

## DOES IT OUTSOURCING PAY OFF? EVIDENCE FROM INDUSTRY-LEVEL DATA

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### ABSTRACT

To leverage advanced technologies and skills at lower costs, firms are increasingly outsourcing their information technology (IT) functions to third parties. Despite the growing importance of IT outsourcing in today's economy, however, research efforts to objectively measure IT outsourcing and estimate its economic contributions have been surprisingly lacking. This study treats IT outsourcing as a factor input in production, and evaluates the economic contributions of IT outsourcing. We estimate an industry production function based on a panel data set from 61 private sector industries in the United States over the 1998 to 2003 period, and find the following results. First, our data and modeling indicate that IT outsourcing has made a positive and significant contribution to industry output growth. Second, our analysis of split data samples based on relative intensity of IT use reveals that high IT intensity industries tend to outsource IT services more than low IT intensity industries. In addition, we find significant differences between high and low IT intensity industries with respect to the contributions of IT outsourcing. For high IT intensity industries, IT outsourcing has made a positive and significant contribution to output growth. In contrast, IT outsourcing has failed to make a positive contribution in low IT intensity industries. Overall, our results imply that firms that invest more heavily in IT tend to not only use more IT outsourcing but also get more out of IT outsourcing.

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**KEYWORDS:** Economic analysis, industry analysis, information technology, IT impacts, IT intensity, outsourcing, output elasticity, production function, production theory, productivity.

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## 1. INTRODUCTION

*Information technology (IT) outsourcing* refers to “the practice of transferring IT assets, leases, staff, and management responsibility for delivery of services from internal IT functions to third-party vendors” (Hirschheim and Lacity, 2000, p. 99). The most common areas for IT outsourcing include systems development and integration, software maintenance and support, hardware maintenance and support, and data processing and management (ITtoolbox, 2004). Despite the sluggish economy over the past several years, IT outsourcing, including foreign or “offshore” outsourcing, has been steadily growing. A report by Gartner Group (2004) indicates that worldwide spending in IT outsourcing will rise from US\$176.8 billion in 2003 to US\$235.6 billion in 2007. Also, “mega-outsourcing” deals are on the rise as the economy improves. For example, six deals valued at a combined US\$11.2 billion were signed during the first half of 2004, including a business process and IT outsourcing agreement between Cap Gemini and TXU Corporation in May 2004 that alone was worth US\$3.5 billion (Hoffman, 2004).

A fundamental question of interest in this area is why firms outsource their IT functions. Previous studies such as Loh and Venkatraman (1992) found that vendors’ production cost advantages are one of the main reasons. Indeed, a recent survey by ITtoolbox (2004) found that the top reason for firms’ IT outsourcing is “cost savings” (37.9% of total responses) followed by “need for special skills/services/equipment” (20.9% of total responses). In other words, firms use IT outsourcing to leverage advanced technologies and services at lower costs.

However, it is not clear whether IT outsourcing actually creates value for the firms that outsource their IT functions. On one hand, IT outsourcing may benefit firms in terms of reduced costs, effective use of staff, and access to advanced technologies and facilities (Rao, et al., 1996). However, IT outsourcing also may hurt firms because outsourced IT services may be of inferior quality to those produced in-house (Gorg, et al., 2004). In addition, there are hidden costs

associated with IT outsourcing such as transition costs and management costs (Aubert, et al., 1998), and more importantly, firms may lose their IT expertise by outsourcing their IT functions (Earl, 1996).

Measuring the economic contributions of IT outsourcing, the focus of this study, is of great importance because it will assist senior managers in gauging the aggregate impacts in the economy from outsourcing, and enable them to make decisions related to IT outsourcing with an awareness of what micro-level outcomes are likely to obtain. Nevertheless, to date research efforts to objectively measure IT outsourcing and its economic contributions have been surprisingly lacking. Most of the studies on IT outsourcing have focused on outsourcing practices and decisions (e.g., Ang and Straub, 1998; Baldwin et al., 2001; Lacity and Wilcocks, 1998). Moreover, the studies that have dealt with the performance of IT outsourcing mainly have relied on anecdotal evidence or practitioners' perceptions (e.g., Grover et al., 1996; Lacity and Willcocks, 1998; Lee and Kim, 1999), and their reports have been mixed.<sup>1</sup> Therefore, we cannot make a definitive conclusion regarding the economic contributions of IT outsourcing.

We believe the lack of quantitative analysis of the economic impact of IT outsourcing can largely be attributed to unavailability of necessary data. To the best of our knowledge, there are no data available at the firm or industry level that can directly measure the magnitude of IT outsourcing—much less its economic contributions. In this way, the study of the quantitative economic impact of IT outsourcing is similar to where the study of the business value of IT was in the mid-1980s: an abundance of anecdotal evidence, but little in the way of empirical evidence or the appropriate econometric or scientific methods to back it up.

In this study, we use new industry-level data from the United States Bureau of Economic

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<sup>1</sup> For example, Lacity and Willcocks (1998) find that two of the seven total outsourcing cases, expected cost savings were achieved by the firms. A case study by Levina and Ross (2003) indicates that a company realized estimated cost savings of over US\$1 million in data center processing costs.

Analysis (BEA) and the Bureau of Labor Statistics (BLS) to measure IT outsourcing and evaluate its economic contributions. Employing the production function framework that has been widely used by IT and productivity researchers, we treat IT outsourcing, measured as *purchased IT services*, as a factor input in production process, and estimate the output contributions of IT outsourcing. The key research questions of this study are as follows:

- How can we conceptualize and measure IT outsourcing at the aggregate level?
- Has outsourcing made positive contributions to American industries?
- Are there any systematic differences between American industries with respect to the use and economic impact of IT outsourcing?

The rest of the paper is organized as follows. Section 2 reviews the related literature from Economics and Information Systems (IS). Section 3 presents the production function framework and develops our empirical model. Section 4 describes our data set and the estimation procedure. Section 5 presents our empirical findings. Finally, Section 6 discusses the results and concludes the paper.

## **2. RELATED LITERATURE**

Our analysis of the aggregate contributions of outsourcing has been informed by research literature in three streams of Economics and IS research: (1) IT outsourcing, (2) the impacts of services outsourcing, and, (3) IT and economic performance.

### **2.1. IT Outsourcing**

Most previous studies on IT outsourcing drew upon economic theories such as transaction costs economics and production economics to identify factors impacting firms' IT outsourcing decisions. Transaction costs are the costs of carrying out the transaction and the contractual risks that are involved (Williamson, 1985). Although transaction costs involved in hiring and dealing

with vendors were shown to influence IT outsourcing decisions (e.g., Ang and Straub, 1998), stronger empirical support was found for the production economics perspective, which argues that production cost advantages offered by vendors are the main reason for IT outsourcing (e.g., Loh and Venkatraman, 1992). These production cost advantages include economies of scale, economies of scope, economies of specialization (Clemons, et al., 2000). IT outsourcing is value-enhancing only when the production cost advantages from the vendors outweigh the relevant transaction costs.

Another important economic theory related to IT outsourcing is the theory of incomplete contracts (Grossman and Hart, 1986; Hart and Moore, 1990). The theory provides a set of determinants for optimal asset ownership structures, including vertical integration or outsourcing. Applied to the context of IT outsourcing, the theory suggests that when the vendor has developed skills and expertise to deliver the IT services that a buyer firm does not have, it is value-enhancing to outsource the services to the vendor. The vendor's specific investments related to the IT assets can create greater value than those of the buyer firm. The theory also suggests that when the vendor possesses complementary assets necessary for the IT services, outsourcing is optimal or value maximizing. Related to this, analyzing several cases of application management outsourcing and drawing on the concept of complementarity in organization design (Milgrom and Roberts, 1990), Levina and Ross (2003) found that a vendor's comparative advantages (which act as value propositions to its customers) stem from the set of core competences and complementarities (e.g., methodology, IT personnel career development, and client relationship management) that it has developed over time.

These studies suggest that IT outsourcing can create value for customer firms of the services. However, because most of the studies rely on anecdotal evidence or practitioners' perceptions,

we cannot make any conclusion about whether IT outsourcing actually makes significant economic contributions on the whole.

## **2.2. Impacts of Services Outsourcing**

In Economics, the impact of outsourcing of both materials and services has been studied using industry level data. However, whether outsourcing has made positive economic contributions is not clear. Some studies find that services outsourcing contributes to higher labor productivity. For example, based on U.S. industry-level data, Amiti and Wei (2004) found that foreign services outsourcing contributes to higher productivity. Similarly, using data from U.S. economic sector-level input-output tables, ten Raa and Wolff (2001) argue and provide evidence that multifactor productivity growth in manufacturing industries is positively related to an increased use of outsourcing, defined as inputs purchased from services industries. Also based on industry-level data for the U.S., Fixler and Siegel (1999) found that outsourcing has led to short-run reductions in service sector productivity, but has positive effects in the long run. In contrast, some studies found no significant relationship between service outsourcing and productivity growth (e.g., Siegel and Griliches, 1991).

In addition, there has been some work on the impact of outsourcing on employment and wages. Amiti and Wei (2004) estimated the impact of foreign outsourcing of services on employment, and found that service outsourcing is negatively related to employment using disaggregated industry data for 450 different industries. Feenstra and Hanson (1996, 1999) found that foreign outsourcing of services, defined as transfer of unskilled activities to low-wage countries, is positively related to the increase in the relative demand for skilled labor, measured as non-production-workers share of the industry wage bill.

These studies are related to our work in that they examine the impact of services outsourcing at the industry level. Because these studies analyze aggregate services as a whole, any differences between different types of services are averaged away. The overall mixed results of the impact of services outsourcing may be due to the averaging out by aggregation. We believe IT-related services are different from other services because of the fast pace of the changes in technologies and skills involved in the services. In this study, we specifically examine the impact of IT outsourcing.

### **2.3. IT and Economic Performance**

Since Solow (1987) stated that one could see IT everywhere except in the productivity statistics, there has been a considerable debate about whether IT investments have led to higher productivity (Brynjolfsson, 1993). During the late 1990s, for example, a large number of studies in both Economics and IS examined the contribution of IT investments to economic performance at different levels. Different authors studied the *business process level* (e.g., Barua et al., 1995; Kauffman and Kriebel, 1988a; b), the *firm level* (e.g., Brynjolfsson and Hitt, 1995; 1996), the *industry level* (e.g., Gordon, 2000; Oliner and Sichel, 2000) and the *country level* (e.g., Dewan and Kraemer, 2000).<sup>2</sup>

The early studies, for the most part, did not find a positive contribution from IT investments to firm performance (e.g., Loveman, 1994). However, most of the studies in this line of research found a positive relationship between IT investments and economic performance at different levels using different methodologies (e.g., Banker and Kauffman, 1988; Dos Santos et al., 1993; Lee and Barua, 1999; Nault and Dexter, 1995; Tallon et al., 1999). Although it is now well established that IT investments make positive economic contributions leading to higher

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<sup>2</sup> For a more complete review of the literature on IT and economic performance, see Dedrick, et al. (2003).

productivity, no research has examined whether IT outsourcing contributes to economic performance.

Two related approaches have been used to model the relationship between IT and economic performance: the *production function approach* and the *growth accounting approach*. The production function approach relates the output of a firm, industry, or economy to the inputs that are consumed based on estimation models derived from a *production function*. The Cobb-Douglas production function is one of the most commonly used functional forms. In this approach, IT capital is treated as an input in the production function, along with labor and non-IT capital, and the contribution of IT is measured by output elasticity of IT capital. Most firm-level studies use this approach. In the growth accounting approach, observed economic growth is broken down into components associated with changes in factor inputs and the *multifactor productivity* (MFP) or *Solow residual* that reflects technological progress and other elements. The studies at the industry or sector level use growth accounting, along with the production function approach, to measure the contribution of IT to the growth of *average labor productivity* (ALP) and MFP. ALP is typically expressed in terms of output per unit labor hour.

In this study, we use the production function approach to estimate the contributions of IT outsourcing to the growth of output in the industries that purchase IT services. We do not use the growth accounting approach because it requires data on MFP. Unfortunately, MFP data are not available for the entire period (1998-2003) we examine. We only will be able to analyze the contribution of IT outsourcing to the ALP and MFP as the necessary data become available.

The review of related literature reveals that there is a paucity of research on estimating the economic impact of IT outsourcing. We believe that the lack of quantitative analysis of the economic impact of IT outsourcing is due to unavailability of necessary firm- or industry-level

data. Although previous studies on IT outsourcing suggest that IT outsourcing can create value, the evidence provided so far has been mainly anecdotal. In this study, we attempt to fill this gap in the literature by estimating the contributions of IT outsourcing at the industry level. We treat IT outsourcing as part of intermediate inputs (i.e., purchased services and materials) in the industry production function. We draw upon the available studies on services outsourcing, and IT and productivity.

There are several reasons to believe that IT services outsourcing will make a positive contribution (e.g., in the form of higher productivity) in the industries that use IT services. First, the IT service providers have production costs advantages based on economies of scale, economies of scope, and economies of specialization (Clemons et al., 2000), which enable the customer firms to use IT services at lower costs. Second, the quality of the service provided by third parties can be higher because they may have accumulated complementary assets or competences that the buyer firms do not have (Levina and Ross, 2003). In addition, as Cheng and Nault (2005) found, IT investment by upstream industries (e.g., IT services providers) can have a positive impact on the productivity of downstream industries (i.e., the customer firms) through improved intermediate inputs—or purchased IT services in this case.

### 3. A PRODUCTION FUNCTION FRAMEWORK

Drawing upon the IT and productivity literature, we employ the production function framework. We treat IT outsourcing as an input factor, in particular, as part of the intermediate inputs that are consumed in the production process. We measure IT outsourcing as *purchased IT services*, and consider the following industry production function,

$$Y = f(K, L, M, Z_K, Z_M),$$

where  $Y$  is the industry output, and  $K$ ,  $L$  and  $M$  are non-IT capital, labor, and non-IT services

intermediate inputs. Finally,  $Z_K$  and  $Z_M$  are IT capital and IT services intermediate inputs (i.e., IT outsourcing). We use *gross output* as the output concept for our study because it corresponds to a well-defined output concept at the industry level, and hence is more appropriate for productivity analysis than a measure of value-added (Stiroh, 2002).

To measure the contribution of IT outsourcing on output, we adopt the widely used *Cobb-Douglas production function*,

$$Y = AK^\alpha L^\beta M^\gamma Z_K^\delta Z_M^\omega,$$

where  $A$  is a *technological change parameter*, and  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ , and  $\omega$  are *output elasticities* of the non-IT capital, non-IT labor, non-IT services intermediate inputs, IT capital, and IT services intermediate inputs. The Cobb-Douglas function has been considered to be a good approximation of the underlying production function in the IT and productivity research (Brynjolfsson and Hitt, 1996; Dewan and Min, 1997; Dewan and Kraemer, 2000). For estimation, we take the natural log:

$$y = a + \alpha k + \beta l + \gamma m + \delta z_K + \omega z_M.$$

Each lower-case letter represents the log of the corresponding upper-case letter. The estimated  $\omega$  represents the average percentage increase in gross output associated with 1% increase in spending in IT outsourcing.

## 4. DATA AND METHODS

We next provide information on our unique data, and the decisions we made about how to handle the specification of the variables and the information structure of our evaluative models.

### 4.1. Data and Variables

We use data for 61 industries in the United States private sector provided by the BLS and the

BEA for the period of 1998 to 2003. We converted the data into Year 2000 U.S. dollars using the appropriate deflators. (See Table 1 for details of the sources, construction procedure, and deflators used.) We used *chain-type quantity indexes* as deflators. These indexes show the growth of output (or other variables) over time holding prices constant. They were introduced by BEA in 1996 to improve the accuracy of the estimates of the growth in real GDP by eliminating the bias present in fixed-weight indexes. Chain-type indexes can be calculated by taking the geometric mean of fixed-weight and variable-weight quantity indexes. Real (chained-dollar) values were obtained by multiplying nominal (current) values in the base year (2000) by chain-type quantity indexes.

For industry *gross output* and (total) *intermediate inputs*, we use the data that the BEA recently published based on improved National Income and Product Account information.<sup>3</sup> To calculate IT and non-IT capital stock, we use the BEA's fixed assets tables. For example, for *IT capital*, we aggregated the net stock of private fixed assets that belong to the category of "information processing equipment and software," as defined by the BEA and reported in Grimm et al. (2003).<sup>4</sup> These assets are computer and peripheral equipment, communications, instruments, photocopy and related equipment, office and accounting equipment, and software. The *non-IT capital* data were obtained by subtracting the IT capital stock from the total net stock of private fixed assets.

To obtain data on *IT outsourcing*, we use input-output accounts for the 1998 to 2003 period

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<sup>3</sup> In June 2004, BEA released the results of the comprehensive revision of the annual industry accounts for the 1998-2003 period based on its' new estimating methods (Moyer, et al., 2004). The new methodology combines source data between the annual input-output accounts and the GDP-by-industry accounts to improve accuracy and consistency. This new methodology has resulted in industry accounts that provide a more accurate and consistent picture of the U.S. economy than the previously published accounts.

<sup>4</sup> In this study, we measure IT capital and non-IT capital as *stocks* while we measure labor and intermediate inputs as *flows*. Alternatively, one can use the value of service flows derived from stocks to measure capital inputs (Jorgenson and Griliches, 1967). Capital stocks and flows are related through the rental prices, and capital stock measures can be converted to service flows by using the *rental price methodology* (Chwelos et al., 2004).

that were recently produced by the BEA. The Use Tables in the input-output accounts show the value of output produced by one industry that is used by another industry for each pair of industries in the economy. We measure an industry's IT outsourcing as the IT-related services the industry purchases from two IT services industries: Information and Data Processing Services (NAICS 514) and Computer Systems Design and Related Services (NAICS 5415). (See the Appendix for details of these two industries.) There is a potential measurement issue here. Although the industries within Computer Systems Design and Related Services are directly related to IT outsourcing, some industries within Information and Data Processing Services are not directly relevant to IT outsourcing (e.g., News Syndicates and Libraries and Archives). As a result, our measure of IT outsourcing is likely to be greater than "true" value of IT outsourcing. However, this issue is not as serious as it looks. According to data from the 1997 Economic Census, about 95% of the revenue generated by Information and Data Processing Services comes from the industries that are directly linked to IT outsourcing (e.g., Data Processing Services).

*Non-IT services intermediate inputs* were calculated by subtracting IT outsourcing from total intermediate inputs. The *Labor input* was constructed by multiplying the total employment by average work hours of 2,080 hours, based on the annual Occupational Employment Statistics from the BLS. The values of the constructed variables are summarized in Table 2. (See the Appendix for the correlations among the independent variables.)

**Table 1. Data Sources and Construction Procedure**

<b>Data Series</b>	<b>Source</b>	<b>Construction Procedure</b>	<b>Deflator</b>
<b>Output</b>	BEA Annual Industry Account	Gross output by industry converted to 2000 dollars by multiplying current 2000 values by chain-type quantity index.	Chain-type quantity index for output
<b>IT Capital</b>	BEA Fixed Assets	Net stock of “information processing equipment and software” defined by BEA (computer and peripheral equipment, communications, instruments, photocopy and related equipment, office and accounting equipment, software) by industry converted to 2000 dollars.	Chain-type quantity index for fixed assets
<b>Non-IT Capital</b>	BEA Fixed Assets	Net stock of private fixed assets excluding information processing equipment and software by industry converted to 2000 dollars.	Chain-type quantity index for fixed assets
<b>Labor</b>	BLS Occupational Employment Statistics	Total employment by industry multiplied by average annual work hours (2080 hours).	NA
<b>IT Outsourcing (Purchased IT services)</b>	BEA Industry Input-Output Account (Use tables)	Sum of an industry’s intermediate inputs purchased from 514 (Information and data processing services) and 5415 (Computer systems design and related services). Converted to 2000 dollars.	Chain-type quantity index for intermediate inputs
<b>Non-IT Services Intermediate Inputs</b>	BEA Industry Input-Output Account (Use tables)	An industry’s total intermediate inputs from the Use table excluding purchased IT services. Converted to 2000 dollars.	Chain-type quantity index for intermediate inputs
<b>Note:</b> <i>Chain-type quantity indexes</i> show the growth of output (or other variables) over time holding prices constant. Real (chained-dollar) values can be obtained by multiplying nominal (current) values in the base year (2000 in this study) by chain-type quantity indexes.			

**Table 2. Summary Statistics, 61 Private Sector Industries in the United States (1998-2003)**

<b>Data Series</b>	<b>Overall Mean</b>	<b>Std. Dev.</b>	<b>% of Output</b>
<b>Output</b> (in millions of 2000 US\$)	262,072.0	274,624.6	100
<b>IT capital</b> (in millions of 2000 US\$)	20,594.5	37,318.2	7.86
<b>Non-IT capital</b> (in millions of 2000 US\$)	329,715.8	1439,717.0	125.8
<b>Labor</b> (in millions of work hours)	3,537.1	4,805.5	NA
<b>IT outsourcing</b> (in millions of 2000 US\$)	1,998.1	2,385.7	0.76
<b>Non-IT services intermediate inputs</b> (in millions of 2000 US\$)	119,195.4	106,700.8	45.5
<b>Note:</b> The mean value of non-IT capital stock is disproportionately large relative to the mean value of output because of the two industries with huge non-IT capital (in particular, structures): 482 (Rail transportation) and 531 (Real estate). Excluding these industries does not affect our qualitative results.			

## 4.2. Estimation Procedure

Because we use a cross-sectional time-series data set, there are potential econometric problems of heteroskedasticity across industries and autocorrelation across time periods. According to a likelihood ratio test for panel-level heteroskedasticity, we can reject the null hypothesis that errors are homoskedastic ( $\chi^2 = 547.22, p < 0.001$ ). It is also possible that errors are contemporaneously-correlated across panels (i.e., industries) (Parks, 1967). However, the structure of our data set does not allow us to take this into account. In addition, the Wooldridge (2002) test for autocorrelation in a panel dataset indicates the presence of first-order autocorrelation (AR1) in our dataset ( $F = 53.63, p < 0.001$ ).

In the presence of heteroskedasticity and autocorrelation in the errors (i.e., “nonspherical” errors), *pooled ordinary least square* (OLS) regression may be problematic. Although the OLS estimators will still be unbiased and consistent, they will no longer be efficient and the standard errors will not be correct (Beck and Katz, 1995; Greene, 2000). One way to deal with these issues is using *feasible generalized least square* (FGLS) procedures that allow corrections for heteroskedasticity and autocorrelation (Parks, 1967; Wooldridge, 2002). However, using FGLS for cross-sectional time-series data can be also problematic because the standard errors of the estimated coefficients may understate the true sampling variability (Beck and Katz, 1995). Therefore, in this study we use *OLS with panel-corrected standard errors* (PCSE), as suggested by Beck and Katz (1995), to estimate the production function. Their Monte Carlo analysis shows that PCSE performs well.

Because the AR1 process may have a common coefficient across industries, or the coefficient may be industry-specific (i.e., panel-specific), we consider both possibilities in our estimation.

We used the PCSE routines in STATA 8.0 ([www.stata.com](http://www.stata.com)) to estimate the model with the following error structures:

- Heteroskedasticity, plus a common AR1 coefficient across industries (HET-AR1)
- Heteroskedasticity, plus industry-specific AR1 coefficients (HET-PSAR1)

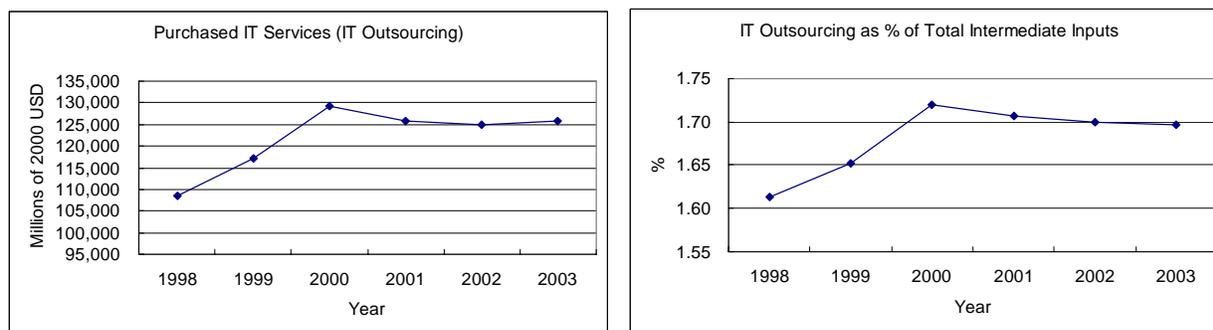
## **5. EMPIRICAL RESULTS**

We first examine the overall trend of IT outsourcing based on our measure of IT outsourcing, purchased IT services. Then, we present the estimation results from our full sample of 61 industry sectors. In addition, we report the results from an analysis of sample splits based on different levels of IT intensity.

### **5.1. IT Outsourcing Trend**

Figure 1 shows the trend of IT outsourcing that has occurred in private industry sectors in the United States over the period from 1998 to 2003. The left panel shows the change in the total volume of IT outsourcing over the period in millions of 2000 U.S. dollars. The right panel shows how the ratio of IT outsourcing to the total intermediate inputs has changed. The two panels are almost identical in terms of the trend.

IT outsourcing increased until 2000, reaching about US\$130 billion. We believe this increase partially reflects firms outsourcing the efforts to get their information systems “Y2K-ready.” Our data indicates that IT outsourcing dropped in 2001 due to the recession following the dot-com crash and the 911 terrorist attacks. Since 2001, IT outsourcing has remained almost at the same level. Based on the trend prior to 2001, we believe IT outsourcing would have increased continuously if it had not been for the 2001 recession.

**Figure 1. Trend in IT Outsourcing in U.S. Private Industries (1998-2003)**

## 5.2. Estimation: IT Outsourcing Output Contributions, Full Sample Results

To examine whether IT outsourcing has contributed to the output growth in U.S. economy, we estimated the Cobb-Douglas production function using our full sample consisting of 366 observations from 61 private sector industries in the U.S. over six years. As is shown in Table 3, all the output elasticity coefficient estimates, including the coefficient for IT outsourcing, are positive and significant ( $p < 0.05$ ) under both the HET-AR1 and the HET-PSAR1 error structures.

The coefficient estimates for IT capital are similar to those in other industry-level studies that examined different time periods (pre-2000) (e.g., Cheng and Nault, 2005; Mittal and Nault, 2004). This adds to the face validity of our dataset. The sum of the output elasticities slightly exceeds one (1.041 and 1.042), implying slightly increasing returns to scale, which is consistent with previous studies (e.g., Brynjolfsson and Hitt, 1996).

To more accurately compare the contribution of IT outsourcing relative to other inputs, we examine *gross marginal product (GMP)*. GMP is defined as the output produced by one more unit of a given input, and can be calculated by dividing the output elasticity of an input by its factor share. As shown in Table 4, the GMP of IT outsourcing (474% and 526%) is significantly greater than that of non-IT services intermediate inputs (136% and 133%). This indicates that although the volume of IT outsourcing is much smaller than the rest of the intermediate inputs, IT outsourcing has made substantially greater contributions to output growth in U.S. industries

over the period we examined. We further note that the GMP of IT capital is also substantially greater than the GMP of non-IT capital. This is consistent with previous studies on IT and productivity.

**Table 3. Coefficient Estimates for Full Sample, 61 Industries (1998-2003)**

Error Structure for Regression	Coefficient Estimates (Output Elasticity)					Returns to Scale
	IT capital	Non-IT capital	Labor	IT outsourcing	Non-IT services intermediate inputs	
<i>HET-ARI</i>	0.062** (0.013)	0.106** (0.019)	0.216** (0.013)	0.036** (0.008)	0.621** (0.013)	1.041
<i>HET-PSARI</i>	0.082** (0.010)	0.099** (0.013)	0.216** (0.011)	0.040** (0.008)	0.605** (0.017)	1.042

**Note:** 366 observations, \*\* =  $p < 0.01$  and \* =  $p < 0.05$ , standard errors in parenthesis. HET: heteroskedasticity; ARI: first-order autocorrelation with a common coefficient across panels; PSARI: first-order autocorrelation with panel-specific coefficients. We also estimated our model using simple *ordinary least squares* (OLS) without panel correction in standard errors, and *feasible generalized least squares* (FGLS). The results are similar.

**Table 4. Marginal Products of Factor Inputs**

Error Structure for Regression	Gross Marginal Product				
	IT capital	Non-IT capital	Labor	IT outsourcing	Non-IT services intermediate inputs
<i>HET-ARI</i>	78.9%	8.4%	NA	474%	136%
<i>HET-PSARI</i>	104%	7.9%	NA	526%	133%

**Note:** Gross marginal product (GMP) is the output produced by one more unit of given input.  $GMP = \text{output elasticity} \div \text{factor share}$ .

To evaluate the net contribution of IT outsourcing, we examine the *net marginal product (NMP)*, which is GMP net of the cost, as in Brynjolfsson and Hitt (1996). It is straightforward to calculate NMP because both IT outsourcing is a flow variable. Because a dollar of IT outsourcing costs one dollar, the GMPs of 474% and 526% imply that the net benefits of IT outsourcing is \$4.00 on the average. In comparison with these high net benefits of IT outsourcing, a dollar of non-IT services intermediate inputs has the average NMP of \$0.35.

### 5.3. Analysis of Sample Splits Based on IT Intensity

Industries in our data set may have structural differences in terms of their production processes. As a result, estimation of the production function using the full sample cannot

properly address such differences. In particular, we believe that the way IT is acquired, deployed and used will vary across industries. Therefore, we split the industries based on *IT intensity*. This sample-split analysis is in line with Dewan and Min (1997) and Stiroh (2002), who used sector and IT intensity for grouping industries.

Previous studies have used different measures for IT intensity. For example, Dewan and Min (1997) measured IT intensity as the factor share of IT capital among the inputs to production. Mittal and Nault (2005) use the ratio of IT capital to value added to measure IT intensity. In this study, we measure IT intensity by the *share of IT capital in total capital*. Stiroh (2002) argues that this measure is better than other measures of IT intensity in identifying those industries that expend a considerable portion of their tangible investment resources on IT. We rank-ordered the industries based on their mean IT intensity over 1998 to 2003 period, and split them into two groups below and above the median value of IT intensity: the *high IT intensity group* (with 30 industries) and the *low IT intensity group* (also with 30 industries). Another approach is to use visual inspection analogous to a scree plot of the data to find a natural split as in Mittal and Nault (2005). We also tried this method and found qualitatively identical results. (See the Appendix for summary statistics for these two industry groups.)

To test whether there are differences in the degree of IT outsourcing between these two groups, we use the concept of *IT outsourcing intensity*, measured by the ratio of purchased IT services to total intermediate inputs. We use a t-test for comparing two samples (Rice, 1995) to examine if the IT outsourcing intensity of the industries in the high IT intensity group is different from the industries in the low IT intensity group. The result ( $t = 2.94, p = 0.005$ ) indicates that there is a statistically significant difference between the mean IT outsourcing intensity for the high IT intensity group and the low IT intensity group. This indicates that high IT intensity

industries use a significantly higher proportion of IT outsourcing in its intermediate input mix as compared with low IT intensity industries. Another natural measure of IT outsourcing is the *ratio of purchased IT services to gross output*. Analysis with this measure yielded corroborating results. Our results are consistent with Bartel, et al. (2005), who found that more IT-intensive industries are more likely to purchase outside services. We obtained the same results ( $z = -3.09$ ,  $p = 0.002$ ) by performing the Mann-Whitney U test (also called the Wilcoxon rank sum test) (Rice, 1995). This is a non-parametric method that does not assume that the data follow any particular distributional form.

**Table 5. Test of Mean IT Outsourcing Intensity between High and Low IT Intensity Groups**

Group	IT Outsourcing Intensity (%)		Two-sample t-test	Mann-Whitney test
	Mean	Std. Dev.		
<i>High IT Intensity</i>	2.595	2.239	$T = 2.94$ $(p = 0.005)$	$z = -3.09$ $(p = 0.002)$
<i>Low IT Intensity</i>	1.193	1.344		
<b>Note:</b> We use the median value of IT intensity to divide the industries. Each group has 30 industries. The data set covers the period of 1998 to 2003. For both tests, the null hypothesis is that the (mean) IT outsourcing intensity is identical between the groups.				

Now that we have found that high and low IT intensity industries are structurally different with respect to the use of IT outsourcing, we next examine whether the two industry groups differ with respect to the economic contributions of IT outsourcing. To this end, we run separate regressions for the high and low IT intensity industry groups as in Dewan and Min (1997) and Mittal and Nault (2005). The results of the regressions are provided in Table 6. Differences in the coefficient estimates between the two groups are quite noticeable. First, the output elasticities for IT outsourcing are positive and significant for the high IT intensity group, whereas the output elasticities for IT outsourcing are positive but insignificant for the low IT intensity group. Second, the output elasticities for IT capital are significantly larger in the high

IT intensity group while the output elasticities for non-IT capital are significantly larger in the low IT intensity group.

**Table 6. Comparison of Coefficient Estimates for High and Low IT Intensity Groups**

Parameter	High IT Intensity (30 Industries)		Low IT Intensity (30 Industries)	
	HET-AR1	HET-PSAR1	HET-AR1	HET-PSAR1
<i>IT capital</i>	0.101** (0.019)	0.091** (0.023)	0.022 (0.023)	-0.002 (0.022)
<i>Non-IT capital</i>	-0.032 (0.027)	0.005 (0.037)	0.189** (0.020)	0.215** (0.019)
<i>Labor</i>	0.295** (0.020)	0.307** (0.016)	0.173** (0.015)	0.186** (0.025)
<i>IT outsourcing</i>	0.042** (0.012)	0.029* (0.012)	0.008 (0.007)	0.010 (0.008)
<i>Non-IT services intermediate inputs</i>	0.609** (0.031)	0.627** (0.022)	0.610** (0.023)	0.630** (0.019)

**Note:** 180 observations in each group, \*\* =  $p < 0.01$  and \* =  $p < 0.05$ , standard errors in parenthesis. The data set covers the period of 1998 to 2003. HET: heteroskedasticity; AR1: first-order autocorrelation with a common coefficient across panels; PSAR1: first-order autocorrelation with panel-specific coefficients.

Furthermore, the output elasticities for non-IT capital in the high IT intensity group are not significantly different from zero, while the output elasticities for IT capital in the low IT intensity group are insignificant. These results indicate that there are structural differences between the two groups in terms of the way the factor inputs contribute to output growth. In high IT intensity industries, IT capital and IT outsourcing make substantial contributions to output growth while the contribution of non-IT capital is insignificant. However, in low IT intensity industries, this pattern is reversed. It is now non-IT capital that makes substantial contributions while the contributions of IT capital and IT outsourcing are insignificant.

## 6. DISCUSSION AND CONCLUSIONS

### 6.1. Discussion of the Results

This study estimated an industry production function based on a panel data set of 61 private sector industries in the United States. We found that IT outsourcing has made a positive and significant contribution in U.S. industries over the 1998 to 2003 period. This implies that IT

outsourcing-related spending has paid off, at least in our sample of industries. We also learned that industries with high IT intensity tend to use more IT outsourcing than those with low IT intensity. This result might seem a bit counterintuitive because one can argue that IT is more likely to be a core competence in the high IT intensity industries than in the low IT intensity industries. However, as McClelland, et al. (1995) found, some firms may outsource IT functions even though they see them as core and delivering competitive advantage.

There are several possible explanations for this result. First, it is likely that the pace of technological changes is faster in high IT intensity industries than in low IT intensity industries. When the technologies change fast, the current technologies become obsolete sooner, and so firms have to frequently upgrade to new technologies with improved functionality. Otherwise, they are likely to be locked into older technologies that might put them at a competitive disadvantage. Outsourcing allows firms to use IT services based on leading-edge technologies without incurring the large and inevitable sunk costs of adopting the new technologies (Bartel et al., 2005; Gilley and Rasheed, 2000).

Second, firms which outsource their IT functions are likely to incur transaction costs associated with negotiating, monitoring and enforcing outsourcing contracts. We argue these costs will be smaller for the firms that possess better knowledge and expertise related to IT, which we believe is the case in high IT intensity industries. Firms in high IT intensity industries are likely to have invested more heavily in IT and accumulated greater knowledge and expertise regarding various technologies over time. By leveraging the firms' use of their own technologies and their ability to use others' technologies, this IT knowledge and expertise will allow the firms to incur lower transaction costs compared to low IT intensity firms (Bartel, et al., 2005).

Another major finding of our work is evidence of significant differences between high and low IT intensity industries with respect to the contributions of IT outsourcing. For high IT intensity industries, IT outsourcing has made a positive and significant contribution to output growth. In contrast, IT outsourcing has failed to make a positive contribution in low IT intensity industries.

Again, we believe that the IT knowledge and expertise which the high IT intensity industries have accumulated over time may enable them to better manage outsourced IT functions and projects. The difficulty of managing outsourced IT projects is illustrated in a survey that was recently reported by ITtoolbox (2004) that shows “managing and communication” are the biggest challenges in IT outsourcing. As such, the ability of the firm to effectively manage IT outsourcing is critical to its capacity to capture value from IT outsourcing. In this regard, IT knowledge and expertise can help better manage and exploit IT outsourcing. This observation is closely linked to the concept of “absorptive capacity,” which refers to an organization’s ability to evaluate and utilize external knowledge (Cohen and Levinthal, 1990). Cohen and Levinthal (1990) argue that an organization’s *prior related knowledge* is an important source of its absorptive capacity. Applied to the context of IT outsourcing, this means that prior IT knowledge accumulated by a firm can help develop its IT related absorptive capacity. This is consistent with Boynton et al. (1994) who found that “managerial IT knowledge,” a measure of IT-related absorptive capacity, brings about high levels of IT usage by facilitating information exchanges and joint problem solving among managers.

## **6.2. Limitations**

This study has the following limitations. First, the time period of 1998 to 2003 is relatively short compared with other productivity studies. This is mainly due to the change in the industry

classification scheme from SIC to NAICS—NAICS-based industry-level data are not currently available prior to 1998. Although guidelines for conversion between these two schemes are available from the U.S. Census Bureau, conversion is a daunting task because SIC industries and NAICS counterparts have many-to-many relationships. We are currently working on this to extend the data set to pre-1998 years.

In addition, there were several unique historic events during our sample period including Y2K, the dotcom crash, the 911 terrorist attacks, and the ensuing recession in 2001. Because of the short period in our data set, it is possible that these events might have had significant influence on our results. We believe our empirical model has resolved part of this issue by taking heteroskedasticity into account. However, it is likely that all the industries have been affected at the same time by these exogenous shocks. Therefore, we need to consider contemporaneous correlation across industries in our estimation. Estimation of the model including contemporaneous correlation requires the number of time periods to be greater than the number of panels (that is, industries). Unfortunately, this is not the case in our data set. We will be able to take this into account after extending our data set.

### **6.3. Conclusions**

In this study, we estimated the economic contributions of IT outsourcing using the production function framework and a panel data set from 61 private sector industries in the United States. To the best of our knowledge, this is the first study that objectively measured IT outsourcing and its economic contribution. In addition, our treatment of IT outsourcing as a factor input in production is novel. Our results indicate that IT outsourcing has paid off, at least in the industries in our data set, by making substantial contributions to output growth.

Our most significant result is that there seem to be systematic differences in the way IT

outsourcing is used by industries, depending on the relative IT intensity of industries. We found that those industries which invest more heavily in IT tend to not only use more IT outsourcing. They also get more out of IT outsourcing, probably based on their superior IT-related knowledge accumulated from their extensive use of IT over time.

Our results will assist senior managers in gauging the aggregate impacts in the economy from IT outsourcing. This, in turn, will enable them to make decisions related to IT outsourcing with an awareness of what micro-level outcomes are likely to obtain.

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## Appendix 1. Correlations among the Independent Variables

	Non-IT capital	IT capital	Labor	Non-IT services intermediate inputs	IT outsourcing
Non-IT capital	1.0000				
IT capital	0.0116	1.0000			
Labor	0.0182	0.2459	1.0000		
Non-IT services intermediate inputs	0.3966	0.3790	0.5438	1.0000	
IT outsourcing	0.0719	0.3902	0.5420	0.4839	1.0000

## Appendix 2. Description of United States Private Sectors and Industries

1997 NAICS Code	Sector and Industry Title	IT Intensity
<b>11</b>	<b>Agriculture, forestry, fishing, and hunting</b>	-
111, 112	Farms	Low
113 – 115	Forestry, fishing, and related activities	Low
<b>21</b>	<b>Mining</b>	-
211	Oil and gas extraction	Low
212	Mining, except oil and gas	Low
213	Support activities for mining	High
<b>22</b>	<b>Utilities</b>	Low
<b>23</b>	<b>Construction</b>	High
<b>31 – 33</b>	<b>Manufacturing</b>	-
311, 312	Food and beverage and tobacco products	Low
313, 314	Textile mills and textile product mills	Low
315, 316	Apparel and leather and allied products	Low
321	Wood products	Low
322	Paper products	High
323	Printing and related support activities	High
324	Petroleum and coal products	High
325	Chemical products	High
326	Plastics and rubber products	High
327	Nonmetallic mineral products	Low
331	Primary metals	High
332	Fabricated metal products	Low
333	Machinery	Low
334	Computer and electronic products	Low
335	Electrical equipment, appliances, and components	Low
3361 – 3363	Motor vehicles, bodies and trailers, and parts	High
3364 – 3366, 3369	Other transportation equipment	Low
337	Furniture and related products	High
339	Miscellaneous manufacturing	Low
<b>42</b>	<b>Wholesale trade</b>	High
<b>44, 45</b>	<b>Retail trade</b>	Low
<b>48, 49</b>	<b>Transportation and warehousing</b>	-
481	Air transportation	High
482	Rail transportation	Low
483	Water transportation	High

1997 NAICS Code	Sector and Industry Title	IT Intensity
484	Truck transportation	Median
485	Transit and ground passenger transportation	High
486	Pipeline transportation	High
487, 488, 492	Other transportation and support activities	Low
493	Warehousing and storage	Low
<b>51</b>	<b>Information</b>	-
511	Publishing industries (includes software)	High
512	Motion picture and sound recording industries	High
513	Broadcasting and telecommunications	High
514	Information and data processing services	High
<b>52, 53</b>	<b>Finance, insurance, real estate, rental, and leasing</b>	-
52	Finance and insurance	-
521, 522	Federal Reserve banks, credit intermediation, and related activities	High
523	Securities, commodity contracts, and investments	High
524	Insurance carriers and related activities	High
525	Funds, trusts, and other financial vehicles	Low
53	Real estate and rental and leasing	-
531	Real estate	Low
532, 533	Rental and leasing services and lessors of intangible assets	High
<b>54 – 56</b>	<b>Professional and business services</b>	-
54	Professional, scientific, and technical services	-
5411	Legal services	High
5415	Computer systems design and related services	High
5412 – 5414, 5416 – 5419	Miscellaneous professional, scientific, and technical services	High
55	Management of companies and enterprises	High
56	Administrative and waste management services	-
561	Administrative and support services	High
562	Waste management and remediation services	Low
<b>61, 62</b>	<b>Educational services, health care, and social assistance</b>	-
61	Educational services	Low
62	Health care and social assistance	-
621	Ambulatory health care services	High
622, 623	Hospitals and nursing and residential care facilities	High
624	Social assistance	Low
<b>71, 72</b>	<b>Arts, entertainment, recreation, accommodation, and food services</b>	-
71	Arts, entertainment, and recreation	-
711, 712	Performing arts, spectator sports, museums, and related activities	Low
713	Amusements, gambling, and recreation industries	Low
72	Accommodation and food services	-
721	Accommodation	Low
722	Food services and drinking places	Low
81	Other services, except government	Low

### Appendix 3. Summary Statistics for High IT Intensity Industries (30 Industries)

Data Series	Overall Mean	Std. Dev.	% of Output
<b>Output</b> (in millions of 2000 US\$)	300720.0	234142.5	100
<b>IT capital</b> (in millions of 2000 US\$)	35694.27	48296.7	11.9
<b>Non-IT capital</b> (in millions of 2000 US\$)	125882.7	121729.1	41.9
<b>Labor</b> (in millions of work hours)	3873.3	4173.7	NA
<b>IT outsourcing</b> (in millions of 2000 US\$)	2903.1	2749.9	0.97
<b>Non-IT services intermediate inputs</b> (in millions of 2000 US\$)	135781.9	106552.3	45.2

### Appendix 4. Summary Statistics for Low IT Intensity Industries (30 Industries)

Data Series	Overall Mean	Std. Dev.	% of Output
<b>Output</b> (in millions of 2000 US\$)	225493.5	309813.7	100
<b>IT capital</b> (in millions of 2000 US\$)	5996.9	7483.0	2.66
<b>Non-IT capital</b> (in millions of 2000 US\$)	542533.7	2030283.0	240.6
<b>Labor</b> (in millions of work hours)	3228.8	5425.5	NA
<b>IT outsourcing</b> (in millions of 2000 US\$)	1062.5	1519.8	0.47
<b>Non-IT services intermediate inputs</b> (in millions of 2000 US\$)	103014.2	106372.9	45.7

### Appendix 5. Details of IT Services Industries

1997 NAICS Code	Industry Description	1997 NAICS Code	Industry Description
<b>514</b>	<b>Information Services and Data Processing Services</b>	<b>5415</b>	<b>Computer Systems Design and Related Services</b>
<b>5141</b>	Information Services	<b>54151</b>	Computer Systems Design and Related Services
<b>51411</b>	News Syndicates		
<b>51412</b>	Libraries and Archives	<b>541511</b>	Custom Computer Programming Services
<b>51419</b>	Other Information Services		
<b>514191</b>	On-Line Information Services	<b>541512</b>	Computer Systems Design Services
<b>514199</b>	All Other Information Services	<b>541513</b>	Computer Facilities Management Services
<b>5142</b>	Data Processing Services		
<b>51421</b>	Data Processing Services	<b>541519</b>	Other Computer Related Services