The International Journal of Economic Policy Studies
Volume 2 2007 Article 9

IT AND FIRM-LEVEL PERFORMANCE IN THE PHILIPPINES, 1999-2006

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ABSTRACT

Information technology, or IT, has become an integral part of a country's development. Governments have provided policies to facilitate the growth of the IT sectors of their respective economies, while firms have utilized IT in improving their production process. This study aims to assess the economic impacts of IT on the productivity of Philippine firms in terms of revenue.

Using the production function approach, secondary panel data on 50 firms for the period 2001-2004 was analyzed to measure the contributions of IT capital on firm output. Results showed that IT capital contributes significantly to the output of the firm and outweighs the contribution of the non-IT inputs; confirming previous researches. Different panel estimation techniques were utilized in this study, where it was found that the fixed effects model (FEM) is better suited to analyze the data compared to the random effects model (REM). Still, the presence of heteroskedasticity and autocorrelation justifies the use of the feasible generalized least squares (FGLS) estimation, which produces the best results among all the employed panel estimations. It was further found that a firm belonging to either the finance or manufacturing sectors benefits less from using IT capital, suggesting that extensive use of IT capital in these sectors has led to diminishing returns over time.

IT's contributions extend beyond its tangible benefits. Quality improvements, improved technology and organization, and improvement in workers' human capital are just some of IT's intangible elements. Given the significant effects of IT's contribution to firms' production, the government needs to ensure a vibrant macroeconomic environment in conjunction with continuing improvements in the digital infrastructure and certain institutional reforms to ensure the continued promotion of IT use in the country.

Key words: *IT, Firm Behavior, Firm Productivity*
JEL Classification: D21 Firm Behavior; O3 Technological Change

[1] The lead author would like to express his appreciation to his undergraduate thesis adviser, Dr. Elizabeth Martha S. Paterno, and his graduate seminar paper adviser, Dr. Joseph J. Capuno, for their guidance in the earlier works of this paper.

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1. INTRODUCTION

It is without a doubt that information technology (IT) has had a huge impact in all facets of life in today's modern world. Some say that the waves created by IT are tantamount to a Third Industrial Revolution, similar to the steam engine of the First, and the electricity, internal combustion engine, and chemical industry of the Second (Greenwood and Jovanovic, 1999). In fact, the East Asian miracle is attributed partly to the rapid rise of the IT industries in those countries[2]. In developing countries, IT is touted to enhance the competitiveness of key industries, modernize basic infrastructure, and reduce the costs of economic transactions (Nagy, 1995). IT, after all, has the power to reduce costs in coordination, communication, and information processing (Brynjolfsson and Hitt, 2000).

The Organization for Economic Cooperation and Development (OECD) multi-country report (ICT and Economic Growth: Evidence from OECD Countries, Industries and Firms, 2003) indicates that the huge impact of IT among the OECD-member economies is well felt on the productivity of firms and in effecting a sustained increase in economic growth, although the "impact on national indicators has proved slower to materialize than was expected and is much affected by synergies with complementary factors, such as the regulatory environment and the availability of human capital" (Dryden, 2003; OECD, 2004). Firm-level evidence gathered from 13 member economies shows that from 1995-2001, the 0.3 and 0.8 percentage points growth in GDP per capita was attributed to IT investment. Furthermore, countries with higher ICT investments further strengthen their ICT service sectors and this poses greater competitive advantage over those whose ICT sector was generally weaker. The same report also established that the massive IT investment led firms to a situation of "capital deepening" as reflected on the rising capital input per employee. In increasing efficiency in combining capital and labor (multifactor productivity), this caused a more efficient production in their value chain and business processes, and a sustained increase in output per worker. The report also accounted for the increasing significance and economic impact of networking and interaction between and among firms and sectors of the economy, such as consumers, as a consequence of IT investment, as this further facilitates innovation and reduction in transaction costs (Dryden, 2003; OECD, 2003, 2004).

IT pertains to a complex network of information exchange systems that use sophisticated computer and telecommunications technology to link diverse individuals and organizations within and among countries (APO, 1997). IT also refers "to the collective means to assemble and electronically store, transmit, process, and retrieve words, numbers, images, and sounds, as well as to electronic means to control machines of all kinds, from everyday appliances to vast automated factories" (Gerstein, 1987). On the other hand, the more encompassing definition, ICT, refers to a convergence of various information-based, broadcast, and mass media communication technologies. Examples include computers, multimedia, modems, satellites, telephones, cable television networks, and microelectronics. For this study, the smaller definition IT will be more widely used, since communication technologies are not emphasized in this research.

Inoue (1998) comments that innovation, as the engine of economic growth is an undeniable fact in the fields of economic growth theory and economic history. With the economy now shifting to increasingly conceptual and intangible economic resources, innovations in IT are changing all areas of economic activity. The information that flows through the physical conduits adds value to the technology and imparts productivity to various sectors of the economy (Tolentino, 1998). Thus, the close relationship between technology and economic production suggests that the focus must be on information resources, on the use value of those resources for producers, and on the mechanism by which those resources are developed and distributed since information itself is embodied in IT (Monk, 1992). Improved macroeconomic performance is noted as new industries are promoted, human capital is increasingly accumulated, and productive resources are allocated more efficiently. At the firm-level, the introduction of new technologies and usage of improved goods and services as inputs in the production process results in improved economic efficiency, positive network externalities, and returns to scale.

For the Philippines, IT is the key with which the country can pole-vault into the new century. Hence, the government has come up with its most comprehensive IT policy thus far, the IT21 of the National Information Technology Plan (NITP). Its ultimate aim is to transform the country into a Knowledge Center in Asia – a leader in IT education, IT-assisted training, and application of information and knowledge to business, professional services, and the arts (Dairo, 1999). Both government and private sector firms play crucial roles in promoting both IT production and IT use in the economy. The government's efforts in encouraging IT use are clearly shown by the provision of desktop computers in government offices. With government policies that promote increased IT investments, namely industrial, trade, competition, and other related policies, the private sector is expected to seek its global competitive niches and develop the Philippines as a highly competitive production site for global electronics and IT-related industries in the Asia-Pacific region (NITC, 1997). IT use would continue to be diffused throughout private industries, as emphasized by the "IT in Industry" component of the NITP. Also, implementation of key IT projects involving participation by business, academia, the science and technology community, and civil society will be carried out through the joint cooperation between the private sector and the government (NITC, 1997).

This study thus provides evidence on the quantity impacts of IT on top-earning Philippine firms. The rest of the paper is organized as follows: Section II provides a review of the literature. Section III discusses the framework and empirical methods. Section IV addresses various data and

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[2] See Nagy et al. (1996)

estimation issues. Section V presents an eight-year profile of Philippine firms ranked as the top users of IT. Section VI presents the results and Section VII concludes.

2. REVIEW OF LITERATURE

Nagy (1991) cited the continued high rate of technical change in the IT industries as the primary driving force behind the ongoing information revolution. Some technical improvements in computing and communications include: a continued 20 percent annual decline in the real cost of hardware for storing, processing, and transmitting information for the last four decades (compared to the 18th century Industrial Revolution's 50 percent decline in energy costs over a 30-year period), increased miniaturization, portability, and diversity of information-processing and communication devices, and recent advances in artificial intelligence, expert systems, optical storage discs, and other cutting-edge technologies.

While initial studies focused on IT as an industrial sector (production of electronics products and components, computer hardware and software, telecommunications equipment), there has been an emerging abundance of research on the role of IT as a generic industry technology, applicable across industries, production processes, and products. The latter first focused on industry- and sector-level analysis in the United States which then evolved into cross-country comparisons, with firm-level studies following suit.

IT contribution to growth, through labor productivity, is measured from capital deepening, IT production, and spillover effects to other sectors. Despite increasingly large investments in IT in the 1970s up to the early 1990s, economy- and sector-level research in the US on the relationship between IT and productivity during this time period found little evidence of such a relationship. Oliner and Sichel (1994) attributed this to the small fraction of computing equipment in capital stock. Other studies, however, floated the existence of a productivity paradox, a term first coined by Solow (1957), which means that a rapid increase in IT investment does not cause the acceleration of productivity growth. Measurement errors in economic statistics, adjustment costs of introducing new technology, time lags before benefits appear, external and spillover effects of new technologies, and misallocation of resources at the firm-level emerged as some of the explanations for the IT paradox (Inoue, 1998; Pohjola, 1998; Royol, 1999; Kuroda and Nomura, 1999). Jorgenson and Stiroh (1999) stated that returns to investment in IT equipment have been successfully internalized by computer producers and users (the substitution effect) instead of resulting in spillovers to third parties (technical change).

Productivity revival was observed in the late 1990s (empirical evidence from Jorgenson and Stiroh (1999; 2000) and Oliner and Sichel (2000)). Gordon (2000), however, noted that the revival occurred only in the durable manufacturing sector, which comprises 12% of the economy. Given that at least three-fourths of all computers are found in the wholesale and retail trade, finance, insurance, real estate, and other service sectors, it was thus surprising that computer investment has had a nearzero rate of return in the rest of the economy. Oliner and Sichel (2000) cited that while Gordon (2000) focused on trend productivity growth, their study emphasized actual productivity growth.

Recent cross-country studies also reinforce IT's effects on labor productivity attributed to capital deepening and total factor productivity (TFP) growth. Haacker and Morsink (2002) found that IT has a large, positive, and significant impact on generalized TFP growth. Also, their results provide evidence of the gradual spillover effects of IT usage as IT expenditures increase over time. Lee and Khatri (2003) ascribed TFP growth more to capital deepening among Asian countries in the 1990s. The study also decomposed TFP via the contributions of non-IT capital stock, IT capital stock, and labor.

Traditional macroeconomic approaches, though, have certain limitations in capturing the effects of intangible organizational investments and product and service information associated with computers; their focus is only on the relatively observable aspects of output and investment (Brynjolfsson and Hitt, 2000). Thus, firm-level studies have significant measurement advantages over growth accounting frameworks.

Firm-level inquiries through time have centered on the interrelationships between IT, organization, and human capital investments in relation to enhancing productivity. Brynjolfsson and Hitt (1995, 1996) and Lichtenberg (1995) estimated production functions with the firm's output or value-added as the dependent variable and the IT capital and labor inputs separated from the traditional capital and labor inputs; their results showed significant contributions of IT inputs to output. Brynjolfsson and Hitt (2000) estimated the average annual contribution of computer capital total output to generally exceed \$0.60 per dollar of capital stock, which in most cases significantly exceed the expected rate of return of approximately \$0.42[3]. Black and Lynch (1997) examined the impact of workplace practices, IT, and human capital on productivity while Bresnahan et al. (1999) added the demand for skilled labor into the argument. Their results illustrate that higher productivity is associated with decentralized organizations with good establishment practices: both characteristics encourage workers to think and interact in increasing production.

Still, Pilat (2004) opines in his survey of various approaches analyzing the economic impacts of IT, that an examination at the firm-level requires a more complex procedure, a methodology, and a survey data set that are more sophisticated and perhaps more complex compared with studies, and analyses that are by nature macroeconomic and sectoral in approach. Appendix A provides an exhaustive menu of firm-level approaches and survey data requirements in examining the impact of IT.

In the Philippines, the framework for quantifying the impact of IT on productivity was established by Royol (1999). This study utilizes this existing framework, extending the analysis using panel data, and explores the applicability of different estimation methods.

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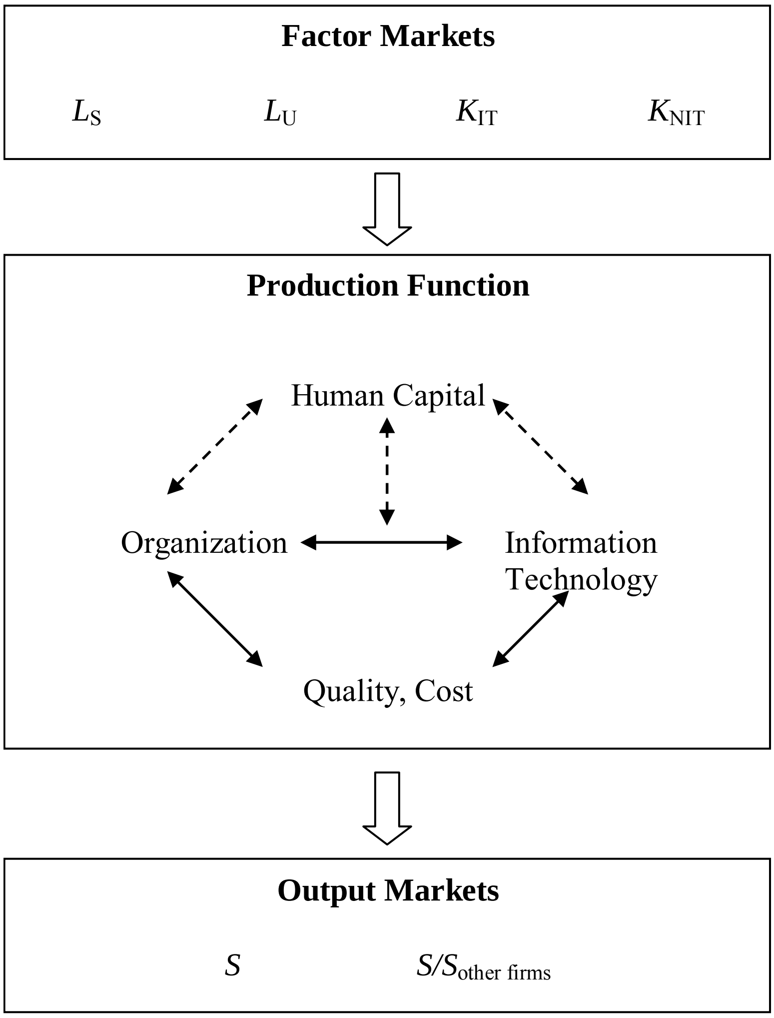
[3] This suggests either abnormally high returns to investors or the existence of unmeasured costs or barriers to investment.

3. THEORETICAL FRAMEWORK

The firm, as the basic production unit, produces goods and services using inputs, called factors of production, such as labor and capital. Figure 1 illustrates this "black box" of production. The top box represents the factor markets for skilled labor (L_S) and unskilled labor (L_U) and for IT capital (K_{IT}) and other capital (K_{NIT}). The production process is shown in the center, while the output markets are in the bottom, with sales of the firm (S) and sales relative to other firms ($S/S_{\text{other firms}}$). The solid arrows represent the emerging view of complementarity among three distinct kinds of technical change, namely, technical change embodied in IT capital, new and improved products and services (quality), and organizational change (Bresnahan et al., 1999).

As shown, firms use high human-capital based production along with IT-based and reorganized workplaces to make higher quality goods and services. The adoption of IT and the increasing intensity of its use transform the production function and modify both the composition and quality of its factors of production (Greenan et al., 2001). There are then two effects of these changes: the direct effect involves a growing volume of computer equipment (with increasingly high performance) in firms' capital stock, while machines and other equipment become more dependent on electronic equipment and computer software. Thus, IT-using workers are needed to manage and maintain these new systems, and these workers in turn must acquire specific knowledge and skills, thereby raising human capital. But the indirect effects are also substantial. Embodied technical change is represented by the expanding capabilities of the technology; for example, computers are becoming easier to use, are more powerful, and are easier to network together. Also, where the internal organization is easily dependent on information, better measurement and communication associated with IT permits more objective management and a decentralized organizational structure. Moreover, IT-based production improves efficiency resulting in lower costs to the firm and often changes the quality, timeliness, variety, and nature of a firm's outputs (Bresnahan et al., 1999). Yet the co-evolution of these complementarities does not necessarily imply causality (Greenan et al., 2001).

Figure 1: Production Function, Factor Markets, and Output Markets



Source: Adopted from *Bresnahan et al.*, 1999.

Difficulty stems in measuring organizational change given its variety and the lack of organizational variables. Also, quality changes cannot be directly observed. Thus, this study's primary focus will be on how the firm's choice of IT and its subsequent demand for IT (K_{IT}) affect output.

Formally, the firm's problems involved maximizing profits subject to a given technology. Profits are the difference between revenue and cost; revenue is the output quantity times the output price whereas cost is the sum, over all inputs, of the input level times the return of each input (Intriligator et al., 1996). Wages and rents are the returns to labor and capital, respectively. In the neoclassical framework, technology is represented by the production function, which indicates the maximum output given various combinations of the inputs. Most empirical work shows output y as a function of homogeneous inputs capital K and labor L:

$$y = f(K, L). \quad (1)$$

Of these variables, measuring capital proves to be problematic. First, there are aggregation problems due to diversity and different technical characteristics such as productivity and efficiency. Second, the assumption that all capital is rented is unrealistic, given that firms do own some capital. It becomes necessary to impute a rental value to the capital that is owned, which is dependent on depreciation figures that are considered to be unrealistic. Lastly, there is the difficulty of accurately measuring capacity utilization; only capital that is actually utilized should be treated as an input.

Despite this difficulty in capital measurement, the production function in this study is expressed as a function of inputs wherein IT capital is distinguished from its non-IT counterpart. A good starting point for analyzing IT impacts would be assessing the importance of the computer as a factor of production; computers are widely believed to be at the forefront of the IT revolution (Pohjola, 1998). For lack of better measures, the study proxies the amount of IT capital with the quantity of computer hardware present in the firm, with the assumption that basic operating system (OS) software is included when the hardware was purchased. Impacts of additionally purchased software and computer services are relegated to the residual. Compared to measuring the purposes of business information systems (IS) in which the IT capital is embedded, this hardware-based view of IT has considerable measurement advantages and is closely linked with external technological advances (Bresnahan et al., 1999).

Land and natural resources also enters the production function, but it is simply included as part of the non-IT capital input. (Royol, 1999). The production function is therefore:

$$y = f(C, K, L, O), \qquad (2)$$

where C is IT capital; K is non-IT capital; L is labor; and O represents other factors. For simplicity, a Cobb-Douglas specification is used. This form is represented as:

$$y_i = AC_i^{\gamma}K_i^{\alpha}L_i^{\delta}, \qquad (3)$$

where A, γ, α, and δ are fixed positive parameters[4], and i = 1, …, n (firms). The Cobb-Douglas function can also be expressed linearly by taking logarithms and adding a stochastic disturbance term u_i to account for variations in the technical or productive capabilities of each firm:

$$y_i = \ln A + \gamma \ln C_i + \alpha \ln K_i + \delta \ln L_i + u_i, \qquad (4)$$

where the parameters are the partial output elasticities of their respective variables[5]. IT impacts are captured by γ and δ, the partial elasticities of IT capital and IT labor, respectively.

It is assumed here that the parameters (including prices) are the same for all firms, with u_i accounting for all the differences among firms. Hence gross revenue can be used as a proxy for output (Kimbell and Lorant, 1974). This is brought about by the absence of a universal quantity measure of output, particularly when measuring the value of heterogeneous services that financial intermediaries, banks, and insurance companies provide. In a way, though, expressing output in money terms captures

[4] Brynjolfsson and Hitt (2003; 2000) cite that while most early empirical work using production functions utilized a Cobb-Douglas specification, later work using different functional forms, such as the transcendental logarithmic (translog) production function, has little effect in measuring output elasticities.

some intangible quality improvements that would not otherwise be accounted for if quantities were used – an increase in product quality could lead to higher sales.

Concerns abound that firms with substantial market power nullify the assumption of prices being the same. However, price changes brought about by market power would more or less be uniform across firms when all firms exhibit such power, thereby satisfying this assumption (this would not hold if some firms do not have market power).

4. DATA AND ESTIMATION ISSUES

The estimating equation for this study is equation 5, which is similar to equation 4 in all aspects with the addition of sectoral intercept and slope dummy variables and the addition of the time parameter, t:

$$GREV_{it} = \beta_0 + \beta_1 ITCAP_{it} + \beta_2 NITCAP_{it} + \beta_3 LABOR_{it} + \beta_4 FINANCE_{it} + \beta_5 MNFG_{it} + \beta_6 ITFIN_{it} + \beta_7 ITMNFG_{it} + u_{it}, \quad (5)$$

where $GREV_{it}$ is the log of gross revenue; $ITCAP_{it}$ is the log of IT capital; $NITCAP_{it}$ is the log of non-IT capital; $ITLABOR_{it}$ is the log of IT labor; $NITLABOR_{it}$ is the log of non-IT labor; *FINANCE* is the intercept dummy variable which takes on a value of 1 if the firm belongs to the finance sector, 0 if otherwise; *MNFG* is the intercept dummy variable which takes on a value of 1 if the firm belongs to the manufacturing sector, 0 if otherwise; *ITFIN* is the slope interaction dummy variable of firms in the finance sector with IT capital; *ITMNFG* is the slope interaction dummy variable of firms in the manufacturing sector with IT capital (all previous variables refer to some firm i at time t); β_0 is the intercept (ln *A*); and β_1, β_2, and β_3 are the partial output elasticities of the respective inputs. All the coefficients, in line with economic theory, are expected to be positive. β_4, β_5, β_6, and β_7 are the coefficients of the dummy variables of the 2 production sectors which are the heaviest users of IT; it represents the extent to which the production processes of firms in these sectors are affected by their use of IT compared with those of firms in other sectors.

For the study, three types of panel models were considered. The first model is essentially a pooled OLS regression of the data (constant coefficients), embodied by equation 5, and ignores possible differences among firms and/or across time. The second model is the fixed effects model (FEM), sometimes called the least squares dummy variables model, where dummy variables are used to account for the firm and/or time effects. The equation to be estimated now becomes equation 6,

$$GREV_{it} = \beta_0 + \beta_i + \beta_t + \beta_1 ITCAP_{it} + \beta_2 NITCAP_{it} + \beta_3 LABOR_{it} + \beta_4 FINANCE_{it} + \beta_5 MNFG_{it} + \beta_6 ITFIN_{it} + \beta_7 ITMNFG_{it} + u_{it}, \quad (6)$$

with β_i and β_t representing the firm-specific and time-specific effects, respectively.

Estimation of fixed effect panel data models is prone to several problems. First, introducing too many dummy variables rids the model of degrees of freedom necessary to validate statistical tests.

[5] For example, taking the derivative of ln *y* with respect to ln *C* yields $(C/y)(dy/dC)$, which is the slope of *C*.

Secondly, the time-series nature of panel data leaves it prone to the problem of autocorrelation, where estimates are still unbiased but are inefficient due to large sample variances (Gujarati, 2003). Finally, the problem of heteroskedasticity leads to unbiased but inefficient estimates, and thus confidence intervals will be incorrect and will invalidate hypothesis tests for standard OLS regressions. In the event that autocorrelation and/or heteroskedasticity are/is observed for the sample, feasible generalized least squares (FGLS) estimates can be used, given a large enough sample size.

Given the various problems of FEM, a random effects model (REM) can also be used, such that the differences among firms is now incorporated into the error term in place of additional dummy variables (equation 7):

$$GREV_{it} = \beta_{0i} + \beta_1 ITCAP_{it} + \beta_2 NITCAP_{it} + \beta_3 LABOR_{it} + \beta_4 FINANCE_{it} + \beta_5 MNFG_{it} + \beta_6 ITFIN_{it} + \beta_7 ITMNFG_{it} + u_{it},$$

$$\beta_{0i} = \beta_0 + v_i$$

$$GREV_{it} = \beta_0 + \beta_1 ITCAP_{it} + \beta_2 NITCAP_{it} + \beta_3 LABOR_{it} + \beta_4 FINANCE_{it} + \beta_5 MNFG_{it} + \beta_6 ITFIN_{it} + \beta_7 ITMNFG_{it} + w_{it} \quad (7)$$

where $w_{it} = u_{it} + v_i$. Instead of treating β_{0i} as fixed, it is assumed to be a random variable with a mean value of β_0 such that the individual firm differences are now reflected in the error term v_i. As long as the firm-specific random effects have no significant correlation with the regressors, the REM is more appropriate and more powerful than the FEM (Gujarati, 2003). The Hausman specification test was utilized to compare which of the two models is better suited for the study.

Secondary data was obtained from various sources. The Premier 100 yielded data on IT capital (sum of nodes and servers), and the total number of employees. On the other hand, figures for gross revenues[6] and fixed assets were sourced from the Top 1,000 Corporations. Fixed assets refer to physical properties that are used for more than a year in the production of goods and services[7]. Hence, total capital stock is held to be equivalent to fixed assets. Incomplete figures for the number of employees, gross revenues and fixed assets were obtained directly from the Securities and Exchange Commission (SEC). The data set included 50 firms from the period 2001 to 2004, for a total of 200 observations. Appendix B provides the descriptive statistics of the data while Appendix C provides correlations among the independent variables.

Deriving the quantity of non-IT capital stock required finding a proxy computer price with which capital stock can be stated in terms of physical (computer) units. Historical price estimates of brand new desktop computer packages hover around the P25,000-P30,000 level for the period under study (*www.pcworld.com.ph*). However, the bulk of computer equipment used by the surveyed firms is mostly existing equipment, subject to depreciation. The survey fails to provide a break down of the computer hardware each firm possesses, making it difficult to arrive at an accurate valuation.

[6] See Top 7,000 Corporations (any year) for the definition for gross revenues.
[7] These include land, buildings, machinery, tools and equipment, furniture and fixtures (less depreciation), and natural resources (less depreciation).

Furthermore, prices of the same computer package fall across time as better and more powerful computers are sold. Considering these two factors, a proxy computer price of P20,000 was used for the study. Thus, IT capital and non-IT capital can now be treated separately, since the unit of measurement is now uniform between the two.

This is essentially one of the most important limitations acknowledged by the author regarding the computer proxy price; it is quite arbitrarily set. However, sensitivity analysis on the use of other prices such as P15,000 and P25,000 had minimal effects on the values and no effects on the significance of the coefficients. Still, this limitation was brought about by the lack of data on quality differences among the inputs, specifically the IT capital inputs. A primary data survey would be able to classify and break down the different qualities of computers, which would greatly help in determining a more precise and accurate measure of IT capital. Also, software was unaccounted in the analysis since most computers used by firms utilize the same operating system, which would have led to minimal variations in the data set. Despite these limitations, however, the results of this study can provide some crude, yet important, insights on IT's impact on firms in the Philippines.

5. PROFILE OF IT USAGE IN THE PHILIPPINES

The Computerworld Philippines' Premier 100 was the first Philippine end-user survey of its kind. It effectively serves as a roster of companies that use IT considerably in their firm operations (Wong, 1999). It is based on an annual survey of computing resources of Philippine firms that are among the top 500 corporations in the country[8]. Responding firms are then ranked according to the number of nodes[9], or end-user computing devices, that a firm uses; from these, the top 100 IT users are then arrived at.

Table 1 summarizes IT statistics based on the number of nodes for 1999 to 2006, broken down among the different major sectors of the economy. Table 2 also shows the distribution of the 100 firms by sector. The majority of modern industries are significantly affected by computerization (Brynjolfsson and Hitt, 2000), and the Philippines is no exception. Even though IT usage benefits both local and multinational firms, local firms in developing countries are able to improve their capabilities in facing the competition from multinational firms or in developing partnerships with them (Pohjola, 1998). This is despite the fact that local companies have a slight disadvantage with regards to resource immobility: according to an APO (1997) report, multinational firms, compared to local corporations, can transfer their resources (including IT) to countries where they can produce products at a lower cost.

The finance sector is unquestionably the heaviest user of IT. Most of the services that banks provide involve delicate and accurate transactions. That the banking industry has constantly acquired

[8] This is derived from the Top 1,000 Corporations rankings of Businessworld Philippines magazine based on gross revenues.

[9] This total encompasses the number of personal computers (PCs), notebook PCs, workstations, terminals, network computers (NCs), and thin clients.

PCs, workstations, laptop computers/notebooks, and workstations in an effort to provide accurate, fast, and reliable banking services does not come as a surprise. One cannot imagine how hundreds of thousands of transactions can be manually processed efficiently in the space of a day. IT also translates into conveniences for bank clients, with automated teller machines (ATMs) as a prime example. Moreover, insurance companies' usage of IT reduces transaction costs and provides a reliable manner for storing data, given the nature of their services.

Manufacturing firms' increased automation in their factories, especially in the use of robotics in the manufacturing process, is one clear manifestation of IT usage in the industry. The automation of production lines not only improves technical efficiency but also frees up some manpower, previously used in the production of other tasks. Furthermore, IT is also present in sales and in support and administrative functions. Efficient integrated information systems facilitate business decisions, especially in firms with geographically dispersed subsidiaries and field offices. Year-on-year, the manufacturing and finance sectors comprise more than 60 percent of the total nodes.

Table 1: IT Statistics of the Top 100 Philippine IT-Using Firms by Sector (based on number of nodes)

Sector	1999	2000	2001	2002	2003	2004	2005	2006
Agriculture, Fishery, and Forestry	—	—	3,212	3,212	1,935	1,938	2,558	2,558
Business Services and Real Estate	2,482	4,462	3,475	5,495	1,261	1,468	2,429	909
Communication	6,632	2,494	7,150	5,040	10,940	11,290	10,034	3,664
Community, Personal, and Social Services	689	1,144	2,515	5,310	6,631	7,203	7,737	6,401
Construction	244	543	850	530	722	580	580	580
Electricity, Gas & Water	8,624	4,570	10,420	10,852	10,789	11,202	11,469	11,583
Finance	15,164	21,349	56,506	55,149	69,463	64,556	83,052	77,325
Manufacturing	18,925	10,028	22,140	32,922	34,050	41,005	39,578	39,966
Mining and Quarrying	—	—	550	—	—	—	—	—
Transportation and Storage	1,225	1,104	4,388	5,930	6,650	7,377	4,624	3,824
Wholesale and Retail Trade	2,090	729	4,254	6,086	8,922	6,937	8,607	8,920
Total	56,075	46,423	115,460	130,526	151,363	153,553	170,668	155,730

Sources: *Premier 100*; IT Resource Philippines, various years. Computerworld Philippines; Media G8Way Corporation

Table 2: Distribution of Top 100 Philippine IT-Using Firms by Sector

Sector	1999	2000	2001	2002	2003*	2004*	2005	2006
Agriculture, Fishery, and Forestry	—	—	1	1			1	1
Business Services and Real Estate	9	10	4	3			3	2
Communication	9	10	6	5			3	2
Community, Personal, and Social Services	5	6	4	6			5	5
Construction	2	3	2	1			1	1
Electricity, Gas & Water	5	3	3	5			5	5
Finance	18	27	35	31			34	32
Manufacturing	39	34	32	33			33	36
Mining and Quarrying	—	—	1	—			—	—
Transportation and Storage	3	3	5	5			4	4
Wholesale and Retail Trade	10	4	7	10			11	12

*Data for years 2003 and 2004 not available
Sources: *Premier 100*; IT Resource Philippines, various years. Computerworld Philippines; Media G8Way Corporation

Even with the small representation in the Premier 100, the electricity, gas, and water industry can be inferred to be the third largest IT–using sector of the economy. IT is inevitably helpful in constructing and maintaining power plants. Power distribution to end-consumers also requires IT. A highly integrated information system enables customers to pay anywhere, particularly to the office closest to them, or even through banks. IT facilitates collections, applications for the particular service, and data retrieval when attending to questions regarding billing. The same can also be said about the water and gas services.

Other industries also rely on IT; for example, IT is important in communications, where digital lines enable both domestic and international telephone calls. Billing is made easier with IT. Also, computerized automation systems provide integrated control of television broadcast equipment. Radio operations are subject to state-of-the-art music scheduling software. In the wholesale and retail trade, IT helps keep track of sales and inventories. Combined with the bar code reader, the point of sale system (POS) is one of the many innovations of IT.

The total number of nodes used by the top IT-using firms has increased over the eight-year period, with the exception of the decreases in 2000 and 2006. The decline in 2006 is attributed to less spending on IT compared to previous years, along with firms, particularly banks, downsizing their IT systems and getting rid of old equipment without replacing them. Moreover, some heavy IT users that were included in previous years were unable to provide information on their IT installations for 2006.

6. ANALYSIS OF RESULTS

Results of the OLS estimation of equation (5) and FEM and REM estimation of equations (6) and (7), respectively, are summarized in Table 3. Confirming previous empirical studies, the contribution of IT capital to output is significant; OLS estimates show that gross revenues increase by 0.782 percent for every one percent increase in IT capital usage. For the REM, coefficient estimates are lower, at 0.250 percent. Non-IT capital is also significantly positive for all models. The OLS and REM estimates support the earlier findings by Brynjolfsson and Hitt (2000) which cite that the gross rate of return on computer investment considerably exceeds the rate of return on other investments. This suggests that IT usage by Philippine firms has had significant impact on their production processes which translated to higher revenues. However, the results also show that the labor coefficient is significant and positive for the FEM and REM (0.419 and 0.358 percent, respectively), outweighing the contributions of either type of capital. This reflects the continuing labor-intensiveness of various production processes despite efforts to mechanize or computerize some of them. For the sector dummy variables, only the finance intercept and slope dummies are significant with the pooled OLS regression; both intercept dummies were dropped in the FEM and the manufacturing dummies were insignificant in all models.

All estimated models are statistically different from zero. In the fixed effects model estimation, the F-test for firm effects showed F(49,145) = 56.83, statistically significant at 1%. This implies that firm effects are non-zero, hence rendering the pooled regression model estimates unreliable. With respect to the choice of the better model between the FEM and the REM, the Hausman specification test indicated a chi-square value of 92.22, also significant at the 1% level. Thus, the firm's random effects are correlated with the regressors, suggesting that the FEM is the more appropriate of the two models. However, the estimate for the contribution of IT capital is insignificant and it sign does not conform with economic theory. Modified Wald tests for group-wise heteroskedasticity in fixed effects models and Wooldridge tests for autocorrelation in panel models were both highly significant at the 1% level (chi(50) = 27,467,64 and F(1,49) = 30.3281, respectively), invalidating the usual t- and F-tests (Gujarati, 2003). Fortunately, FGLS allows for the efficient estimation of heteroskedastic and auto-correlated panel models. FGLS estimates are also shown in Table 3, wherein all explanatory variables are highly significant except the manufacturing intercept and slope interaction dummies (significant at 5 and 10% levels, respectively). FGLS thus yields the most efficient estimates among all panel estimation methods. For every one percent increase in IT capital, gross revenues increase by 0.531 percent. Non-IT capital and labor also have significant positive contributions to gross revenues, pegged at 0.271 and 0.215 percent, respectively. Adding up the coefficients (1.017) confirms the constant returns-to-scale property of the Cobb-Douglas function, such that raising all inputs by the same amount leads to an output increase of the same magnitude.

Table 3: Panel Regression Equations with Gross Revenue as the Dependent Variable[a]

Variable	Coefficients (p-values)b			
	OLS	FEM	REM	FGLS
IT capital	0.782*** (0.000)	-0.001 (0.994)	0.250* (0.053)	0.531*** (0.000)
Non-IT capital	0.251*** (0.000)	0.201*** (0.000)	0.218*** (0.000)	0.271*** (0.000)
Labor	0.012 (0.887)	0.419*** (0.000)	0.358*** (0.000)	0.215*** (0.000)
Finance intercept dummy	2.421*** (0.003)	dropped	0.676 (0.472)	2.652*** (0.000)
Manuf'g intercept dummy	0.908 (0.274)	dropped	0.825 (0.436)	1.496** (0.016)
Finance slope dummy	-0.414*** (0.001)	0.112 (0.515)	-0.140 (0.313)	-0.442*** (0.000)
Manuf'g slope dummy	-0.065 (0.619)	0.054 (0.787)	-0.080 (0.622)	-0.164* (0.084)
Constant	14.610*** (0.000)	16.980*** (0.000)	16.006*** (0.000)	14.616*** (0.000)
R-squared	0.6710	0.4184	0.5954	—
F-statistic/ Wald test (model significance)	55.95*** (0.000)	13.80*** (0.000)	139.40*** (0.000)	629.73*** (0.000)

[a] Both dependent and independent variables measured in logarithms, except IT sector dummy
[b] p-values in parentheses; * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Analyzing the sector intercept and slope interaction dummies yielded interesting results. Both intercept dummies are positive and highly significant. Firms belonging to the finance sector enjoy relatively higher revenues compared to firms in other sectors except in manufacturing. The same can also be said of firms in the manufacturing sector. This suggests better production techniques for firms in these 2 sectors compared to other production sectors in the economy. However, both slope interaction dummies were found to be negative. It implies that the positive significant contribution of IT capital for a firm in the finance sector is lower at 0.089 percent (0.531+ (-0.442) percent) compared to firms in other sectors excluding manufacturing. The same result is also noted with the manufacturing sector, although to a lesser degree (0.531+ (-0.164) percent). This suggests diminishing returns in the use of IT for these 2 sectors wherein firms are heavy users of IT inputs; increases in non-

IT and labor inputs are not fast enough to complement the ever-increasing IT inputs. Also, firms, most especially in the finance sector, have downsized their IT systems through time without replacing them, possibly rendering their networks and production systems less efficient.

For all models, around 42 to 67 percent of the variation in output is attributed to the independent variables. The rest of the variation in output is captured by the residual, which includes both short-term (quality changes) and long-term (technological and organizational improvements) effects. According to Brynjolfsson and Hitt (2000), there is a clear positive relationship between multifactor productivity (MFP) and IT investment; for example, unmeasured and gradually changing organizational systems (also known as the fixed effect) significantly affect the returns to investment. The value of IT is further enhanced by the complementary organizational investments, examples of which are business processes and work practices, which IT facilitates. Quality changes also fall in this category. Thus, increases in IT investment increase the value of these IT-related intangible assets. Consequently, variable coefficients would be raised if there exists a good measure to capture these intangible assets. Brynjolfsson and Hitt (2000) reported that the returns to computer investment are higher than what is actually assumed in the neoclassical growth accounting method if the intangible assets are included. Therefore, IT's impact goes beyond substituting IT inputs for traditional (labor and non-IT capital) inputs.

Black and Lynch (1997) reported higher productivity in firms where there are a greater proportion of non-managerial workers that use computers. It was also noted in Bresnahan et al. (1999) that both IT and the new organization are complementary to worker skills. Thus the technical progress that results from increased IT investments relatively shifts demand from the less skilled to the highly skilled workers. These highly skilled workers are more able to discover and implement ways to fully gain from the computer's abilities (Bresnahan et al., 1999). The firm should therefore focus on training ordinary employees in IT usage, aside from investing in workers specializing in IT.

Government policies can greatly affect the extent to which firms make such IT investments. Nagy (1995) cites both demand- and supply-side factors. On the demand side, the government should strive for a stable macroeconomic environment, promote competition, and provide incentives to reduce risk aversion to technology. Like any investment decision, macroeconomic conditions such as interest rates, exchange rates, prices, and fiscal and monetary policies influence firms' decisions in investing in technological improvements such as IT. Competition compels firms to improve productivity, quality, and product design – which in turn induce them to acquire better technologies and to introduce better work practices. Firms thrive and are more likely to seize opportunities and take advantage of IT innovation if the economic and business environment is more competitive and less regulated. Reducing uncertainty about the technology through increased awareness and appropriate incentives prevents suboptimal investment.

Supply-side factors should also be addressed. Specifically, the government must facilitate access to technology and market information, provide infrastructure that will ultimately reduce the costs of IT diffusion, including the costs of hardware and other capital inputs, indirect costs related to licensing, standardization, and the usage costs of networking facilities such as telecommunications networks, and provide services for increasing the skills of its workers. Firms importing foreign technology require information both to accurately assess the impacts of such technology, and to adapt the technology to local conditions. IT diffusion requires excellent infrastructure, particularly telecommunications. Constantly improving skills are essential in moving up the technological ladder. Only then will firms be able to fully harness the benefits of investing in IT capital and IT labor. It is therefore essential that the government must be at the forefront in enhancing the skills of the workforce through quality investment in human capital, education and training. To improve labor productivity and accelerate IT-related innovation, firms must be equipped in upgrading employment skills to enable them take advantage of IT diffusion particularly when they have the ability and willingness to restructure and reorganize their work practices and employment structure. Consistent with the works of Brynjolfsson and Hitt (1998), OECD (2004) argues that the "…adaptability and organizational capital within firms plays a crucial part in maximizing the value of ICT investment ... Company managers should therefore focus on steps to maximize the return they achieve on their ICT investments, such as skill upgrading and innovation in organizational management. While this is true of all kinds of investment, it may be particularly important in the case of ICT investment because of the extent to which ICTs transform the intellectual as well as the physical content of work."

7. CONCLUSION

Through time, the finance sector has emerged as the largest user of information technology (IT) in the country, which can be attributed to the need for efficient, reliable, and accurate services to facilitate numerous transactions. Automation is the biggest reason for the emergence of the manufacturing industry as the second largest IT-user. The electricity, gas, and water sector rounds out the top three IT-using sectors.

Panel data estimation using 50 firms tracked across the years 2001 to 2004 yielded the result that IT capital contributes significantly to the output of the firm. Furthermore, the rate of return on IT capital exceeds the rate of return on non-IT capital, supporting past international researches. The fixed effects estimates are more powerful compared to their random effect counterparts, although the presence of heteroskedasticity and autocorrelation leads to the use of FGLS estimates. The results also showed that the production processes of firms in the finance or manufacturing sectors, the two largest IT-using sectors, are statistically better compared to other firms, although the positive contributions of IT in their production is significantly lower as firms in these sectors might already be experiencing diminishing returns in production.

Although this study is significant as one of the first and few studies on IT contributions in the Philippines with a microeconomic emphasis, the firm-level framework used can still be improved.

Particularly with IT capital, future measures could account for quality differences in the inputs. Other types of IT capital like computer software and communications equipment could be quantified for a more encompassing measure of IT capital. Also, the linkages between different types of IT-related intangible assets like organizational change, output quality change and changes in human capital could be examined. Economy and industry-level research for the Philippines is difficult at this juncture due to the absence of price indices that reflect substitutability of IT inputs with traditional inputs at the macroeconomic level.

As a guide for policymakers, a good, sound macroeconomic environment accompanied with improvements of the needed infrastructure and certain institutional reforms are needed in order to encourage firms to continue utilizing IT in their production process. The formulation of the IT21 Agenda of the National Information Technology Plan and the 2004-2010 Medium-Term Philippine Development Plan are crucial steps in achieving the goal of further use of IT in the economy. However, these plans should be reviewed as to whether the goals are being met; proper implementation and certain revisions, if necessary, are needed to ensure the achievement of these goals.

REFERENCES

Alonzo, D.B. (1997). The IT Plus Factor, IT2000 (April-June 1997), 27-30pp.

Asian Productivity Organisation (APO). (1997). Information Technology and Rural Development in Asia-Pacific Region. Report of an APO Study Mission. Tokyo.

Bangko Sentral ng Pilipinas (BSP) Selected Philippine Economic Indicators. May 2002.

Black, S. and L. Lynch. (1997). How to Compete: The Impact of Workplace Practices and Information Technology on Productivity. Working Paper 6120. National Bureau of Economic Research (NBER).

Bresnahan, T., E. Brynjolfsson, and L. Hitt. (1999). Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. Working Paper 7136. NBER.

Brynjolfsson, E. and L. Hitt. (2003). Computing Productivity: Firm-Level Evidence. Working Paper 139. eBusiness@MIT.

______________________. (2000). Beyond Computation: Information Technology, Organisational Transformation and Business Performance. *Journal of Economic Perspectives* 14(4): 23-48.

______________________. (1998). Beyond the Productivity Paradox: Computers Are the Catalyst for Bigger Changes. *Communications of the ACM* 41(8): 49-55.

______________________. (1996). Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending. *Management Science* 42(4): 541-58.

______________________. (1995). Information Technology as a Factor of Production: The Role of Differences Among Firms. *Economics of Innovation and New Technology* 3(4): 183-200.

Businessworld Philippines Top 1,000 Corporations. (various years).

Computerworld Philippines Premier 100. (various years).

Dairo, J. (1999). Improving R&D Support for I.T. and Microelectronics. *Milepost* 1(6): 20-21.

Dryden, J. (2003). ICT, the Economy and Society – Challenges of Measurement and Analysis. Organization for Economic Cooperation and Development (OECD), France: Paris.

Gerstein, M.S. (1987). The Technology Connection. Reading, MA: Addison-Wesley.

Gordon, R. (2000). Does the "New Economy" Measure Up to the Great Inventions of the Past? *Journal of Economic Perspectives* 14(4): 49-74.

Greenan, N., J. Mairesse, and A. Topiol-Bensaid. (2001). Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm Level Data. Working Paper 8075. NBER.

Greenwood, J. and B. Jovanovic. (1999). The Information-Technology Revolution and the Stock Market. *American Economic Review* 89(2): 116-122.

Gujarati, D. (2003). Basic Econometrics, 4^{th} ed (International Edition). New York: McGraw-Hill.

Haacker, M. and J. Morsink. (2002). You Say You Want a Revolution: Information Technology and Growth. Working Paper 02/70. IMF.

Inoue, T. (1998). Impact of Information Technology and Implications for Monetary Policy. Discussion Paper Series 98-E-7. Institute of Monetary and Economic Studies (IMES).

Intriligator, M., R. Bodkin, and C. Hsiao. (1996). Econometric Models, Techniques, and Applications, 2^{nd} ed. New Jersey: Prentice Hall.

IT Resource Philippines. The Annual Sourcebook of the Philippine Information Technology Community. (various years).

Jorgenson, D. and K. Stiroh. (2000). Raising the Speed Limit: US Economic Growth in the Foreign Age. Working Papers No. 261. Paris: OECD.

______________________. (1999). Information Technology and Growth. *American Economic Review* 89(2): 109-115.

Kimbell, L. and J. Lorant. (1974). Physician Productivity and Returns to Scale. Chapter 20 in University of California, Human Resources Research Center, An Original Comparative Economic Analysis of Group Practice and Solo Fee-for-Service Practice: Final Report. Springfield, Va: National Technical Information Service, U.S. Department of Commerce.

Kuroda, M. and K. Nomura. (1999). An Explanation of the Productivity Paradox: TFP Spillover Through Capital Accumulation. Discussion Paper Series 99-E-10. IMES.

Lee, I.H. and Y. Khatri. (2003). Information Technology and Productivity Growth in Asia. Working Paper 03/15. IMF.

Lichtenberg, F. (1995). The Output Contributions of Computer Equipment and Personal: A Firm-Level Analysis. *Economics of Innovation and New Technology* 3: 201-217.

Medium-Term Philippine Development Plan (MTPDP). 2004-2010. National Economic Development Authority.

Monk, P. (1992). Innovation in the Information Economy in C. Antonelli, ed., The Economics of Information Networks. Netherlands: Elsevier Science Publishers B.V.

Nagy, H., S. Boyson, and S. Gunamine. (1996). The East Asian Miracle and Information Technology: Strategic Management of Technological Learning. Discussion Papers 326. World Bank.

Nagy, H. (1995). The Diffusion of Information Technology: Experience of Industrial Countries and Lessons for Developing Countries. Discussion Papers 281. World Bank.

_______. (1991). The Information Technology Revolution and Economic Development. Discussion Papers 120. World Bank.

National Information Technology Council (NITC). IT21 Philippines Asia's knowledge center: IT Action Agenda for the 21st century. October 1997. Manila, Philippines.

OECD. (2004a). The Economic Impact of ICT – Measurement, Evidence and Implications. OECD, France: Paris.

____. (2004b). ICTs and Economic Growth in Developing Countries. OECD, France: Paris.

____. (2003). ICT and Economic Growth: Evidence from OECD Countries, Industries and Firms. OECD, France: Paris.

Oliner, S. and D. Sichel. (2000). The Resurgence of Growth in the Late 1990s: Is Information Technology the Story? *Journal of Economic Perspectives* 14(4): 3-22.

___________________. (1994). Computers and Output Growth Revisited: How Big is the Puzzle?" *Brookings Papers on Economic Activity* 2: 273-317.

Philippine Business Profiles and Perspectives, Inc. (2001). Top 7,000 Corporations 2000-2001: The Philippines in the New Economy.

Pilat, Dirk. (2004). The ICT Productivity Paradox: Insights from Micro Data. *OECD Economic Studies No. 38, 2004*. OECD, France: Paris.

Pohjola, M. (1998). Information Technology and Economic Development: An Introduction to the Research Issues. Working Papers 153. UNU/WIDER.

Royol, R. (1999). An Economic Assessment of the Information Technology (IT) Sector in the Philippine Economy: A Survey of Alternative Approaches. Undergraduate thesis, UPLB.

Tolentino, M.C. (1998). The Economic and Social Impact of Information Technology in Southeast Asia: Focus on the Philippines", *Policy Digest* 2(10): 30-36.

Wallace, T.D. and J.L. Silver. (1988). Econometrics: An Introduction. USA: Addison-Wesley.

Wong C.W. (2000). "Sales of PCs, LANs, printers up in '99", *Computerworld Philippines* (June 30, 2000), 1, 15pp.

Appendix A: Approaches Followed in Some Recent Firm-Level Studies of ICT and Economic Performance

Study	Countries	Survey Covering ICT	Method	Economic Impacts
Arvanitis (2004)	Switzerland	Survey of Swiss business sector	Labour regressions	Labour productivity complementarities
Atrostic et al. (2004)	Denmark, Japan, United States	US Computer Network Usage Survey, Denmark survey of ICT use, Japan survey of IT workplaces	Labour productivity regressions	Labour productivity (US, Japan), Multi-factor productivity (Japan)
Baldwin and Sabourin (2002)	Canada	Survey of Advanced Technology	Labour productivity and market share regressions	Market share, labour productivity
Clayton et al. (2003)	United Kingdom	ONS e-commerce survey	Labour productivity and TFP regressions	Labour productivity, TFP, price effects
Crepon and Heckel (2000)	France	BRN employer file	Growth accounting	Productivity, output
Criscuolo and Waldron (2003)	United Kingdom	Annual Respondents Database	Labour productivity regressions	Labour productivity
De Gregorio (2002)	Italy	Structural business survey	Multivariate analysis	IT adoption, e-commerce, organisational aspects
De Panniza et al. (2002)	Italy	E-commerce survey	Principal components	Labour productivity
Doms, Jarmin, and Klimek (2002)	United States	Asset and expenditure survey	Labour productivity and establishment growth regressions	Labour productivity, establishment growth
Gretton et al. (2004)	Australia	Business longitudinal survey, IT Use Survey	Labour productivity regressions	Labour productivity, IT adoption
Haltiwanger et al. (2003)	Germany, United States	US Computer Network Usage Survey, German IAB establishment panel	Labour productivity regressions	Labour productivity
Hempell et al. (2004)	Germany, Netherlands	Innovation surveys, structural business statistics	Regressions based on production function	Value added, contribution of IT capital, innovation labor productivity
Hempell (2002)	Germany	Mannheim innovation panel	Regressions based on production function	Sales, contribution of ICT capital, innovation, lab productivity
Hollenstein (2004)	Switzerland	Survey of Swiss business sector	Rank model of ICT adoption	ICT adoption
Maliranta and Rouvinen (2004)	Finland	Internet use and e-commerce survey	Labour productivity regressions, breakdown of productivity growth	Labour productivity, productivity decomposition
Milana and Zeli (2004)	Italy	Enterprise survey of economic and financial accounts	Malmquist indexes of TFP growth, TFP correlations	TFP growth
Motohashi (2003)	Japan	Basic survey on business structure and activities (BSBSA); ICT Workplace Survey	Production function, TFP regressions	Output, TFP, productivity

Source: *OECD* (2003; 2004a); adopted from Pilat (2004).

Appendix B: Descriptive Statistics of the Data

Variable		Mean	Std. Dev.	Min	Max	Obervations
GREV	overall	22.43728	1.233466	20.20407	25.73446	N = 200
	between		1.227849	20.28153	25.6272	i = 50
	within		0.191192	21.8007	22.90104	t = 4
ITCAP	overall	6.49274	1.088727	3.828641	9.295049	N = 200
	between		1.061985	4.122832	8.813787	i = 50
	within		0.272975	4.445376	7.394788	t = 4
NITCAP	overall	10.53367	1.96468	4.70048	15.28829	N = 200
	between		1.956616	5.520998	15.2293	i = 50
	within		0.298893	8.86099	11.67324	t = 4
LABOR	overall	6.98462	1.166013	4.510859	9.531409	N = 200
	between		1.16404	4.555788	9.473793	i = 50
	within		0.158191	6.258385	7.774897	t = 4
FINANCE	overall	0.38	0.486605	0	1	N = 200
	between		0.490314	0	1	i = 50
	within		0	0.38	0.38	t = 4
MNFG	overall	0.38	0.486605	0	1	N = 200
	between		0.490314	0	1	i = 50
	within		0	0.38	0.38	t = 4
ITFIN	overall	2.32996	3.033649	0	8.058328	N = 200
	between		3.054704	0	7.923979	i = 50
	within		0.111723	1.844201	2.97057	t = 4
ITMNFG	overall	2.63792	3.442887	0	9.295049	N = 200
	between		3.461206	0	8.813787	i = 50
	within		0.235273	0.59055	3.539962	t = 4

Appendix C: Correlation Matrix

	ITCAP	NITCAP	LABOR	FINANCE	MNFG	ITFIN	ITMNFG
ITCAP	1.0000						
NITCAP	0.6231	1.0000					
LABOR	0.7323	0.7534	1.0000				
FINANCE	0.3238	0.0907	0.1609	1.0000			
MNFG	-0.2604	-0.2164	-0.0822	-0.6129	1.0000		
ITFIN	0.4358	0.1703	0.2539	0.9811	-0.6013	1.0000	
ITMNFG	-0.1650	-0.1556	-0.0085	-0.6028	0.9835	-0.5914	1.0000