ICT AND HUMAN CAPITAL INTENSITIES IMPACT ON ASEAN5 PRODUCTIVITY

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ABSTRACT
This study assesses the impact of information and communications technology (ICT) and human capital intensities on productivity of ASEAN5 (Malaysia, Indonesia, Philippine, Singapore and Thailand). The factors identified as influencing the labour productivity of ASEAN-5 are the individual contributions of capital deepening (intensity), ICT intensity, human capital intensity and the simultaneous contribution of the quality of these factors. That is expressed as the total factor productivity (TFP) intensity.
The results show that the productivity growth of ASEAN-5 is input-driven. The study also finds that the impact of ICT and human capital intensities appears to have been reasonable with little contribution of TFP intensity growth. The results also confirmed that capital intensity had strongly significant role in achieving reasonable labour productivity contribution that produced by these economies through using huge input to produce output.

1. Introduction

Information and Communication Technology (ICT) includes an array of hardware, software, telephones, businesses, services, and networks that enable to access to internet. ICT usually support by the equipment such as computers, the internet, CD-ROMS and other software, radio, video, television, and digital cameras that can be used in the works.
Human capital can define as the skills and knowledge intensity of the labour force in an economy, which are essentially acquired through schooling and training. The relevance of human capital accumulation to the process of economic development stems from its potential beneficial impact on macroeconomic productivity and on the long-run distribution of incomes, once some basic conditions are met.

There is no one standard definition of the knowledge-based economy but an acceptable one must place importance on the generation and exploitation of knowledge to create new value in the economy. Indeed, knowledge is information that is put to productive work.
Knowledge includes information in any form, know-how and know-why. Knowledge is not only embodied in goods and services, particularly in high technology based industries, but also in knowledge as a commodity itself, manifested in forms such as intellectual property rights or in the tacit knowledge of highly mobile key employees.
And it involves the way people interact as individuals and as a community. Unlike capital and labour, knowledge is a public good and sharing it with others involves zero marginal cost. In addition, technological breakthrough based on knowledge creates technical platforms that support further innovations and drive economic growth (Bank Negara Malaysia, 1999). The knowledge-based economy is not confined to information and ICT.
Before the advent and proliferation of ICT, it was knowledge that was embodied in human beings, namely 'human capital' and technology that was embodied in the capital investment undertaken by the Asian economies that brought about the so called Asian miracle. These two types of investments had helped to close the 'knowledge gap' between the developed and emerging countries on how to transform inputs into desired outputs. With ICT developments, the management of this knowledge gap has become more complex as the globalisation process gains momentum (Bank Negara Malaysia, 1999).

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The performance of the East Asian economies in terms of economic growth and human development, including in education, made them enviable for many developing economies such as China and Malaysia. Obviously other developing economies are eager to draw lessons from the East Asian experience. Until recently developing economies identified with Western economies as embodiments of their ideal goals, and have been trying to borrow and adopt their models of development in their endeavours toward transforming themselves from low-into high-income economies.

On a theoretical front, new growth theory predicts that physical investments should have a greater impact on productivity growth than traditional growth accounting would suggest, due to the positive externalities associated with such activities. In the contributions of Romer (1986), and Grossman and Helpman (1991), these externalities arise because of 'knowledge spillovers'–increases in physical investments of profit-seeking firms contribute to the general stock of knowledge upon which subsequent firms can build. In Delong and Summers (1991), investment externalities arise as a result of the 'learning by doing effect'–workers and managers learn new skills and more efficient methods of production by using newly installed equipment. These models suggest that the information and communications (IT) sector, which has been one of the most technologically dynamic sectors of the economy over the last 20 years, is likely to have a greater impact on productivity growth than other sectors.

A number of recent empirical studies based on firm-level data have also confirmed a positive and statistically significant relationship between IT and productivity.
Gordon (2000), Loveman (1988), Roach (1987, 1988), and Strassman (1997) showed that productivity gains from ICT in the aggregate economy have been limited, despite the rapid improvement in price-performance ratio of computers and heavy investment in ICT. This argument was based in part on the fact that the United States invested heavily in ICT during the 1970s and 1980s, yet productivity growth slowed during that period compared to the earlier post-war years. This has been referred to as the 'productivity paradox'. Among development agencies such as the International Monetary Fund (IMF) and the World Bank, there is likewise disagreement as to what role ICT should play in various development projects.

A study by Chen and Dahlman (2004) assessed the effects of knowledge on economic growth. By using an array of indicators, each of which represents an aspect of knowledge, as independent variables in cross-section regressions that span 92 countries for the period 1960 to 2000, the paper showed that knowledge is a significant determinant of long-term economic growth. In particular, they found that the stock of human capital, the level of domestic innovation and technological adaptation, and the level of ICT infrastructure all exert statistically significant positive effects on long-term economic growth.
More specifically, with regard to the growth effects of the human capital stock, the paper found that an increase of 20% in the average years of schooling of a population tends to increase the average annual economic growth by 0.15 percentage point. In terms of innovation, this study found that a 20% increase in the annual number of USPTO patents granted is associated with an increase of 3.8 percentage points in annual economic growth. Lastly, when the ICT infrastructure, measured by the number of phones per 1000 persons, is increased by 20%, the study found that annual economic growth tends to increase by 0.11 percentage point.

This study intends to investigate the impact of ICT and human capital intensities on ASEAN5 productivity.

Section 2 contains descriptions on the estimation methods employed in this paper, Section 3 demonstrates details of the data. Results of the empirical analysis are explained in Section 4. Finally, Section 5 presents the concluding remarks.

2. Methodology and Estimation Procedures

In this study, Cobb-Douglas production function estimation model and the Solow's residual model were used as modified model to fill the gaps of both models cast doubts on the results generated.

The production function for an economy can be represented as follows:

$$GDPt,i = F(Kt,i, Lt,i, ICTt,i, HCt,i, Tt,i) \quad (1)$$

where Country i = 1, 2, …, 5 in Year t =1965-2004, real Gross Demotic Product (GDP) is a function of real fixed Physical capital K, labour input L, the number of phones per 1000 persons, that proxies for ICT, expenditure in education that proxies for Human Capital (HC) and time T, that proxies TFP as a technological progress of the of the economies.

The present study attempts to close the above mentioned gaps by developing this model into parametric model and providing statistical analysis for it in the first step as follows: -

$$\ln GDPt,i = a + \alpha.\ln Kt,i + \beta.\ln Lt,i + \lambda.\ln ICTt,i + \theta.\ln HCt,i + \varepsilon t,i \quad (2)$$

$$t = 1965\text{-}2004$$

where

α is the output elasticity with respect to aggregate capital

β is the output elasticity with respect to aggregate labour

λ is the output elasticity with respect to ICT

θ is the output elasticity with respect to human capital

a is the intercept or constant of the model[2]

ε is the residual term[3]

ln is the logarithm to transform the variables.

Following Dollar and Sokoloff, (1990), Wong (1993), Felipe (2000) and Elsadig (2006), when constant returns $\beta = (1 - \alpha - \lambda - \theta)$ to scale is imposed, equation (2) becomes: -

$$\ln GDPt,i = a + \alpha.\ln Kt,i + \lambda.\ln ICTt,i + \theta.\ln HCt,i + (1-\alpha-\lambda-\theta).\ln Lt,i + \varepsilon t,i \quad (3)$$

$$t = 1965\text{-}2004$$

For the purposes of this study, equation (3) was transformed by dividing each term by L (labour input) and then the output elasticity was calculated with respect to capital deepening, ICT intensity and human capital intensity, i.e. $\alpha = \alpha 1 + \alpha 2$, $\lambda = \lambda 1 + \lambda 2$ and $\theta = \theta 1 + \theta 2$, respectively. According to Dollar and Sokoloff, (1990) and Elsadig (2006), the production function can be in the form:

$$\Delta \ln(GDP/L)t,i = a + \alpha_1.\Delta \ln (K/L)t,i + \alpha_2[\Delta \ln (K/L)t,i]^2 + \lambda_1.\Delta \ln (ICT/L)t,i$$

$$+ \lambda_2[\Delta \ln (ICT/L)t,i]^2 + \theta_1.\Delta \ln (HC/L)t,i + \theta_2[\Delta \ln (HC/L)t,i]^2 + \varepsilon t,i \quad (4)$$

$$t = 1965 - 2004$$

Then, it follows that:-

[2] The intercept term, as usual, gives the mean or average effect on dependent variable of all the variables excluded from the model.

[3] The residual term proxies for the total factor productivity growth that accounting for the technological progress of the economy through the quality of input terms.

$\Delta \ln(GDP/L)t,i$ is the labour productivity contribution (output per worker)

$\overline{\alpha}.\Delta \ln \overline{(K/L)} = \alpha_1.\Delta \ln(K/L)t,i + \alpha_2[\Delta \ln (K/L)t,i]^2$

is the contribution of the capital deepening

$\overline{\lambda}..\Delta \ln \overline{(ICT/L)} = \lambda_1.\Delta \ln(ICT/L)t,i + \lambda_2[\Delta \ln (ICT/L)t,i]^2$

is the contribution of the ICT intensity

$\overline{\theta}.\Delta \ln \overline{(HC/L)} = \theta_1.\Delta \ln(HC/L)t,i + \theta_2[\Delta \ln (HC/L)t,i]^2$

is the contribution of the human capital intensity

$\varepsilon t,i$ is the residual term that proxies for TFP intensity growth ($\Delta \ln(TFP/L)t,i$)

Δ is the difference operator denoting proportionate change rate

The intercept (a) has no position in the calculation of the productivity growth rate indicators it becomes: -

$$\Delta \ln(GDP/L)t,i = \overline{\alpha}.\Delta \ln \overline{(K/L)}t,i + \overline{\lambda}.\Delta \ln \overline{(ICT/L)}t,i + \overline{\theta}.\Delta \ln \overline{(HC/L)}t,i + \Delta \ln(TFP/L)t,i \quad (5)$$

where $\overline{\alpha}$, $\overline{\lambda}$ and $\overline{\theta}$ denote the shares of capital deepening, ICT intensity and human capital intensity, and (TFP/L), is the translog index of TFP intensity growth.

To calculate the average annual growth rate of the TFP intensity as well as of other productivity indicators contribution in the model, equation (5) becomes

$$\Delta \ln(TFP/L)t,i = \Delta \ln(GDP/L)t,i - [\overline{\alpha}.\Delta \ln \overline{(K/L)}t,i + \overline{\lambda}.\Delta \ln \overline{(ICT/L)}t,i + \overline{\theta}.\Delta \ln \overline{(HC/L)}t,i] \quad (6)$$

Thus, equation (6) expresses the decomposition of labour productivity growth into the contributions of capital deepening, increasing usage of ICT intensity, human capital intensity and TFP intensity contribution.

3. Sources of Data

The data for this paper were collected from various sources. Real Gross Domestic Product (GDP), real fixed physical capital, number of employment, real expenditure in education and the number of phones per 1000 persons, were collected from Asian Development Bank: Key indicators of developing Asia and Pacific countries, Statistical and Data Systems Division, and international financial statistics of International Monetary Fund yearbook. As well as from the individual countries data based and the International Labour Organization

4. Results and Discussion

Autoregressive estimator has been applied to Equation 4 of the model being generated from Cobb-Douglas production function to measure the shift in the production functions of ASEAN-5. An annual time series data over the period of 1965-2004 for GDP, aggregate fiscal capital, number of employment, expenditure in education and the number of phones per 1000 persons, were employed for the individual countries.

Analysis of the data using Equation 4 showed that the estimated coefficient of the explanatory variables of the model mainly were significant at 5% and 10% levels. According to Durbin-H values the model has no problem of autocorrelation (Table 1).

Since the model used in this study was specified in first differences and the calculated growth rates were used in the discussion of results and findings of the study, the model was found to be stationary. Engle and Granger (2003), state that if economic relationships are specified in first differences instead of levels, the statistical difficulties due to non-stationary variables can

be avoided because the differenced variables are usually stationary even if the original variables are not.

Table (1): Estimated Coefficients of ASEAN 5, 1965-2004

Country	Intercept	Capital Intensity		HC Intensity		ICT Intensity		Ad. R^2	D-H
1. Indonesia	1.12	α_1	α_2	$_2\beta_1$	β	λ_1	λ_2	0.93	-0.73
	(0.60)	0.22	0.21	0.12	0.20	0.12	0.13		
		(2.70)**	(1.82)*	(1.86)*	(2.03)**	(1.76)*	(2.03)**		
2. Malaysia	1.04	α_1	α_2	$_2\beta_1$	β	λ_1	λ_2	0.98	-0.66
	(2.52)**	0.21	0.13	0.14	0.22	0.18	0.12		
		(2.48)**	(1.77)*	(1.86)*	(1.93)*	(2.86)**	(1.93)*		
3.Philippines	1.10	α_1	α_2	$_2\beta_1$	β	λ_1	λ_2	0.75	-0.65
	(1.83)*	0.18	0.16	0.20	0.21	0.14	0.11		
		(2.37)**	(1.73)*	(2.15)**	(1.64)*	(2.15)**	(1.64)*		
4. Singapore	0.62	α_1	α_2	$_2\beta_1$	β	λ_1	λ_2	0.80	-0.72
	(1.42)	0.20	0.13	0.19	0.17	0.14	0.17		
		(2.33)**	(1.75)*	(2.06)**	(1.64)*	(1.75)*	(1.64)*		
5. Thailand	-1.71	α_1	α_2	$_2\beta_1$	β	λ_1	λ_2	0.76	-0.65
	(-1.76)*	0.20	0.15	0.19	0.17	0.16	0.13		
		(1.98)**	(1.72)*	(2.56)**	(1.74)*	(2.56)**	(1.79)*		

Note: Figures in parentheses are t-values

** Indicate significant at 5% level

* Indicates Significant at 10% level

Figures in Table 1 were estimated using equation (4)

4.1 Empirical Analysis

Analysis was carried out to compare the productivity indicators between the ASEAN-5 economies for the entire period of 1965-2004. In order to study the effect of governments' policies in improving the productivity growth, the study period was divided into two phases. These phases, which corresponded to the major policy changes, were 1965-1987; 1988-2004. The period of the 1960s; and 1970s witnessed the labour driven policies in these countries. The decades of 1980s, 1990s and 2000s saw a further diversification of the economies into more advanced industries through investment driven policies. As a result of these polices the range of economic activities and sources of growth had become more diversified. In addition, these decades witnessed further diversification of the economies of these countries into more advanced industries. During these decades, the economic structural transformation took place in most economies of these countries. The manufacturing sector became the engine of growth in these countries. Finally, this includes the period of 1997-2004, i.e. was the period during and after the Asian financial crisis of 1997 and its negative impact continued until 2000 with significant damage to the Asian economies

However, the contribution of TFP intensity growth to the economies of these countries in terms of average annual productivity growth was low (Table 2). The highest contribution of labour productivity by including ICT and human capital intensities in the model to the productivity growth of the ASEAN-5 was the contribution of the sub period of 1965-1987 in most countries under study (Table 2). In addition to the contribution of labour productivity to the productivity growth of the economies of these countries was light also during the entire period and sub-period of 1965-1987 (Table 2). The sub-period of 1965-1987 was found to be a combined period of labour and investment driven. And the sub period of 1988-2004 was the perceived period of investment driven. As a result the performance of the economies of these countries was rapid compared with the period before the transformation of these economies into investment driven that supported by foreign direct investment (FDI). The TFP

intensity growth contribution was low and the labour productivity was not the highest one to contribute to the economy's productivity growth. The reasons behind that were the economic recession of 1973, 1985 and the financial crisis of 1997 and the quality of human capital and the technology involved in the production of these economies.

The highest contribution of capital deepening to labour productivity in terms of average annual productivity growth of the ASEAN-5 was during the sub-period of 1965-87. Similarly, the contribution of ICT and human capital intensities to labour productivity in terms of average annual productivity growth of these countries was fair during all the periods of the study (Table 2). This reflects the fact of the comparative advantage in unskilled labour intensive that eventually helped to attract FDI in the latter half of the 1980s. These countries accelerated trade liberalisation policies and drastically eased restrictions with respect to capital ownership of foreign companies. That fostered the significant increase of global capital.

By examining the role of ICT and human capital intensities to achieve knowledge-based economy through the contribution of TFP intensity growth, it was found from the results that there was a positive contribution of ICT and human capital intensities to TFP intensity growth of the economies of these countries during all the periods of study (Table 2). FDI is considered to be the source of technology transfer to these countries through Transnational Corporations (TNCs), investment.

Table (2): ASEAN 5 Productivity Indicators (in percentage)

Country	Labour Productivity	Capital Intensity	HC Intensity	ICT Intensity	TFP Intensity
1. Indonesia					
1965-2004	3.34	9.16	7.65	2.11	1.23
1965-1987	5.04	11.2	10.8	3.32	1.64
1988-2004	3.14	6.11	5.20	2.25	1.24
2. Malaysia					
1965-2004	5.34	5.70	5.56	3.24	1.42
1965-1987	7..81	11.8	7.12	4.43	1.98
1988-2004	4.16	10.7	7.92	5.11	1.51
3. Philippines					
1965-2004	3.31	3.82	3.70	1.95	1.57
1965-1987	5.01	3.36	2.40	2.98	1.41
1988-2004	3.2	4.42	2.5	3.91	1.31
4. Singapore					
1965-2004	3.26	12.0	4..31	4.23	2.04
1965-1987	4.92	18.8	8.33	5.27	2.51
1988-2004	4.00	23.7	8.91	6.18	1.85
5. Thailand					
1965-2004	3.34	9.51	5.32	2.22	1.49
1965-1987	5.09	12.10	9.83	3.21	2.11
1988-2004	4.8	4.10	6.33	4.20	1.57

Note: Figures in Table 2 were calculated using equation (6).

5. Concluding Remarks

The factors identified as influencing the labour productivity (that is indicated as a good measure of standard of living rather than output because it measures output per person) of ASEAN-5 from intensive growth theory model are the individual contributions of capital deepening, ICT intensity, human capital intensity and the simultaneous contribution of the quality of these factors that have been expressed as the total factor productivity intensity.

The results show that the productivity growth of ASEAN-5 is input driven. The study also finds that the impact of ICT and human capital intensities appears to have been reasonable with little contribution of TFP intensity growth. The results also confirm that capital intensity had strongly significant role in achieving light labour productivity contribution that are being

possesses produced by these economies through using huge input to produce output. Thanks to FDI that helped the manufacturing sectors to become the engine of economic growth instead of agricultural sectors when economic structural transformation took place at these economies in 1980s.

In the meantime, the results of this study are expected to be useful for ICT and human capital policy formulation. In this context, a comparison of the contributions between ICT and human capital to productivity growth in the ASEAN-5 economies provides a guideline for the policy makers to formulate appropriate national, regional and international ICT and human capital policies.

This study finding will also help policy formulation in promoting ICT and human capital investment in developing the human resources and infrastructure needed to support effective use of the technology. It is possible that ASEAN-5 can capitalise on its synergy with other nations in Asian countries and make full use of the competitive advantages in these countries to overcome its insufficiencies. In that case, ASEAN-5 will be able to accelerate the movement towards becoming technology-savvy nations.

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