The Role of Policy in the Relationship between ICT Adoption and Economic Development: A Comparative Analysis of Singapore and Malaysia

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ABSTRACT

Current studies in the effects of ICTs on development consider the key variables that effect Gross Domestic Product growth. However it appears that there are a number of variables that affect this relationship over time. The same variable may be affected by growth while it also effects growth. An understanding of these relationships can enable a better understanding of the role of ICTs in development and how it acts as part of a larger development system. Further many existing studies examine the effects of ICT investments rather than the ways in which ICT is adopted and used. This paper considers the relationships that affect the ways in which ICT brings about economic growth. It considers how ICTs are adopted and used by considering the public policies and how they were implemented for two countries, Singapore and Malaysia. These countries have pursued public policies in ICT adoption and use but have very different outcomes. Following an analysis of time series data over about 30 years, we arrive at conclusions as to effectiveness of ICT in transforming an economy. Our findings suggest that there is a strong role for early coordinated intervention in markets to foster the growth and coordinated use of ICT.

INTRODUCTION

Information Technology has been seen to transform organizations through re-engineering, organizational restructuring investments in IT, changing work practices, alignment between an organizations IT infrastructure and strategy. Transformation is the change in certain variables or

factors that bring about subsequent alterations in the state of a society or economy. It appears that with the convergence of computing, internet and mobile telecommunications technologies, Information and Communication Technology (ICT) has the ability to transform the lives of people. ICT is a factor that has enabled transformation in banking, healthcare, education, government and spurred innovations in business sectors. It has the potential to increase the efficiency of other factors of production, thus bringing about an increase in Gross Domestic Product. While much has been reported on the benefits of ICTs for promoting development, recent studies indicate that the technologies themselves cannot bring about positive changes in people's lives, it this ways in which these technologies are used, the infrastructures available to access these technologies and institutional frameworks that protect those that do use these technologies. Often it is these other factors that enable positive transformation to be undertaken to enable development to take place.

ICTs tools (Information and communication technologies), such as the internet or the cell phone, not only have shortened geographic distances by increasing the speed of communication but also by becoming a tool for economic development and growth. As a result, research in Information Technology (IT) for Development provides different insights for the ways in which IT can be use as a tool for economic development (Kamal and Qureshi, 2009). On the one hand, many theories have recognized the importance of education and training as a tool for economic development. While on the other hand, other theories have recognized the importance of ICTs as a tool to the modernization of economies (Kottemann and Boyer-Wright, 2009).

While it appears that while ICT may enable growth, the results are contradictory. Authors suggest that often ICT implementations fail in developing regions because they are undertaken without any consultation or involvement with local citizens (Zheng 2009, Hosman, Fife and Armey 2008, Cecchini and Scott 2003, Adam and Urquhart 2007). The majority of efforts undertaken in ICT adoption focus on access, infrastructure, diffusion and impact such as the work of Baliamoune-Lutz (2003), Pick and Azari (2008), Kauffman and Kumar (2008), and Kottemann and Boyer-Wright (2009). These have been valuable in discovering the relationships between ICT and outcomes such as Growth. There appears to be a positive relationship between countries in which ICT investments are connected to a rising human development index and education (Bollou, and Ngwenyama 2007, Diaz Andrade and Urquhart 2008, Kottemann and Boyer-Wright 2009). It appears therefore that the social capital in a country affects its ability to

develop using its ICT investments (Díaz Andrade and Urquhart 2009, Hosman, Fife and Armey 2008). These studies also suggest that there is a relationship between ICT adoption and economic development. It appears that when people have more income they will invest in more technology. However, it is yet to be seen how uses of ICTs can enable economic development to take place.

Given the above, it seems that ICT may be one of the many key factors that affect the ability of countries to develop their capacities to grow. The capacity of a country's information and communication technology infrastructure can potentially stimulate growth if coupled with adoption as it relates to local needs. Even though IT capacity is an important component of development, it is rarely discussed in the literature. Adam and Urquhart (2007) define IT capacity building as the process of creating or enhancing local human and organizational abilities to use IT to perform specific tasks in organizations in order to attain organizational objectives, and it is based on the idea of human capital." They add that three major conditions are necessary for capacity building to take place: (a) an enabling environment with appropriate methods, tools, policies, and legal framework; (b) an institutional development that supports community participative development efforts; and (c) human resources development through training and education.

This paper considers the simultaneous relationships that affect the ways in which ICT brings about economic growth in Singapore and Malaysia. These countries at have pursued public policies in ICT adoption and use but have very different outcomes. Following an overview of how ICTs were adopted and used by considering their public policies, this paper investigates three hypotheses: 1) Countries that have plans that specifically address ICT adoption and infrastructure see a greater impact of ICT on Economic growth, 2) The countries that adopt ICT earlier will have greater long term benefits in terms of economic growth and 3) The more intense the adoption of ICTs the greater the effect on economic growth. Through an analysis of time series data over about 30 years, we arrive at conclusions as to effectiveness of ICT in transforming an economy. Our findings suggest that there is a strong role for early coordinated intervention in markets to foster the growth and coordinated use of ICT.

THEORETICAL BACKGROUND

In the past decades ICT innovations have meant that economies are able to grow in ways that was not previously foreseen. For example the convergence of internet, mobile and computing technologies has brought about innovations in micro-finance. Examples include the M-Pesa system used in Africa to make payments using cell-phones and the ability to make micro-loans to large segments of the population that are not served by traditional banks. This innovation has enabled payments to be made from immigrant workers in different countries to families in their home countries. According to Oliver Teves, more than 5.5 million Filipinos now use their cell phones as virtual wallets, making the Philippines a leader among developing nations in providing financial transactions over mobile networks. Mobile banking services, which are also catching on in Kenya and South Africa, enable people who don't have bank accounts to transfer money easily, quickly and safely. It's spreading in the developing world because mobile phones are much more common than bank accounts. These innovations have also had the effect of giving people an "address". Especially those people living in the shanty towns of Johannesburg are able to use text messaging services to communicate with large numbers of people to alert each other when the bulldozers arrive. Such uses of technologies have mobilized entire townships and enabled these previously disenfranchised populations to have a voice.

Information and communications technologies (ICTs) as factor for economic growth

The literature existing regarding information technology (IT) and economic development is extensive. Throughout the years, scholars have studied its impact on the economic growth of both developed and developing nations around the world. Many of their findings arrive at the same conclusion, information technology has become one of the factors that has influenced the accelerate growth of many countries worldwide. In fact, studies such as the one made by Freeman (2004), agree that higher levels of economic development can and will be achieved by increasing the levels of public investment in IT infrastructure and intellectual capital.

For example, at the macroeconomic level, the impact of information technology differs across sectors and occupations. That is, while some countries have engaged in the development, commercialization and trade of IT tools, other countries have become recipients of these technologies lagging their possibilities to be technologically independent. Some researchers have concluded that, IT investment levels have grown disproportionately with the level of income;

"more than one for one with GDP growth" (Mann, 2005). Moreover, price elasticity has been estimated to be greater for services and software, than for hardware products.

Economic growth is deemed to be a desirable outcome of ICT infrastructures in a country (Bollou, and Ngwenyama 2007, Diaz Andrade and Urquhart 2008, Kottemann and Boyer-Wright 2009, Hosman, Fife and Armey 2008). Authors such as Roller and Waverman (2001) suggest that there is a positive impact of ICT on economic growth and development. While it appears that these constructs are related, the direction of this correlation is not clear – whether an increase in GDP growth brings about development or is it an increase in ICTs that bring about GDP growth. According to Schumpeter's theory of economic development, innovations, such as Information Technologies, can enable an economy to stimulate growth (Backhaus, 2002). He also suggests that education has the effect of increasing the ability of factors of production to generate income and growth. He suggests that through technical and organizational progress, development takes place as knowledge progresses. New technical innovations can bring about development if they offer opportunities for new enterprises. This has been further studied by Kosempel (2007) who found that knowledge and technology bring about economic development. Additional researchers have found that technological infrastructures do increase the competitiveness of countries (Freeman 2004, Roller and Waverman 2001, Goransson and Soderberg 2005, Narayan and Sun 2007, Bandias and Vemuri 2005).

The role of innovation in economic development has been studied by many researchers since the seminal growth paper by Mankiw, Romer and Weil (1992). Unlike Mankiw et al., who view technology more as a transformation constant and examine the role of capital stock and labor force changes, other researchers have emphasized the role of innovation in creating economic transformation. In an illustrative study, Papaioannou and Dimelis (2005) analyzed ICTs effects on labor productivity growth across a sample of 42 developed and developing countries between 1993 and 2001. The model included several other independent variables such as the number of workers, human capital, among others. The authors found that ICT impact (defined by the amount of money spent on hardware, software and communications) is greater in developed countries than in developing countries; an educated labor work force and a better capital infrastructure have the potential to generate higher levels of income and growth. Given the results of these numerous studies and the theory cited above, we can form hypotheses with respect to the role of ICTs in economic growth:

Hypothesis 1: *Countries that adopt ICTs more intensively will experience higher levels of economic growth.*

This is a direct corollary to the results of Mann (2005) and strongly suggested by Papioannou and Dimelis (2007), Freeman (2004) and numerous other studies. More intensive adoption of ICTs is predicted to lead to greater gains in economic growth.

Hypothesis 2: *Countries that adopt ICT earlier will have greater long term benefits in terms of economic growth.*

Early adoption leads to a nation gaining a competitive advantage over other countries (Mann, 2005), allowing for the country to become a "supplier" of technology versus a consumer. Factor payments flowing from the suppliers should boost economic growth not only in the short-run but also in the longer-term.

The Role of Public Policies in the Relationship between ICT Adoption and Growth

In this vein, one of the economists whose work has been applied to the IT sector, specifically the telecommunications industry, is the work of the economist Joseph Schumpeter. According to Bauer (1997), Schumpeter's business cycles theory, focuses more on the role of innovations per se than on the role of the entrepreneur as an agent of economic change; for Schumpeter, entrepreneurs are the agents of change, those who are willing to combine existing elements into new technologies. Furthermore, IT innovations have the potential to enhance economic growth (Schumpeter, 2002). As a result when new innovations are created, development occurs as new opportunities for start ups appear (Kamal et al., 2008).

Indeed, in today's economic environment, the globalization of the IT sector has set new parameters regarding productivity growth which in turn has affected employment levels. While new jobs and new skills have been created in the IT sector, the jobs of many people around the world have become obsolete or have been outsourced, thus lowering their salaries or leaving them with no income. In turn, this has created the need to retrain those who have lagged behind the globalization of IT. To illustrate this point, it has been suggested that politicians need to focus their efforts towards programs that will enhance the IT skills of their citizens, thus creating human capital, instead of focusing their efforts on "policies to improve the rate of technology creation" Kosempel (2007). An example of this type of work can be found in east-central

Georgia, U.S. A survey of small local economic development organizations (LEDOs) found that, although LEDOs are useful to bridge the gap between community members and IT, that the end users of the IT tools are those located outside the community. For example, internet is used to find information about the local community itself for non-community members or people within the local community who use IT tools to access external sources of information but do not use IT tools for the economic development of the community itself.

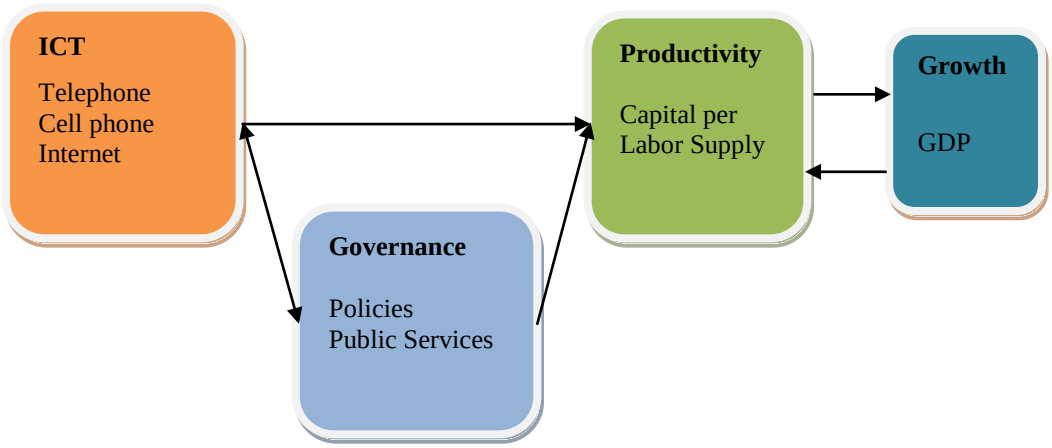
As a tool that increases a country's productivity capacity and international presence, ICTs have decreased the costs associated with the production and exchange of goods and services, enhanced management functions, and increased information access among enterprises. For example, as one of the different ICTs tools available, the internet has become an instrument to improve economic performance by removing physical distances between buyers and sellers; B2B (Business-to-Business) and B2C (Business-to-Consumers) are two examples of the use that internet provides to users worldwide to short distances, increase economic and accounting profits, as well as enhance economic growth. Indeed, it has also created the demand for skill workers, allocate more resources for information technology enterprises, and speed technological innovation.

Likewise, ICTs are also important to create awareness among those in charge of a country's economic policies about their benefits. That is, improvement in a firm's competition capabilities, access to new markets, and the creation and training of skill workers translate into the creation of new jobs. In the long-run, a steady economic growth rate and pattern of wealth creation will be achieved. Therefore, policy makers need to create and facilitate the economic environment needed for the information technology sector to flourish -- an environment with accessible, affordable and good quality infrastructure. For example countries such as Singapore and the United States that implement their ICT strategies in the early 1990s, are among those countries that advanced the most in ICT development. Some of the sectors that can be benefit from implementing ICT are: health, education and manufacturing. Thus, the successful implementation of ICT strategies requires not only the support of policy makers but also the participation of consumers, producers and business organizations. Additionally, developing countries are in need of foreign direct investment (FDI) to improve their current I.T. infrastructure along with a stable economic environment in other markets such as international commerce, banking and finance sectors to guarantee a constant flow of investors. Thus, in order

to secure economic growth and welfare it is necessary to translate ICT benefits into opportunities.

Building off the work of Stephen (2007), Kosempel (2007), and Sciadas (2003) we develop a model that views the policy framework as a mediating factor in the relationship between ICT adoption and economic growth (Figure 1).

Figure 1: Model of the effects of ICT Adoption on Economic Growth



This model suggests that ICTs measured in terms of telephone lines, cell phone and internet connections lead to an increase in productivity. Government policies and public services are the mediating factors that can potentially increase the effect on productivity of ICT adoption if implemented appropriately. Other studies have considered more complex associations between ICTs and productivity. In particular, Sciadas (2003) explains how ICTs are both consumable (info-use) and productive assets (info-density) by nature. That is, while from the productive side ICTs are the aggregation of a nation's ICT stocks (capital and labor); from the consumable side they represent a nation's consumption of ICTs per period. In other words, networks (fixed telephone lines, internet bandwidth and mobile subscribers) and skills (School enrollment and literacy) are info-density indicators; Uptake (computers, internet users, household TV) and intensity (broadband subscribers and international outgoing telecommunications traffic) are info-use indicators; with info-state being the aggregation of info-use and info-density.

We suggest that ICT adoption in itself has an effect on growth through greater capital accumulation and labor productivity. However, effective governance and policies both foster

greater levels of ICT adoption and have an amplifying effect of ICT on productivity and growth. From this model, we develop our final hypothesis.

Hypothesis 3: *Countries that have policies that specifically address ICT adoption and infrastructure realize a larger benefit from ICT on economic growth.*

In order to investigate these hypotheses we need to consider: 1) Countries that have plans that specifically address ICT adoption and infrastructure (H3) , 2) the adoption ICTs in countries and their term benefits in terms of economic growth (H2) and 3) the intensity of adoption of ICTs and the effect on economic growth of this adoption (H1). The following section provides case studies of Singapore and Malaysia's government policies and the extent to which they specifically address ICT adoption and infrastructure (H3) and the intensity of adoption of ICTs (H1) in both these countries. We then develop an ICT adoption index and analyze time series data over about 30 years to map the plans and policies to ICT adoption for both of these countries. We then enter the ICT variable into a multivariate time-series vector autoregression model to capture its effect on economic growth.

CASE STUDIES

This research pursues a mixed-method approach to assessing the role of ICTs in transforming the economies of Singapore and Malaysia. The first step in the research was to pursue an in-depth case study of the historical development of ICTs and how they affected the development of both countries. This should provide a "thick, rich" contextual understanding of the role of ICT in the growth patterns of each country. In particular we sought to investigate the countries' ICT plans and visions, the effects of donor agencies, contributions from other governments, regulatory frameworks and how they may have developed and utilized eGovernment. In particular the emergence of a knowledge industry and ways in which the economies have developed will be described in the light of how ICTs have transformed these economies.

The first step for this study is that it will report on the effects of ICT's on the economic growth of Singapore and Malaysia. This will entail a description of the ICT capacities of both countries. Then the case studies will provide descriptions of the ways in which ICTs have transformed the economies as stated in the paragraph above. Then the effects of ICTs on the economic growth of both countries will be analyzed. This analysis will enable the level of transformation to be assessed and the effects of ICT Capacity on the growth of Singapore and Malaysia.

Transformation of Singapore

In 1964 when Singapore separated from Malaysia its per capita income was comparable to many African countries. Now its growth and per capita income is that of an OECD country. Its transformation can be seen to have taken place through judicious government policies and interventions that supported the development of skills through educational reforms and institutions that enable productivity in improvements. Together these three factors enable the uptake and innovations in technology to bring about growth.

The Singapore economy has undergone significant changes since the 1960's It has grown from a regional port and distribution center in the 1960's to an international manufacturing and service center in the 1970's and 1980's , and now into a center of science-based manufacturing and knowledge intensive industries. The foundation for sustainable growth was based on a principles of fiscal discipline, the use of price incentives for public service delivery, equitable sharing of opportunities for economic progress, strong political institutions, good governance and the rule of law (Lee et al 2008).

Singapore has a history of technology enabled transformations as it has relied primarily on its workforce to produce exportable goods and services and attract foreign direct investments through multinational corporations. Its emphasis has been on educating its workforce through vocational and technical institutes to full fill the demand for these skills by local and multinational businesses. This strategy has meant that Singapore has developed the talent pools needed to attract businesses to it and also encourage its own people to build businesses. The technological innovations funded by the government have enabled new jobs to be created in industries that would otherwise not have been that efficient.

The first stage of Singapore's development was export-oriented industrialization (EOI). The primary objective of this strategy was to provide jobs for its people through foreign direct investment by multinational corporations. The government proactively promoted the state through tax and investment incentives that brought foreign direct investment in Singapore's manufacturing sector from S$239 million 1966 to S$ 6,349 million in 1979 (Lee et al 2008). The success of Singapore's EOI strategy was largely dependent upon adopting modern science and technology to catch up with more advanced countries. A new ministry of science and technology was established in 1968 to address this gap by formulating policies and coordinating the

development of science and technology personnel. Several industrial training and vocational institutes were created in the 1970s to prepare people to take on the jobs provided by the expanding manufacturing sector. When the oil crisis of 1973 increased protectionism in the world economy, the Singapore government transitioned to a developing a higher skilled labor force.

The second stage of Singapore's development which began in the 1980's was severely hampered due to a shortage of skilled labour, qualified technical and engineering personnel, and management trained in modern techniques. As a result Singapore's growth was a low 3% compared to 7% for Hong Kong and Taiwan. As a short term solution, the government liberalized the conditions under which skilled people could migrate to Singapore and become permanent residents and citizens. Two main strategies for the restructuring of Singapore during this time were: a) continued efforts to attract MNCs to invest in high technology operation on Singapore and b) the promotion of science and technology use and research and development activities (Lee et al 2008). This increased the ability of Singapore as a nation to increase the productivity of its people through training and capital investments through the innovations made possible through Research and Development.

The early 1980s was also the time when the first national IT plan was created and implemented. According to Tan (2007), the first IT plan could be analyzed as a period in which the government created the supply of IT capabilities and know-how (supply-push) by developing the fundamental infrastructure and applications of public services. Its role was basically to 'lead by example' and influence the adoption of IT. Known as "The National Computerisation Plan", its main focus was to computerize all civil service departments and agencies to increase work efficiencies and productivity through the automation of tradition work functions. The civil service computerization programme (CSCP) was an important exercise, as it streamlined and re-engineered many redundant traditional processes. The outcomes were impressive when operational efficiencies increased in the public sector. For example, there was shorter turnaround time for applications or for enquiries of services and information, and it was noted that each visitor's passport was cleared within thirty seconds at the airport, and registration of companies which used to days was done within a few minutes. An audit in 1988 found that there was a return of S$2.71 for every $1 spent on the CSCP (NCB, 1986). Consistent with its goals, IT

manpower grew from 850 to 5,500 and the computer software and services industry grew 10-fold in revenue (Tan 2007).

The second IT plan was created in 1986, and is known as the "National IT Plan (NITP)". IT was seen to be exploited further to improve productivity and competitiveness in every sector of the economy as well as developing a strong export-oriented IT industry (Wong 1992). Considering that Singapore's trading economy consisted of many small and medium sized enterprises (SMEs), it was therefore important to improve the private sectors' productivity along with the public sectors. However, it was difficult to get SMEs to computerize their systems, less create a critical mass of adopters. The Small Enterprise Computerisation Program (SECP, later known as the Local Enterprise Computerisation Program (LECP)) was then set up to provide incentives for SMEs to deploy IT. The incentives included financial subsidies for IT feasibility studies, awareness education and training programmes, and the appointment of advisers from the National Computer Board (NCB) or academia to educate executives on the benefits of using IT. The SECP/LECP scheme provided an attractive package from the following institutions: NCB provided the expertise, and Economic Development Board (EDB) provided financial assistance for consulting fees, the purchase of computers, as well as providing subsidies on training IT skills. There were also tax incentives for the purchase of IT products (Tan 2007). The diffusion of IT was strong as computer penetration at the end of the period increased to 70 per cent for enterprises with more than ten employees (NCB 1994).

During this phase, according to Tan (2007) the government computerization programmes took a more advanced approach in that integrated inter-organization networking systems were developed. The Trade Development Board was set up in 1983 to develop Singapore into an international trading hub by promoting its goods and services, entry into new markets, attracting international traders and advancing external trade interests. The TDB was tasked by the Singapore government to automate trade administration in Singapore and it did so by developing public private partnerships. TDB set up a private sector organization called Singapore Network Services Private Limited (SNS), together with Singapore Telecoms, Port of Singapore Authority, and Civil Aviation Authority of Singapore. The main objective of SNS was to implement and market TradeNet (Teo et al 1997). TradeNet was an innovation that enabled trade to take place in a more efficient and effective manner and increase the productivity and competiveness of the businesses using it. This integrated network system that was developed to facilitate the exchange

of trade documents for clearing of customs. The system allowed the computerized exchange of inter-organization business and trade documents conforming to EDIFACT, an established international standard. With TradeNet, what used to take Customs two to three days to clear trade documents, they were cleared within fifteen minutes (King and Konsynski, 1995). The government provided assistance to the businesses who could benefit from using TradeNet and regulated trade by setting standards were set for clearing trade and custom documents. The government imposed higher fees if documents were cleared manually.

The third stage of Singapore's transformation started in the 1990s with the objective to propel the city state to attain the same standard of living as the Swiss by 2020.The economic policy continued to be pro-MNCs but sought to attract only those firms that were able to invest in industrial clusters that could provide the next wave of economic expansion. Local companies were encouraged to move out to into the Asia Pacific to tap into cheaper production resources and to place Singapore at the center of the region's drive for economic growth. To match this policy, the education system was reviewed and revamped with a focus on innovation, creativity and entrepreneurship. Various initiatives in the information technology master plans were to develop 21st century literacy skills which included computer literacy (Lee et al 2008).

This coincided with the third IT plan which took place from 1992 – 1999 and was known as "IT2000". This plan aimed to transform Singapore into an Intelligent Island where IT could be used pervasively at work, home and play and its purpose was to increase its economic competitiveness as well as to enhance the quality of life. According to Tan (2007), this was a period where the potential of Internet technologies were often reported, and the ambition of the 'Intelligent Island' roadmap was put forward to create a critical node in global networks of commerce, communications and information. As the ambition was to develop a global switching centre for goods, services, capital, information and people, it was necessary to develop the National Information Infrastructure (NII). Called 'Singapore ONE' (One Network for Everyone), the nation's high-capacity fast-speed broadband information network was built based on Asymmetric Digital Subscriber Line (ADSL) and hybrid fibre coaxial connections to cable modems to deliver interactive, multimedia applications and services.

During this phase, the government capitalized on deploying the broadband network by creating demand for it. In order to do so the Inland Revenue Authority of Singapore (IRAS) introduced

'e-filing' of income tax returns. Having built the integrated networking systems to tie the backend of public and private systems, there was a conscious effort to ensure there was a demand for the services. As a result many e-government services can only be accessed electronically, for example, registering a company, filing companies' annual return or even getting information. To further create the demand for online business transactions, a Policy Committee was set up to review the legal, regulatory and enforcement issues to facilitate e-Commerce. Consequently, a policy framework for eCommerce, the Electronic Transaction Act was passed in 1998 (Tan 2007). Electronic commerce flourished during the last few years as the emphasis on IT-driven development came to fruition.

Indicators gathered by international organizations to capture the level of ICT adoption and use show that the high intensity of ICT adoption in Singapore. The nation is ranked number 4 in the Global Economic Forum's Network Readiness Index and has risen from 16 to 15 in its ICT Development Index ranking. Singapore's investment in broadband infrastructure as part of its IT2000 plan has had the most beneficial impact on ICT adoption by raising International Internet bandwidth from 558 megabits per second per person (mbs) in 2000 to 22,783 in 2007. Singapore also was ranked 5 on the World Bank's Global Competitiveness Index. [1]

The Malaysian Experience

Malaysia is a country with a rural population dedicated to agriculture and mining and urban areas focusing on services, manufacturing, and construction (APDIP http://www.apdip.net/projects/dig-rev/info/my/). Prior to independence, many fortunes in Malaysia were made from the rubber plantations that still define much of the landscape; other traditional exports were timber, tin, oil and palm oil. About 37% of Malaysians still live in rural areas and the incidence of poverty is twice as great in the countryside as in the towns. A new agricultural programme, again concentrating on high value-added activities and technological advances (including, for example, exploring the potential of palm oil and other farmed or indigenous products through the application of biotechnological methods) is intended to narrow the gap between the two poles of the income spectrum.In 2006, Malaysia exported about $159bn

[1] Sources: ITU World Telecommunications ICT Indicators Database 2009, World Bank "ICT at a Glance" 2009, The Global Information Technology Report 2008-2009 © 2009 World Economic Forum, Commonwealth Secretariat, ITU ICT Development Index 2009.

worth of goods, making it one of the major exporting nations in the Association of South East Asian Nations (ASEAN) group of countries (Foreign Direct Investment 2007).

According to Genus and Nor (2007), economic growth in Malaysia has accelerated sharply in the last two decades. However, while its gross domestic product (GDP) per capita (an estimated US$9,700 in 2004) is much greater than that of many East Asian and Pacific countries (China and the Philippines both had GDP per capita of less than US$6,000 in 2004), it is much less than that of Singapore (estimated at US$27,800 in 2004) and South Korea (US$19,200 in 2004). Further, developing economies such as China and India have now emerged as more conducive places for investment, due to their cheaper labour and the huge size of their local markets.

Malaysia only relatively recently has sought to generate development through ICT adoption. Malaysia's creation of the Multimedia Super Corridor, incorporating Cyberjaya (an information and communications technology dedicated mini-metropolis intended to foster domestic talent and encourage new entrants), signalled its intention to capitalise on value-added skills and put the country on the map as a sophisticated manufacturer, and research and development (R&D) base. Malaysia knows it cannot compete with more populous regional neighbours as a low-cost bulk producer and is in a sense forced up the value chain by the constraint of its small population (28 million) (Foreign Direct Investment 2007).

Among other initiatives, the government has declared its intention to grow the manufacturing sector through the expansion of existing technology parks and the establishment of new ones, g to develop 20 industrial parks and small and medium-sized enterprise parks, and to deliver infrastructural improvements where they are required. In particular Vision 2020 aims to end absolute poverty by 2010, narrow the Chinese-Malay income gap by 2020, assist Malay entrepreneurs and widen share ownership, promote equal employment, produce high-value goods, and develop world-class universities (Foreign Direct Investment 2007).

Given the relative experiences of Singapore and Malaysia, we can make some preliminary conclusions about the role of ICTs in the development growth paths of both countries. Singapore has focused on ICTs for several years and has been an early adopter with a consistent policy of promoting ICT use and investing in ICT infrastructure. The small nation immediately realized the potential benefits of ICTs in enabling economic growth. The leaders of the Singaporean nation made ICTs the focus of their long-term plans. They also focused on technologies which

might enable an immediate boost to economic growth. By contrast, Malaysian leaders were relatively slow to recognize the potential of ICTs. When they did start developing ICT plans, they were faced with other more pressing issues such as the effects of the Asian economic crises and internal problems that ICT plans became secondary. Given the ICT plans of both economies provided in the above case studies, we posit the following hypotheses:

Malaysia has been a late adopter of ICT and it appears that its investments in ICT adoption have not been as successful. The benefits from investments in Multimedia Super Corridor (MSC) about 50 x 15 kilometres in Kuala Lumpur did not materialize as expected. The MSC corridor comprises two strategic centres, namely Cyberjaya as the multimedia centre and Putrajaya as the administrative centre. There is a Siber Village for small and medium industrial development, High-Tech Village for high industrial technological development, Tele-Suburb for smart housing and educational, and R&D centre for academic institution and corporate research and development.

Malaysia's performance on international measures of ICT adoption shows its relatively slow development of ICT. The nation is ranked number 28 in the Global Economic Forum's Network Readiness Index and number 52 in the most recent ICT Development Index. Malaysia's International Internet bandwidth has also increased, but stands only at 998 mbs in 2007, not much above where Singapore started in 2000. Malaysia also ranks only 21st in the Global Competitiveness Index.

METHODOLOGY, DATA AND RESULTS

In order to test our hypotheses, we conducted a time-series analysis of the two countries' data. We gathered data on variables that are typically included in models of economic growth, along with data on ICT adoption and use. The data were available for the period 1977-2007 (31 years). The variables used in the study are shown in Table 1. The economic variables all follow the standard definitions as found in Mankiw, Romer and Weil (1992), Papaioannou and Dimelis (2007) and others. Per capita income is the measure of economic output that forms the basis for our growth estimates. Per capita capital stock is a measure of private capital stock that many papers have found so important in creating economic growth. Since both variables are in per

capita terms, there is implicity embedded in the analysis the size of the labor force, we are implicitly assuming that output and capital stock must be normalized by the size of the population. The share of government in output has also been shown to be an important control variable predicting the growth of output (see for example Barro 1991). The remaining variables all capture the adoption and use of ICTs in an economy. They are also standard in the literature.

The first step in our research was to develop an index of ICT adoption from the available variables. This method is preferable to the simple insertion of many individual variables into our economic growth model because it reduces the impact of measurement error. Each variable contains a portion of information regarding the latent factor we term adoption of ICTs, but it also contains noise in the form of measurement error. The extraction of an index consisting of only the latent factor information minimizes the noise in the model and should lead to a more precise estimate of the effect of ICTs on growth.

Table 1. Variables Used in the Analysis.

Variable	Description	Source
PCY	Per Capita Gross Domestic Product (GDP)	Calculated from World Bank, *World Development Indicators 2006*; Marquetti, *Extended Penn World Tables*.
PCK	Per Capita Capital Stock	Calculated from Marquetti, *Extended Penn World Tables*.
GOVSHARE	Share of Government Consumption in GDP	Marquetti, *Extended Penn World Tables*.
TELE100	Fixed Telephone Lines per 100 Population	International Telecommunications Union (ITU), *World Telecommunications ICT Indicators Database 2009*.
CELL100	Mobile Cellular Telephone Subscribers per 100 Population	ITU, 2009.
INTER100	International Internet Bandwith (bits per second per 100 Population)	ITU, 2009.

ICT Adoption Index

The ICT index was constructed using the method proposed by Geweke (1977) and Chamberlin and Rothschild (1983) and expanded by Stock and Watson (2002, 1989), Forni, *et.al.* (2000), and numerous other authors. We follow the two-step approach. The first step was to extract the static factors on the raw ICT data (the data was first differenced to achieve stationarity). The method of extracting the factors was through Principal Components Analysis. The results are of this step is shown below:

Table 2. Results of Static Factor Analysis, Singapore. Method of Extraction is Principal Components Analysis.

Principal Components Analysis			
Eigenanalysis of the Correlation Matrix			
Component	Eigenvalue	Proportion	Cumulative
1	2.0105	0.6702	0.6702
2	0.5775	0.1925	0.8626
3	0.4121	0.1374	1.0000
Eigenvectors (component loadings)			
Variable	PC1	PC2	PC3
d_TELE100	-0.578	0.570	-0.583
d_CELL100	0.549	0.801	0.239
d_INTER100	0.604	-0.182	-0.776

Table 3. Results of Static Factor Analysis, Malaysia. Method of Extraction is Principal Components Analysis.

Principal Components Analysis			
Eigenanalysis of the Correlation Matrix			
Component	Eigenvalue	Proportion	Cumulative
1	1.9170	0.6390	0.6390
2	0.6539	0.2180	0.8570
3	0.4291	0.1430	1.0000
Eigenvectors (component loadings)			
Variable	PC1	PC2	PC3
d_TELE100	-0.599	-0.401	0.693
d_CELL100	0.605	0.339	0.720
d_INTER100	0.524	-0.851	-0.039

The first factor (principal component) explains 67% of the variance in the data for Singapore and 63% of the variance in the data for Malaysia. As the second factor has an eigenvalue less than

1.0 only one factor is extracted (Kaiser, 1960). The second step of the index generation process was to model the dynamic properties of the factors using a Kalman filter. An ARIMA (1,1,0) model was indicated for both cases (Tables 4 and 5). The model reduced the serial correlation between observations to a negligible amount, indicated by Box-Ljung Q-statistics and examination of the autocorrelation and partial autocorrelation function.

Table 4. Results of ARIMA (1,1,0) Model, Singapore. Dependent Variable is Static Factor. Estimation is via Kalman Filter.

	Coefficient	*Std. Error*	*z-stat*	*p-value*	
Const	0.120332	0.0655245	1.8364	0.06629	
phi_1	-0.717338	0.192549	-3.7255	0.00019	

Mean dependent var	0.075387	S.D. dependent var	0.750306
Mean of innovations	-0.009374	S.D. of innovations	0.624370
Log-likelihood	-30.69503	Akaike criterion	67.39006
Schwarz criterion	71.78727	Hannan-Quinn	68.84761

Table 5. Results of ARIMA (1,1,0) Model, Malaysia. Dependent Variable is Static Factor. Estimation is via Kalman Filter.

	Coefficient	*Std. Error*	*z-stat*	*p-value*	
Const	0.127062	0.0769544	1.6511	0.09871	
phi_1	-0.320672	0.164697	-1.9470	0.05153	

Mean dependent var	0.123497	S.D. dependent var	0.613698
Mean of innovations	-0.001704	S.D. of innovations	0.570438
Log-likelihood	-27.49707	Akaike criterion	60.99414
Schwarz criterion	65.39135	Hannan-Quinn	62.45169

The predicted values resulting from the ARIMA estimation form the ICT adoption indices (variable name ICT) are illustrated in the following figures: for Singapore (Figure 2) and Malaysia (Figure 3).

Figure 2. ICT Index, Singapore, 1977-2008.

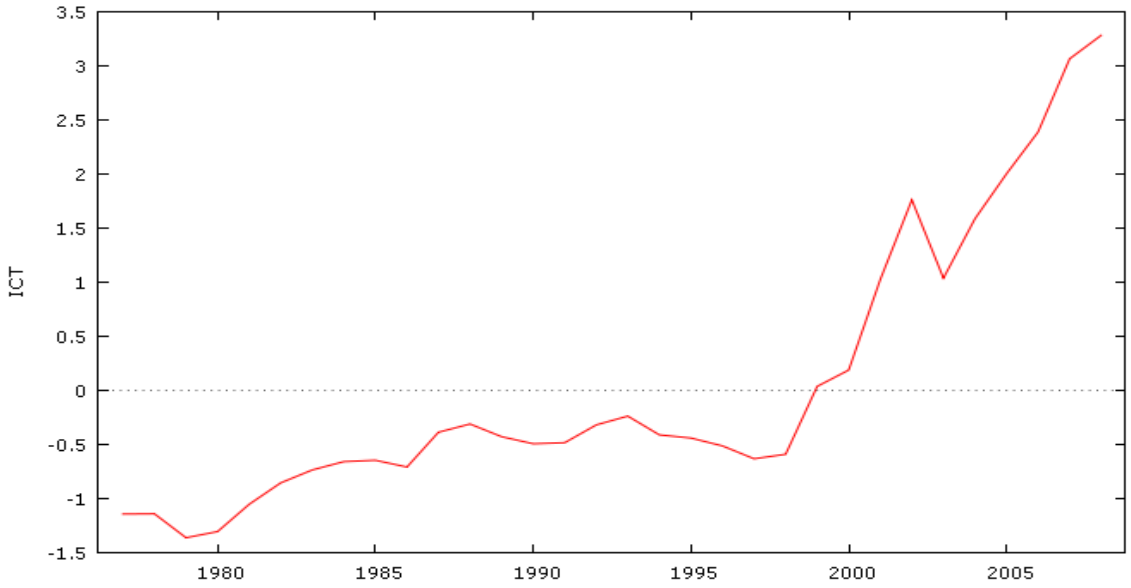
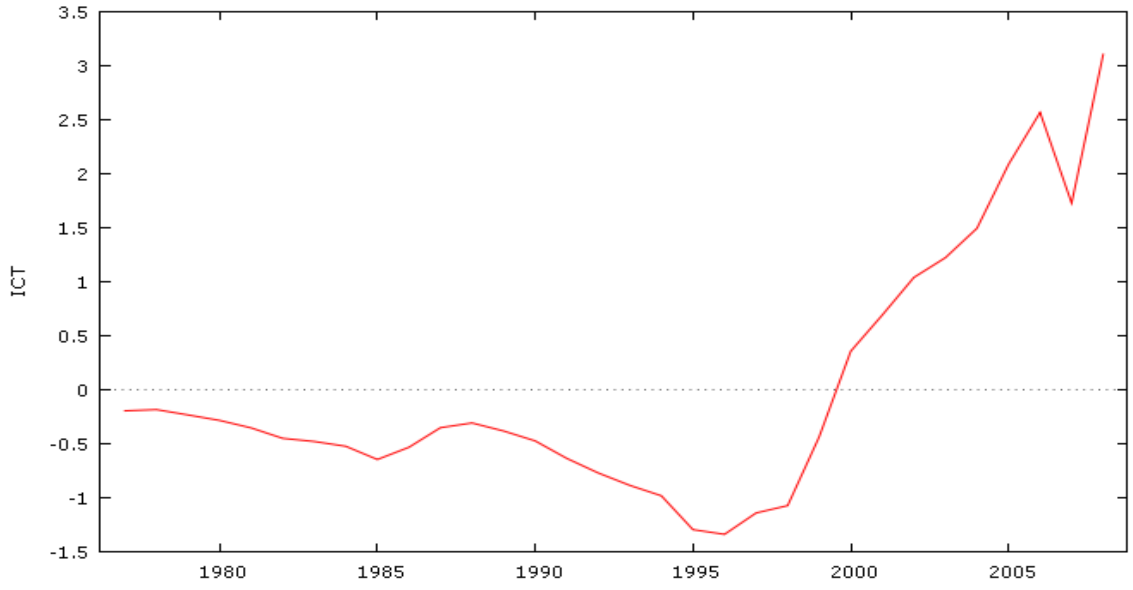


Figure 3. ICT Index, Malaysia, 1977 - 2008.



There are some qualitative differences between the behaviour of the two ICT histories as shown by the index. For Malaysia, the index trends down gradually until 1996 when there is an inflection point and the index climbs steadily until 2008 with the exception of one drop in 2006.

The pattern of ICT adoption is different in Singapore. The downward drift during the period of the 1980s and 1990s is not evident. If anything, the index rises slightly during the 1970s and early 1980s. As the narrative above indicates, Singapore was an early adopter of ICT. Then there was a period of leveling off during the period 1985-1996. Singapore's "take-off" from this base occurred slightly later than Malaysia's (around 1997) but was more dramatic. This inflection point in the data coincides with the passage of the second of Singapore's National Technology Plans in 1996. Both countries had a brief dip in the adoption and use of ICT in the early 2000s. Singapore's downturn occurred earlier and was less pronounced than Malaysia's. However, both countries resumed strong growth in the adoption and use of ICT after the dip.

Effect on Economic Growth

Next, the ICT variable was entered into multivariate time-series systems to capture the effect on economic growth. The structure of the empirical model is that of a vector autoregression (VAR – see among others Stock and Watson, 2003). A VAR is a simultaneous time-series analysis where the endogenous variables in a model are regressed on lagged values of themselves and the other endogenous variables. A VAR can also contain exogenous variables to represent different aspects of a econometric system that are "outside" of the model. The growth model developed for this analysis is:

$$\mathbf{Y}_t = A_1\mathbf{Y}_{t-1} + \ldots + A_k\mathbf{Y}_{t-k} + E_t + u_t \qquad (1)$$

where ***Y*** is a vector of endogenous variables consisting of *PCY*, *PCK*, *GOVSHARE*, and *ICT*, and *E* is an exogenous policy regime varaiable representing the adoption of technological plans for Singapore and the 5-year industrial plans in Malaysia. Lag length (2 for Singapore and 3 for Malaysia) was determined by the Hannan-Quinn criteria and an examination of residuals. Cointegration was suggested for both the Singapore and Malaysia cases, so the final form of the regression was a vector error-correction model (Harris, 1995) which included the vector Γ capturing the long-term common trends in the data:

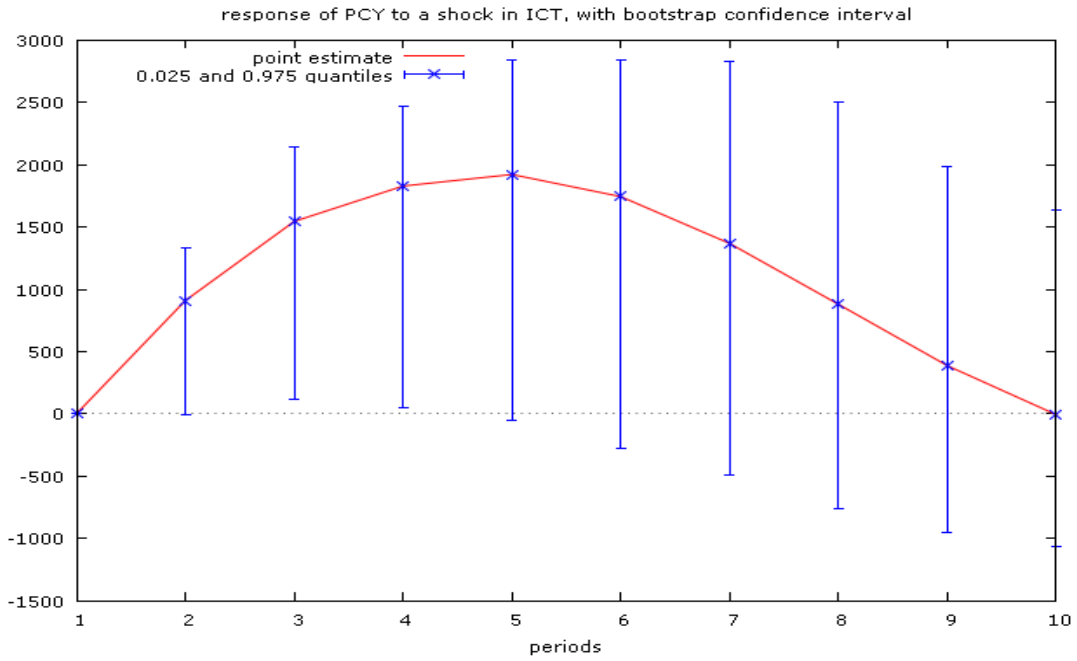
$$\Delta Y_t = \Gamma_1\Delta Y_{t-1} + \ldots + \Gamma_{k-1}\Delta Y_{t-k} + \Pi Y_{t-k} + \Delta E_t + u_t \qquad (2)$$

The results of the VECM estimation are extremely detailed. The model as a whole performs well, explaining about half of the variance in the endogenous variables. The residuals of the model are normal and not correlated. In a VECM, the coefficients of individual variables are not important due to the over parameterization of the model. Therefore, analysis usually is done on the "impulse response function" which shows the simulated response of variables to the changes in other variables. The impulse response functions detailing the effect of ICT on per capita GDP are shown in Figures 3 and 4. These graphs show an estimate of how a one standard deviation increase in ICT adoption as measured by our Adoption Index would effect economic growth as measured by changes in per capita Gross Domestic Product. The cumulative effect can be estimated by adding up the annual change estimates.

There are many qualitative differences between the responses. Singapore's economy reacts very positively and immediately to the adoption and use of ICT. Even though the effects tail off over time, the accumulated effect is dramatic. Over the 10 year period of analysis, ICT adoption is predicted to have raised per capita GDP by a total of $6,205.40 over what it would have been without the adoption of ICT for Singapore.

These results are significant because they show that while Singapore was an early adopter of ICT, its policy of consistently promoting ICT adoption and investing in infrastructure had direct effects on economic development. The intensity of adoption in Singapore has also been very high as the Government has ensured that ICTs are adopted in education, healthcare, government and developed specialized ICT infrastructures for the legal and trading communities. This intensity of ICT adoption had had direct benefits for economic growth through increased and more efficient trade. A more educated workforce is also able to make us of ICTs in innovate ways which leads to an increase the productivity of factors of production. As can be seen from figure 4, the response to economic growth from an increase in ICT adoption leads to an increase in economic growth at increasing rates. However this rate of increase tapers over time. This may mean that additional innovations in ICT adoption would be needed to sustain the initial rates of increase that were seen from the early adoption of ICT.

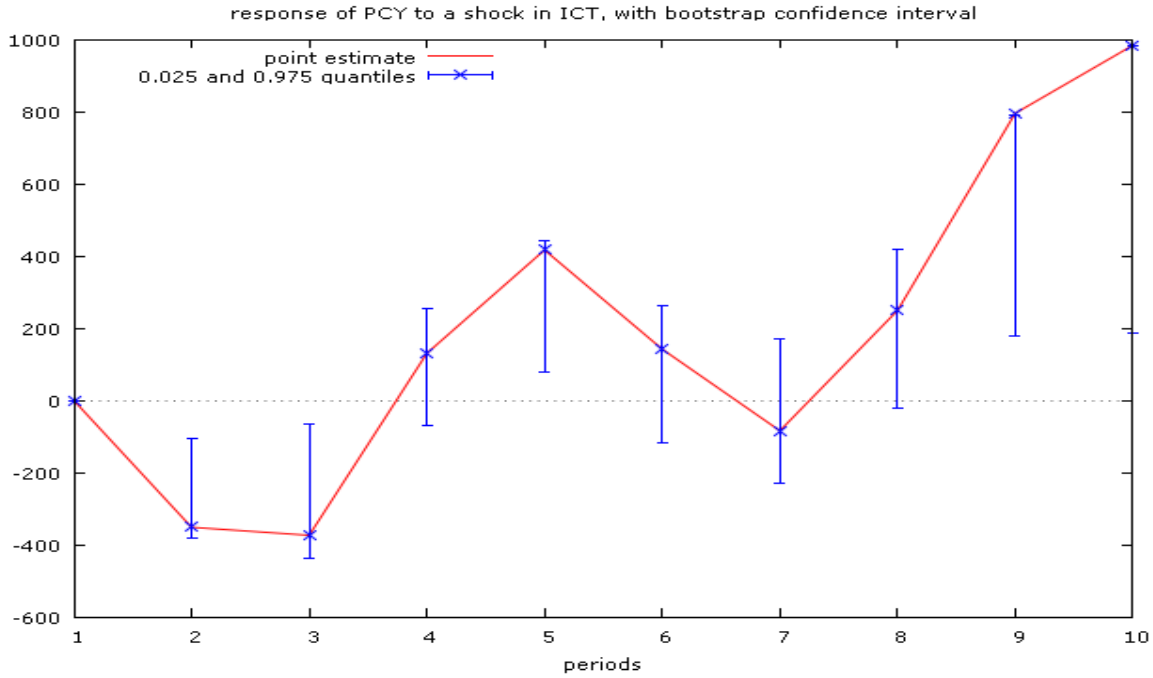
Figure 4. Response of Economic Growth to an Increase in the ICT Adoption index, Singapore.



In Malaysia's case, a "sawtooth" pattern emerges. There is an immediate negative impact of ICT adoption. However, over the medium and long term, these effects reverse and gains to economic growth are suggested. Our estimates indicate that over the 10 year period of analysis, ICT adoption is predicted to have raised per capita GDP by a total of $1,473.84 in Malaysia.

The pattern in Figure 5 appears to reflect the effects of two ICT master plans: the Second Industrial Master Plan (1996- 2005) appears to have brought a decrease in the effect of ICt adoption on economic growth. Vision 2020 identifies globalisation as one of the major underlying 'mega trends' which Malaysia must follow in order to ensure a sound basis for economic development. This view further emphasised by the Third Outline Perspective Plan (OPP3, 2001- 2010).

Figure 5. Response of Economic Growth to an Increase in the ICT Adoption index, Malaysia.



While the effects of ICT adoption on economic development vary for Malaysia, it seems that the rate of increase of the effects of ICT adoption on economic development is rising. Despite the lack of immediate success of its ICT plans, the key indicators for Malaysia illustrate that it is making some progress. It is ranked 28th on the World Economic Forum's Network Readiness index and has fallen from 50 to 52 on the ITU's ICT Development Index. Investments in ICT infrastructure have also been minimal: international Internet bandwidth went from 23 megabits per second per person (mbs) in 2000 to 998 mbs in 2007. Malaysia is ranked 21 in the World Bank's Global Competitiveness Index which is lower than Singapore but shows room for improvement.

The results from the vector autoregressions further confirm the role of policies on ICT growth and adoption. The planning regime variable has a positive sign and is statistically significant in the ICT index equation of the multivariate system for Singapore. For Malaysia, the planning regime variable has a negative sign and is statistically significant. These results suggest that the more IT-focused plans in Singapore led to increased ICT adoption, which in turn contributed to the long-run growth of the city-state. In Malaysia's case, the industrial plans (which in the early

periods lacked IT focus and even led to the likely underinvestment in ICT technologies) led to lower ICT adoption and less of a growth effect.

Finally, the results of the statistical analysis suggest the pathway for the ICT effect. In the Singapore system equation, the impulse response analysis for the effect of an increase in ICT adoption on per capita capital stock shows a strong positive relationship. In the Malaysian system equation, the results are slightly negative, but not statistically significant, indicating that ICT adoption there has been far less effective in fostering increases in capital formation and productivity growth.

Given the above analysis, we conclude with respect to our hypotheses:

Hypothesis 1: *Countries that adopt ICTs more intensively will experience higher levels of economic growth.*

From the case studies we can see how Singapore had the more intense adoption of ICTs. This is confirmed by the trends in the ICT index. The results of the economic growth analysis suggest that this led to a stronger effect on growth. The intensity of adoption by Malaysia was less and the effects on economic growth were also smaller than that for Singapore. The pathway indicated by the results is through capital formation. Per capita capital stock was driven upward in Singapore by the adoption of ICTs, whereas in Malaysia it languished for years as the country became a technology laggard. As found by many previous authors, ICT plays a transformative role in economies if adopted intensively.

Hypothesis 2: *Countries that adopt ICT earlier will have greater long term benefits in terms of economic growth.*

Singapore adopted ICT much earlier, indicated by the numerous initiatives detailed in the case studies and the ICT index having a slightly upward trend throughout the 1980s. Singapore also had a greater long-run impact of ICTs on economic growth. Malaysian ICT adoption also demonstrated a long-run impact on growth, but it was far more muted, possibly owing to the relatively late adoption of technologies. This result is consistent with the findings of Mann (2005) and others who conclude that ICT adoption establishes a competitive advantage for the early adopters.

Hypothesis 3: *Countries that have policies that specifically address ICT adoption and infrastructure realize a larger benefit from ICT on economic growth.*

As we predicted ICT adoption in Singapore, which has had specific targeted ICT policies to promote adoption for several decades, has had a larger direct impact of on economic growth. Malaysia on the other hand has not had specific policies targeting ICT adoption and infrastructure until recently. As a result the adoption of ICT was less intensive in Malaysia and the impact of ICT on economic growth in Malaysia has not been as great as that for Singapore. This finding is consistent with the results of Stephen (2007), Kosempel (2007), and many others.

These findings suggest that countries can use ICT's to transform their economies if they coordinate these efforts by developing their capacity through public policy, education to develop their labour, capital investments and adoption of ICTs in key sectors. It appears that while early adopters may have the most benefits from ICTs, it is the ways in which these are implemented and the innovations that they enable in businesses that are needed to sustain these benefits. This study has shown that ICTs can enable an increase in economic growth to take place in two countries. Further studies will have to show how this growth actually takes place.

SUMMARY AND CONCLUSIONS

Our research has analyzed the effects of ICT adoption and use in two countries with far different approaches to and history with ICTs. Singapore was seen to be an early and intensive adopter of ICTs, whereas Malaysia lagged in the adoption of ICTs and then did not implement ICTs as intensively. Part of the difference in the experience of the two countries was due to the focus in Singapore's policies on technology. While Malaysia concentrated on growing their manufacturing industries, Singapore pursued policies that emphasized growing human capital and implementing value-added technology strategies. Our results suggest that Singapore's approach was relatively more effective in creating economic growth. These results suggest a policy path that countries can take in fostering greater economic growth through ICT adoption. In addition, this research can enable targeted interventions involving ICT adoption, government policy, labour and capital to be developed to stimulate economic development.

Further research is needed to build on our results. Many authors have commented on the role of human capital development in facilitating economic growth and ICT adoption, but few have approached both questions in a simultaneous fashion. Also, research must go beyond simple distinctions of human capital policies versus no policies to include measures of various aspects of skills development and technological preparation.

REFERENCES

Adam, M. S. & C. Urquhart (2007). IT capacity building in developing countries: A model of the Maldivian tourism sector. *Information Technology for Development, 13*, 315-335.

Backhaus, J. (2002). 'The economy as a whole': The seventh chapter of Schumpeter's The Theory of Economic Development. *Industry and Innovation, 9*, 91-92.

Baliamoune-Lutz, M. (2003). An analysis of the determinants and effects of ict diffusion in developing countries. *Information Technology for Development, 10,* 151–169.

Bandias, S. & Vemuri, S. (2005). Telecommunications infrastructure facilitating sustainable development of rural and remote communities in northern Australia. *Telecommunication Policy, 29*, 237-249.

Barro, R.J. (1991). Economic growth in a cross-section of countries. *The Quarterly Journal of Economics, 106*, 407-443.

Bauer, J. M. (1997). Market power, innovation, and efficiency in telecommunications: Schumpeter reconsidered. *Journal of Economic Issues, 31*, 557-565.

Bollou, F. & Ngwenyama, O. (2008). Are ICT investments paying off in Africa? An analysis of total factor productivity in six West African countries from 1995 to 2002. *Information Technology for Development, 14,* 294-307.

Cecchini, S. & Scott, C. (2003). Can information and communications technology applications contribute to poverty reduction? Lessons from rural India. *Information Technology for Development, 10*, 73-85.

Chamberlain, G. and Rothschild, M. (1983). Arbitrage factor structure, and mean-variance analysis of large asset markets. *Econometrica, 51*, 1281-1304.

Foreign Direct Investment**.** (2007, August/September). Supplement: Malaysia-Vision 2020-The long view. *Foreign Direct Investment*, p. 1.

Forni, M., Hallin, M., Lippi, M., & Reichlin, L. (2000). The generalized dynamic-factor model: Identification and estimation. *The Review of Economics and Statistics, 82*, 540-554.

Freeman, C. (2004). Technological infrastructure and international competitiveness. *Industrial and Corporate Change*, *14*, 541-569.

Genus, A. & Nor, M.A.M. (2007). Bridging the digital divide in Malaysia: An empirical analysis of technological transformation and implications for E-development. *Asia Pacific Business Review*, *13*, 95-112.

Geweke, J. (1977). The dynamic factor analysis of economic time series. In D. J. Aigner and A. S. Goldberger (Eds.), *Latent Variables in Socio-Economic Models*. Amsterdam: North-Holland.

Goransson, B., and Soderberg, J. (2005). "Long waves and information technologies – on the transition towards the information society". *Technovation*, Vol. Vol. 25, No. 3.

Harris, R.I.D. (1995). *Cointegration Analysis in Econometric Modelling*. Englewood Cliffs, NJ: Prentice-Hall.

Hosman, L., Fife, E., & Armey, L.E. (2008). The case for a multi-methodological, cross-disciplinary approach to the analysis of ICT investment and projects in the developing world. *Information Technology for Development, 14*, 308-327.

International Telecommunications Union (ITU). (2007). *Measuring the Information Society, ICT Opportunity Index and World Telecommunications/ICT Indicators*, 1- 134. Geneva.

Kaiser, H.F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*, 141-151.

Kamal, M. & Qureshi, S. (2009). Classification of countries based on ict infrastructure, skills and growth: The role of ICT capacity in emerging economies. In K.E. Kendall and U. Varshney (Eds.), *Proceedings of the Fifteenth Americas Conference on Information Systems.*

Kamal, M., Qureshi, S. & Lotfollah, N. (2008, May). *A global analysis of the effect of IT capacity on development – Understanding sourcing of skills*. Paper presented at the International Conference on Information Resources Management (CONF-IRM). Niagara Falls, ON.

Kauffman, R. & Kumar, A. (2008). Mapping the multi-tiered impacts on the growth of IT industries in India: A combined scale-and-scope externalities perspective. *Information Technology for Development, 14*, 225-252.

King, J. & Konsynski, B. (1995). Singapore TradeNet: A tale of one city. *Harvard Business School, Case Study 9-191-009.* Boston: Harvard University.

Kosempel, S. (2007). Interaction between knowledge technology: A contribution to the theory of a development. *Canadian Journal of Economics, 40*, 1237-1260.

Kottemann, J. E. & Boyer-Wright, K.M. (2009). Human resource development, domains of information technology use, and levels of economic prosperity. *Information Technology for Development, 15*, 32-42.

Lee, S.K., Goh, C. B., Fredriksen, B., & Tan, J.P. (2008). *Towards a better future: Education and training for economic development in Singapore since 1965*. The World Bank, National Institute of Education Singapore.

Mankiw, N. G., Romer, D. & Weil, N. D. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics, 107*, 407-437.

Mann, C. L. (2005). Globalization, Information Technology, and US Economic Performance, Globalization: Prospects and Problems. *Conference on Globalization: Prospects and Problems.* Gainesville, FL, January 28-30.

National Computer Board (NCB). (1986). *Singapore Civil Service Computerization Programme*. Singapore: Author.

NCB. (1994). IT usage survey. *IT Focus, October/November,* 7-10.

Narayan P., and Sun, G-Z. (2007). The division of labor, capital, communication technology and economic growth: The case of China 1952–99. *Review of Development Economics, 11*, 645-664.

Papaioannou, S. & Dimelis, P. (2007). Information technology as a factor of economic development: Evidence from developed and developing countries. *Economics of Innovation and New Technology, 16*, 179-194.

Pick, J. & Azari, R. (2008). Global digital divide: Influence of socioeconomic, governmental, and accessibility factors on information technology. *Information Technology for Development, 14*, 91-115.

Röller, L. & Waverman, L. (2001). Telecommunications infrastructure and economic development: A simultaneous approach. *The American Economic Review, 91*, 909-923.

Sciadas, G. (2003). *Monitoring the Digital Divide and Beyond*. Orbicom International Secretariat, pages 8-182.

Stock, J.H. and Watson, M.W. (2003). *Introduction to Econometrics*. Boston: Pearson.

Tan, M. (2007). From wired to wireless: Singapore's ubiquitous digital hub. In Qureshi, S. and Vogel, D. (Eds.), *Information Technology Application in Emerging Economies: A Monograph of a Symposium at HICSS-40*. Retrieved from: http//:www.hicss.hawaii.edu/reports.htm

Teo, H., Tan, B.C.Y., & Wei, K.K. (1997). Organizational transformation using electronic data interchange: The case of TradeNet in Singapore. *Journal of Management Information Systems, 13*, 139-165.

United Nations Conference of Trade and Development (UNCTAD) Secretariat. (2001). *E-Commerce and Development Report 2001*. New York and Geneva: Author.

UNCTAD Secretariat. (2003). *E-Commerce and Development Report 2001*. New York and Geneva: Author.

UNCTAD Secretariat. (2004). *E-Commerce and Development Report 2001*. New York and Geneva: Author.

Wong, S.H. (1992). Exploiting information technology: A case study of Singapore. *World Development, 20*, 1817-28.

Zheng, Y. (2009). Different spaces for e-development: What can we learn from the capability approach. *Information Technology for Development, 15*, 66-82.