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The IT-Productivity Linkage at the Country Level for Developing Economies

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ABSTRACT

Recent evidence suggests that information technology (IT) investments have a positive impact on productivity and economic growth for developed countries. However, for developing countries the relationship between IT investment and economic growth remains unclear. This paper draws on the resource-based view (RBV) theory with its notion of resource complementarity to propose a theoretical model of how factors interact with IT investment to influence economic productivity. The proposed model posits a number of factors effecting the productivity of IT investment in developing economies.

Keywords

Productivity paradox, information technology, resource-based view theory

INTRODUCTION

As organizations become increasingly dependent on information and communication technologies (ICT), increasingly larger percentages of capital investment is being devoted to these technologies. For example, aggregate U.S. data shows that ICT capital investment as a share of total capital investment has increased from 3.5% in 1980 to 9% in 1990 and to 33% in 2000. Given the magnitude of ICT investment, it is essential for economies but particularly developing economies that these investments produce the desired benefits.

This research is concerned with the relationship between IT investments and macroeconomic productivity, a research stream that was triggered by the 1970s productivity slowdown in the US that coincided with a surge in IT spending. In contrast to the conventional wisdom, US based studies conducted a decade or more after the surge, in the late 1980s and early 1990s, failed to find evidence that ICT investments improved productivity (e.g., Roach, 1989, 1991; Oliner and Sichel, 1994). This failure to find evidence supporting a significant positive relationship between ICT investment and macroeconomic performance was so prevalent that it became known as the productivity paradox. The paradox was attributed to the fact that ICT capital expenditures, at the time less than 10% of total capital expenditures (Dedrick, Gurbaxani, Kraemer, 2003), a much smaller share of total capital stock than it is today, seemed to have little or no impact on macroeconomic productivity (Brynjolfsson, 1993; Sichel, 1997). More recent studies, however, have found a significant positive relationship between ICT investment and macroeconomic productivity at least for developed economies (Dewan and Kaeramer 1998; Jorgenson and Stiroh, 2000).

While recent studies of developed economies have demonstrated a significant positive relationship between ICT investment and macroeconomic productivity, suggesting that the productivity paradox is no longer an issue for developed countries, it remains an issue of deep concern for developing economies where the data still fails to show a positive significant relationship between ICT investment and economic productivity (Dewan and Kaeramer, 2000). Despite this lack of evidence, the assumption that developing countries can achieve high rates of economic growth by investing heavily in ITC is widely held by institutions such as the World Bank, International Telecommunications Union (ITU), and International Monetary Fund (IMF). In other words, if developing economies are going to narrow the economic gap, they must make more productive use of ICT than developed countries. Thus, achieving this outcome is of paramount importance to policy makers for both developing countries and international economic development funds.

Despite the obvious need, there is a lack of knowledge of the mechanisms and factors affecting the economic productivity of ICT investment. The current research contributes to this void by (1) delineating the factors that influence the ICT-economic productivity relationship at the macroeconomic country level and (2) proposing a model of how these factors interact with ICT to influence macroeconomic productivity. The relationships posited by the model provide a foundation for empirical studies and, once verified, relationships in the model can provide policy makers in developing countries and funding institutions with a better understanding of how various contextual factors impact the macroeconomic productivity of ICT investments thereby providing developing economies with a road map to increase the productivity of their ICT investments and narrow the gap between their economies and those of the developed world.

Next the paper reviews and synthesizes the literature on the ICT-macroeconomic productivity. This is followed by the introduction of the resource-based view (RBV) theory and development of a series of related hypotheses. The final section presents a summary and directions for future research.

BACKGROUND

At the individual firm level, the value of IT is one of the most researched topics within the computing literatures. Numerous studies have demonstrated the contributions of IT investments to a host of firm-level outcomes, including productivity (Lichtenberg, 1995; Brynjolfsson and Hitt, 1996), business performance (Chan et al., 1997; Bharadwaj, 2000; Sabherwal and Chan, 2001), and competitive position (Sethi and King, 1994; Powell and Dent-Micallef 1997). While the focus of the current work is the linkage between IT investment and macroeconomic productivity, the relationship between IT and firm-level performance and competitive advantage will be delineated to provide a more complete picture of the research including identifying some of the theoretical underpinnings of IT-productivity research.

IT and Firm-Level Performance

A review of the research on the relationship between IT investment and firm-level performance reveals two contrasting schools of thought. The first school of thought, dominant until the early 1990's, took a myopic view of the relationship between performance and IT investments. According to this school, IT investments per se confer sustainable performance and create competitive advantage through perpetual innovation and early IT adoption (Porter, 1985; Clemons, 1986). However, recent (early 1990s to date) evidence indicates that IT investments alone do not produce sustainable competitive advantages nor do they result in superior performance (Clemons and Row, 1991; Kettinger et al., 1994).

Clemons and Row (1991) and Kettinger et al. (1994) identify several reasons for differences in findings. In addition to methodology and sampling flaws, the pervasiveness of IT, the relative ease of acquiring IT in competitive markets, and the ease of imitating and duplicating IT resources have all been cited as possible reasons why IT alone has failed to show a measurable positive contribution to superior economic performance and sustainable competitive advantage. Another explanation, which is of special importance to this research, is offered by the resource-based view (RBV) theory, which was introduced into information systems research by Barney (1991). According to the RBV theory, firms hold heterogeneous resource portfolios- whether by history, accident, or design- and that this resource heterogeneity is responsible for observed variability in financial returns across firms (Peteraf, 1993; Powell and Deant-Micallef, 1997). Combining the empirical evidence from the post-1990s studies of ICT macroeconomic performance with the logic of the RBV theory produces a new paradigm. According to this perspective, organizations cannot expect IT alone to produce sustainable performance and/or competitive advantage. Rather, it is how organizations use their IT resources to leverage and exploit preexisting complementary resources that enables or inhibits superior performance and competitive advantage. As we shall see below, the work presented here draws on the RBV theory as a foundation for explaining the difference in ICT macroeconomic productivity and growth between developed and developing countries.

ICT and Productivity

Over the past three decades, much research has investigated the influence of IT investments on productivity. A review of the IT-productivity literature reveals that the relationship between IT investment and productivity has been researched at three major levels: the country level (e.g., Roach, 1989; Dewan and Kraemer 1998; Dewan and Kraemer 2000), the industry level (e.g., Jorgenson and Stiroh 2000), and the firm level (e.g. Lichtenberg, 1995; Brynjolfsson and Hitt, 1996; Dewan and Min, 1997). Due to space limitations and because the current research is concerned with understanding the IT-productivity link at the macroeconomic level, only select material from the national macroeconomic literature will be reviewed here. A comprehensive review of all three levels can be found in Dedrick et al, (2003).

As stated earlier, contrary to the conventional wisdom that investment in IT leads to higher productivity, studies conducted in the late 1980s and early 1990s failed to find evidence supporting this relationship (Roach, 1989; Oliner and Sichel, 1994; Jorgenson and Stiroh, 1995). The lack of evidence soon became known as the productivity paradox; that is, results failing to show that spending on IT increased macroeconomic productivity, or as Robert Solow, the Nobel Laureate, stated, "the computer age is everywhere but in the productivity statistics". Brynjolfsson (1993) attributed these perplexing results to the then small share of the economy that IT represented, an explanation echoed by Sichel (1997) who contended that IT capital stock was too small a portion of the total capital stock to have a substantial impact. At the time, aggregate US ICT capital investments as a share of total capital investment was less than 10% (Dedrick et al., 2003).

Since then, US ICT capital investment as percentage of total capital investment has grown dramatically. Recent studies have found that US ICT investments have shown a positive effect on productivity and economic growth (Jorgenson and Stiroh,

2000; Jorgenson, 2001; Oliner and Sichel, 2000). For example, Jorgenson and Stiroh (2000) found that IT contributed about 13% of the 3.04% economic growth and 27% of the 1.4% labor productivity growth in the U.S during the period 1973-1995 (Dedrick et al., 2003). Jorgenson (2001) found that IT investment contributed about 28% of the 4.08% economic growth and 42% of the 2.11% labor productivity growth in the U.S during the period 1995-1999 (Dedrick et al., 2003). Extending Brynjolfsson (1993) and Sichel (1997) logic, a possible explanation of the positive IT-productivity findings is the dramatic increase in IT capital investments as a share of total capital investments, which exploded in the 1990s, from 9% in 1990 to 33% in 2000.

Examining aggregate data across 17 developed countries over the period 1985-1992, Dewan and Kaeramer (1998) found that these economies were earning a positive and significant return on their IT investments, concluding that "IT investments are contributing to output and productivity at a rate that is disproportionate to their factor share in production" (p. 61). Schreyer (1999) examined IT's contribution to productivity and economic growth for the G-7 countries during the period 1990–1996. He too found that IT made a positive contribution to productivity and economic growth in all of the G-7 countries over the years studied. These studies provide strong evidence that IT capital is now contributing to productivity and growth in developed countries which renders the productivity paradox as non issue in developed countries. Collectively these and earlier studies also suggest that the productivity paradox may exist until ICT capital investment as a share of total capital investment approaches 33% as it did in 2000 in the US. This does not bode well for developing economies depending on investment in IT to improve productivity.

In addition to dispelling the productivity paradox, finding a positive and significant return on ICT capital investments for developed countries, Dewan and Kaeramer's (1998, 2000) found that non-ICT capital investments were not commensurate with their share of total capital investment. Interestingly, they also found that the situation reversed for the developing countries in their studies, where the developing economies earned a significant return on their non-ICT capital but investments in ICT failed to show a return on investment - an indication of the existence of productivity paradox in developing countries. Two possible explanations were advanced as to why ICT failed to increase productivity in developing countries. First, the insignificance of ICT contributions is attributed to the lack of resource complementarity, with the authors noting that "compared to the advanced countries, less developed countries have poorer infrastructure, inherently less productive human capital (in part due to lower levels of education) and business models that have yet to transition from the industrial to the information age" (Dewan and Kaeramer, 2000, p. 561). In other words, countries, organizations, and individuals must acquire and accumulate a certain level of experience with technologies before they become proficient and investments in IT capital start to earn a return. A related explanation is the relatively low level of IT capital stock in developing countries to have a substantial economic impact – the situation that existed in developed countries until the 1990s.

Collectively these studies indicate that when IT capital investments approach 1/3 of total capital investments in developed countries, ICT investments have a major impact on labor productivity and economic growth. However, prior to reaching this threshold of about 1/3 of total capital investment, investments in ICT fail to impact labor productivity and economic growth. This is particularly problematic for developing countries; countries desperate to improve labor productivity to enhance economic growth.

While structural reasons such as the investment threshold have now been identified, other factors contributing to the effectiveness of ICT investments remain unknown. For example, the regression model proposed in Dewan and (2000), which was derived from the Cobb–Douglas production function, does not include any of the resources that may complement labor and ICT capital to improve productive. In fact, there currently exists no theoretical model that explains the inner working of the ICT-productivity linkage at the country level in terms of how ICT investments affect productivity and what other factors influence the relationship and in what way. The next section proposes a model of how factors interact with IT investment to influence country-level productivity using the resource based view (RBV) theory.

THEORETICAL LENS AND HYPOTHESES DEVELOPMENT

The resource-based view (RBV) is a robust theory that has received wide acceptance in strategic management and information systems research. Although built to investigate firm-level performance, the RBV theory with its resource complementarily notion would seem to provide a solid theoretical foundation for investigating factors that can improve ICT productivity at the country level. At the firm level, the RBV theory postulates that firms hold heterogeneous resources portfolios- whether by history, accident, or design- and that this resource heterogeneity is responsible for observed variability in financial returns across firms (Peteraf, 1993; Powell and Dent-Micallef, 1997). Within the context of IT, the logic of the RBV theory asserts that firms cannot expect IT to produce sustainable performance or competitive advantage alone. Rather, it is how firms use their IT resources in concert with other complementary resources that enables or constrains economic performance. Extrapolating to the country-level, the RBV theory would suggest that country-level returns on ICT investments are dependent on how countries use these investments to leverage and exploit preexisting complementary

resources. This notion of the resource complementarity, the foundation of the RBV theory, was expressed in Dewan and Kaeramer (1998) when they wrote:

> How can we explain these high returns from IT investment in developed countries? A potential explanation is that the estimated returns from IT investment reflect other changes in the economies of developed countries that are complementary to IT investments, such as infrastructure, human capital, and informatization of business processes. In other words, the positive returns are not only due to increases in IT capital per worker, but also reflect simultaneous changes in education, infrastructure and other factors that complement labor and make it more productive.

Combining the empirical evidence with the RBV as a theoretical foundation, the following two competing propositions can be posited:

> **H1a**: IT capital investment influences economic productivity both ***directly*** and ***indirectly*** through interaction with non-IT capital investments.
> **H1b**: IT capital investment influences productivity only ***indirectly*** through interaction with non-IT capital.

Research has suggested a number of factors that may affect the relationship between IT capital and productivity at the country level. Examples of these factors include knowledge capital, informatization of business processes, and government policies which include the enactment of low taxes and tariffs on ICT resources, telecommunication liberalization, and the promotion of education, in general, and for computer professionals in particular (Dedrick at al., 1995; Dedrick and Kraemer, 1998; Kraemer et al., 1996; Dewan and Kraemer, 2000). Based on this, the following hypotheses are posited:

> **H2a**: Knowledge capital investment will interact with IT capital investment to positively affect economic productivity.
> **H2b**: The relationship between IT capital investment and economic productivity will be stronger for countries with high knowledge capital investment than for countries with low knowledge capital stock.
>
> **H3a**: Informatization of business models will interact with IT capital stock to positively affect economic productivity.
> **H3b**: The relationship between IT capital stock and economic productivity will be stronger for countries with high informatization of business models than for countries with low informatization of business models.
>
> **H4a**: Enactment of low taxes and tariffs on IT imports will positively affect economic productivity.
> **H4b**: The relationship between IT capital stock and economic productivity will be stronger for countries with low taxes and tariffs on IT imports than for countries with high taxes and tariffs on IT imports.
>
> **H5a**: Telecommunication liberalization will interact with IT capital stock to positively affect economic productivity.
> **H5b**: The relationship between IT capital stock and economic productivity will be stronger for countries with high telecommunication liberalization than for countries with low telecommunication liberalization.
>
> **H6a**: Promotion of education, in general, and for computer professionals in particular will interact with IT capital stock to positively impact economic productivity.
> **H6b**: The relationship between IT capital stock and economic productivity will be stronger for countries that promote education and computer professional education in particular than for countries with low education standards and poor support for computing education in particular.

Another frequently and consistently advanced explanation for the productivity paradox is the lag between IT investments and benefits (Brynjolfsson, 1993; Dewan and Kaeramer, 2000). It has been suggested that countries, organizations and individuals must acquire and accumulate a certain level of experience with technologies before they become proficient and thus fully exploit the potential of the technology. In explaining the high returns from IT investment in developed countries, Dewan and Kaeramer (1998) asserted that "the developed countries have learned how to use the technology effectively over the past 30 years; part of the cost of their IT investments can usefully be thought of as the tuition paid for that learning". Alternatively, the effects of IT investment on economic productivity were not realized in developed economies until the investment in ICT approached 1/3 of total capital investment. This suggests the following hypotheses:

H7a: IT capital investment makes positive contribution to economic productivity when it reaches a threshold of 1/3 of total capital investment.
H7b: The lag between IT capital investment and a positive impact on economic product is long-term approaching at the country-level.

SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

Based on our review of the literature on IT-productivity at the country level, there exists increasing evidence to suggest that the productivity paradox for developed economies has disappeared. Unfortunately, the productivity paradox still exists for developing countries where investments in IT fail to show a significant impact on productivity. The specifics as to how developed economies make better use of IT investments remain unknown.

Based on a review of the literature, the following factors were identified as potentially contributing to IT productivity: knowledge capital, informatization of business models, enactment of lower taxes and tariffs on computing imports, telecommunication liberalization, the promotion of education in general and computing professionals in particular, and the lag between IT costs and benefits due to learning and threshold ICT capital stock. Using theses factors and the resource based view (RBV) theory, a set of hypotheses were advanced. It is our contention that the proposed model, through its robust theoretical foundation, will provide a rich source for research on the relationships between IT investment and economic productivity for developing economies. Once investigated, finds can be used to support policy makers in developing countries and their investors.

This research is only beginning. We plan to further develop the concepts and empirically investigate many of the hypotheses. We know of no study that has operationalized the impact on IT investment from constructs of knowledge capital, informatization of business models and government policies factors (enactment of low taxes and tariffs on computer imports, telecommunication liberalization, and promotion of education generally and for computer professionals in particular) at the country level. As such much work remains to provide developing economies with the yet opaque and not yet delineated lessons of the developed economies.

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