	-0.426	1

Table 3. Industry-Level Correlation Matrix

	Serv	Growth	HHI	KINT	Size	OINT
Serv	1					
Growth	0.135	1				
HHI	-0.086	0.116	1			
KINT	-0.086	0.070	0.246	1		
Size	0.245	0.120	-0.113	-0.199	1	
OINT	-0.595	-0.076	0.242	0.211	-0.351	1

DISCUSSION

The purpose of this research presented in this paper is to conduct an initial analysis to examine the role industry factors play in the link between IT and firm performance, and to see if a multilevel model might be a useful lens through which to examine this link. To examine this question, we proposed six cross-level hypotheses. The results of these hypotheses are presented in Table 5. Further, the nature of these macro variables and their influence on IT impacts is essential for developing superior management processes and measurement instruments to assess IT performance impacts. In this study, we used hierarchical linear modelling to examine these embedded impacts and to establish the role of industry-level variables in IT performance.

This study is the first to examine the impact of industry-level variables on the impact of IT on firm performance while controlling for aggregation effects and cross-industry variation in IT use. While there have been calls to take industry seriously in IS research (e.g. Chiasson & Davidson, 2005), this has often not happened, or occurred in a methodologically-restrictive manner. For example, Raymond et al. (2013) studied the effect of IT integration on the innovation capability and productivity of manufacturing SMEs but did not consider differences across industries, even though they had firms from more than 15 sectors, such as metal products, wood, plastics and rubber, electrical products, food and beverage, and machinery. Elbashir et al. (2008) tested the relationship between

Table 4. HLM Results

Variable	Model 1	Model 2	Model 3
Intercept (γ_{000})	1.197** (0.072)	1.195** (0.073)	1.196** (0.075)
Firm-level effects:			
Market Share (γ_{100})	-	-.421 (1.264)	0.145 (1.194)
Adv. Intensity (γ_{200})	-	6.010** (2.811)	7.146** (2.652)
R&D Intensity (γ_{300})	-	-0.013 (0.017)	-0.017 (0.016)
IT Intensity (γ_{400})	-	9.402** (1.352)	18.058** (2.086)
Industry-level effects:			
Service industry (γ_{010})	-	-	0.175 (0.195)
Industry growth rate (γ_{020})	-	-	0.007 (0.903)
Industry concentration (γ_{030})	-	-	-0.264 (0.246)
Capital intensity (γ_{040})	-	-	0.754 (0.692)
Industry Size (γ_{050})	-	-	-0.000 (0.000)
Cross-level effects:	**Model 1**	**Model 2**	**Model 3**
Service Industry*IT Intensity (γ_{410})	**-**	**-**	36.039** (6.531)
Growth*IT Intensity (γ_{420})	**-**	**-**	65.797** (27.814)
Market Conc.*IT Intensity (γ_{430})	**-**	**-**	60.820** (16.081)
Outsourcing Int.*IT Intensity (γ_{440})	**-**	**-**	79.123** (23.280)
Industry Size*IT Intensity (γ_{450})			-0.0001** (0.0001)
Deviance (-2 log likelihood)	6245.832	6191.655	6048.617
Degrees of freedom	4	8	18
Deviance difference	-	$\chi^2 = 54.177$**	$\chi^2 = 143.038$**
σ^2	4.59256	4.38544	3.89377
τ	0.34464	0.38604	0.46721
Variance Decomposition			
Across Firms (ICC = $\sigma^2/\ \sigma^2 + \tau$)	93.08%	91.91%	89.29%
Across Industries (1-ICC)	6.92%	8.09%	10.71%

Table 5. Summary of Results

Hypothesis	Supported?
H1: Increased industry concentration positively moderates the association between IT intensity and business value.	Yes
H2: Increased industry growth rate positively moderates the association between IT intensity and business value.	Yes
H3: Increased industry capital intensity positively moderates the association between IT intensity and business value.	Yes
H4: Increased industry outsourcing intensity (decreased vertical integration) positively moderates the association between IT intensity and business value.	Yes
H5: Increased industry size positively moderates the association between IT intensity and business value.	No
H6: The association between IT intensity and business value is greater for service firms.	Yes

business process performance and firm performance, moderated by an industry dummy variable that divided the sample into service and non-service firms. However, their sample included firms from a variety of industries, such as manufacturing, retail and wholesale trading, banking, and hospitality, and this diversity could have been leveraged by studying the role of a specific industry attribute, instead of using a dummy variable. Stoel & Muhanna (2009) examined the impact of IT capabilities on firm performance in sub-samples based on cut-off points of industry attributes (munificence and complexity). Ravichandran and Liu (2011) looked at how industry attributes influenced the choice of IT strategies using standard OLS regression, preventing the richness of their context ("Sixty-five percent of the responding firms were in manufacturing,17.8% were in the financial services, banking, and insurance industries, 6.2% were in retail, and 7.8% were in transportation and utilities.": pg. 551-552) from enhancing their explanation. Given this situation, this paper provides some guidance for future researchers on how they can make better use of their data.

There are two key contributions of this research: 1) assessing the role various industry-level characteristics play in affecting the impact of IT on firm performance; and 2) presenting a methodology whereby the contingencies that impact the value firms obtain from IT can be assessed. Our results clearly indicate that characteristics occurring at a higher level of analysis are influencing outcomes at a lower level. More specifically, our results indicate that industry-level factors do have a significant influence on the value that a firm realizes from its IT investments and that a substantial portion of the impact of IT is due not to direct effects, but rather contextualized impacts resulting from the interplay between IT and environmental factors. This fits with the realization that the strategic choices of firms depend significantly on the trajectories of their industries, which act like highways bounded by heavy barriers that restrict traffic flow onto a particular pathway (McGahan, 2004).

This study's results imply that while measuring the impacts of information systems, it is essential to include contextual industry factors, as they influence the impact of IT. Doing so may help to clarify for managers who they should choose as their comparisons when benchmarking their actions and the performance of their organizations. They will become aware that, for example, if their firm is in a slow-growing manufacturing sector, IT will have a limited impact on their firm's performance, and as such, they should not be contrasting how their firm uses IT with fast-growing service firms. Understanding the broad industry-level attributes that influence the impact of IT on their firm will provide IT managers with a clearer idea of the return on investment that they will obtain from their new investments, and thus improve the quality of the business cases they put forward.

LIMITATIONS AND CONCLUSION

This study is not without limitations. Although utilizing multilevel nested regression techniques allows one to perform a separate regression for different industries, endogeneity still remains a potential concern with our investigation. Also, while we identified six different industry factors in our specific study and developed directional cross-level hypotheses, we fully acknowledge that these factors are not an exhaustive examination of cross-level interaction, but rather serve as a general illustration of the importance of contextualizing IT. Finally, we did not specifically examine firm-level interactions beyond that of IT interacting with different industry effects.

Further research could extend this study in at least two ways. First, additional industry-level variables that are known to influence the impact of IT on firm performance, such as dynamism, uncertainty, clockspeed, information intensity (Ravichandran & Liu, 2011), the level of regulation and regulatory change, and the role of IT in the industry (i.e. automate, informate up or down, transform), could be used as additional covariates. Ideally, the variables that are chosen will be conceptually related, as doing so will help develop a more theoretically-grounded approach for understanding how industry attributes affect the value of IT to firms. For example, researchers have used industrial organization theory to study how industry munificence, dynamism, concentration, and capital intensity influence the extent of IT outsourcing in industries (Qu, Pinsoneault & Oh, 2011). Future researchers interested in studying the value of business analytics could, for example, use resource dependency theory (Pfeffer & Salancik, 1978) to examine how firms use IT to acquire control over key resources, and how their attempts to obtain value from doing so are moderated by the levels of information intensity and uncertainty in their industry.

Second, a panel approach examining effects over time would also seem worthwhile. This approach would help to remove uncertainty over the impact of omitted variables and selection bias (Hsiao, 2006). A panel data approach would be useful because it allows for approaches such as fixed-effects, difference-in-difference, and dynamic models which can control for many sources of endogeneity (Wooldridge, 2010). Interestingly, difference-in-difference could be combined with a hierarchical approach to address both potential endogeneity and nesting issues.

One perspective worth considering is the impact of IT on industry attributes themselves. Traditionally, IT was often used as a means of increasing barriers to entry in an industry, as it was fairly expensive to deploy and required significant expertise. Recently, the diffusion of cheap and high-quality IT hardware and software, as well as the greater availability of IT skills, means that its ability to act as a barrier to entry is limited. Instead, it has led to greater disruption and uncertainty in markets, making them more dynamic and encouraging firms to focus on IT's ability to make competitive moves (Sambamurthy, Bharadwaj & Grover, 2003). An interesting question from this perspective is how IT's impact on industry-level attributes, such as dynamism or munificence, can be accounted for, and how this in turn affects the relationship between IT and performance at the firm-level.

In conclusion, this paper is an attempt to demonstrate how context can be better used to enrich our understanding of the value of IT (Hong et al., 2013). We feel this research study provides substantial evidence as to the value of a multilevel approach to IT business value research and provides evidence as to the importance of including industry factors as explanatory factors rather than control factors. We hope future researchers will consider using multilevel approaches in studies on IT value to enhance the overall contribution of our field.

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