GROWTH, LABOUR PRODUCTIVITY AND ICT INVESTMENT IN THAILAND

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การเจริญเติบโตทางเศรษฐกิจ ผลิตภาพแรงงานและการลงทุนด้านเทคโนโลยีสารสนเทศในประเทศไทย

นายจอ มิน ฮัน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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การศึกษาที่ผ่านมาส่วนใหญ่พยายามวัดผลของเทคโนโลยีสารสนเทศที่มีต่อการเจริญเติบโตและผลิตภาพของทุนในประเทศพัฒนา ในขณะที่การศึกษาความสัมพันธ์ระหว่างการลงทุนด้วยเทคโนโลยีสารสนเทศที่มีต่อผลิตภาพแรงงานในประเทศกำลังพัฒนายังมีน้อยมาก และไม่ยกเว้นแม้แต่ในกรณีของประเทศไทย

การศึกษานี้ทำการวิเคราะห์ผลของการลงทุนด้านเทคโนโลยีสารสนเทศในประเทศไทยในอดีตจนถึงปัจจุบันว่ามีส่วนผลักดันให้เกิดการเพิ่มผลิตภาพเฉลี่ยของแรงงานที่นำไปสู่การเจริญเติบโตทางเศรษฐกิจมากน้อยเพียงใด

การศึกษานี้ประมาณการบัญชีการเจริญเติบโต (Growth Accounting) และพบว่าการสะสมทุนเทคโนโลยีสารสนเทศมีส่วนทำให้ผลิตภาพเฉลี่ยของแรงงานเพิ่มขึ้น และนำไปสู่การเจริญเติบโตทางเศรษฐกิจ

ในช่วง ค.ศ.1991-2005 ประเทศไทยมีอัตราการเจริญเติบโตของผลิตภาพแรงงานเฉลี่ยร้อยละ 3.83 ต่อปี เมื่อวิเคราะห์ที่มาของการเจริญเติบโตด้วยบัญชีการเจริญเติบโต การศึกษาพบว่าการสะสมทุนเทคโนโลยีสารสนเทศมีส่วนผลักดันการเจริญเติบโตทางเศรษฐกิจร้อยละ 6 เทียบกับทุนกายภาพอื่นๆ ที่มีส่วนร้อยละ 41 ในขณะเดียวกันทุนมนุษย์มีส่วนให้เกิดการเจริญเติบโตทางเศรษฐกิจร้อยละ 7 ตามลำดับการศึกษา พบว่าผลิตภาพมวลรวม (TFP) มีส่วนมากถึงร้อยละ 46 ในการอธิบายสาเหตุของการเจริญเติบโตทางเศรษฐกิจ

การศึกษาพบว่า การลงทุนด้านเทคโนโลยีสารสนเทศ ส่งผลให้เกิดการเพิ่มผลผลิตภาพเฉลี่ยของแรงงานอย่างมีนัยสำคัญ และส่งผลให้เกิดพัฒนาการทางเศรษฐกิจอย่างต่อเนื่อง การศึกษาฯ พบว่าทักษะด้านเทคโนโลยีสารสนเทศ เกิดจากการใช้เครื่องมือสื่อสารฯลฯ เช่นเครื่องคอมพิวเตอร์ส่วนบุคคล ร่วมกับการใช้เครือข่ายการสื่อสารไร้สาย (Internet) เป็นสำคัญ

การศึกษานำเสนอนโยบายสำคัญ เช่น การเพิ่มการใช้เทคโนโลยีสารสนเทศ การเพิ่มผู้รู้และผู้มีอาชีพด้านนี้ให้มากขึ้นอย่างพอเพียง ที่สำคัญคือการเพิ่มการเรียนรู้และใช้เทคโนโลยีสารสนเทศในหมู่ผู้ใช้แรงงาน เพื่อส่งเสริมการขยายตัวของผลิตภาพแรงงานให้สูงขึ้นกว่าปัจจุบัน ที่สำคัญที่สุดคือการใช้เทคโนโลยีสารสนเทศลดช่องว่างทางการศึกษาเพื่อพัฒนาเศรษฐกิจและสังคมที่แตกต่างระหว่างเมืองและชนบทให้เป็นรูปธรรมต่อไป

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KEYWORDS : INFORMATION AND COMMUNICATION TECHNOLOGY ICT) / LABOUR PRODUCTIVITY/ ICT CAPITAL/GROWTH/ THAILAND

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Many studies have done on the impact of information and communication technology (ICT) on growth and productivity that they treated ICT capital stock as an individual input in the production process that contributes to productivity and growth. Although ICT has found to be one of the key determinants of productivity in the developed world, few studies have also found out the positive impacts of ICT on the developing world. However, there are still lacks of empirical works in the field that differentiate clearly with the literature which study background and descriptive studies of Thailand's ICT development.

This study attempts to examine the role of ICT in Thailand's economy in the past decades. The study develops the framework by considering ICT as a production factor and applies it to interpret Thailand's economic growth. The study contributes to the empirical literature on ICT and economic growth in Thailand. First, it attempts to estimate the ICT capital stock in Thailand by applying the perpetual inventory method. Second, based on such estimates, the study explore the contribution of ICT to Thailand's economic growth by using growth accounting method that segregates ICT from all others forms of capital.

According to study, ICT capital contributes positively on the Thailand economic growth and labour productivity. Average labour productivity growth rate of Thailand is 3.83 percent during 1991 to 2005. In terms of growth accounting analysis, the study found that, ICT capital contributes 6 percent, non-ICT capital contributes 41 percent, human capital contributes 7 percent and TFP contributes 46 percent respectively to average growth. In other word, average labour productivity has been positively affected by ICT development which comes from increase in ICT skills and ICT intensity such as PC per user and internet per user.

Policy recommendation from our study are as follows: (1) increase ICT utilization in Thailand (2) increase the number of ICT professionals in Thailand (3) increase level of ICT education of the labour force in order to strengthen further labour productivity growth and last but not least (4) reduce digital divide between rural and urban of Thailand.

Field of Study : LABOUR ECONOMICS and HUMAN RESOURCE MANAGEMENT   Student's Signature ....

Academic Year : 2009   Advisor's Signature ....

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CONTENTS

CONTENTS (Cont.)

List of Tables

Page

List of Figures

Chapter I

Introduction

1.1 Introduction and Statement of Problem

The economic impact of Information and Communication Technology (ICT) is growing over the recent years. It seems to be a complex subject and great interest to both developed and developing world in the age of globalization. Researchers, in recent years, studying the impact of ICTs on productivity used different economic models of interpretation. ICT leads to productivity growth in two ways. First, it increases the efficiency of factor inputs (capital and labour) and second, it fosters technological innovation as a source of total factor productivity growth (UNCTAD, 2009). Labour productivity grows as a result of capital deepening by increasing ICT investment and utilized ICT technology into the production process. As a result, it improves efficiency of labour without even changing technology of production. In this framework, many studies have proved that ICT investment has positive impact on growth and productivity especially in developed worlds.

Thailand is one of the growing economies in the age of globalization. There is only few studies that have paid attention to the role of ICT as a potential source of labour efficiency and productivity growth of the economy. As for Thailand, since 1992 the importance of ICT has been recognized and promoted by the government ministries and agencies. The first national IT policy (IT -2000) covered the period of 1996-2000 and focused on 3 agendas: investment in information infrastructure; investment in people to build a literate populace and an adequate technology human resource base; and investment in good governance to ensure that IT will result in a decrease in social and economic gaps. In 2005, ICT investment accounts for 4.1 percent in Thailand GDP. ICT is, therefore, expected to be a crucial driving force for Thailand economic growth in the 21^{st} century. In this paper, it is going to examine the ICT's contribution on Thailand labour productivity and growth.

1.2 Objectives of the Study

The objective of the study is to examine the role of ICT capital deepening in Thailand's productivity and economic growth. The attempt to estimate the size of the ICT capital stock will be an addition to the study. The study will estimate the ICT capital stock by using Perpetual Inventory Method because there is no capital stock data for ICT related investment. In order to derive the ICT related investment series, to calculate ICT capital stock, the study will employ OLS log-log backward projection model.

Based on the ICT capital stock series derived from ICT investment, the study will mainly adopt growth accounting production function that segregates contribution of ICT capital to labour productivity and economic growth from the other form of capital.

1.3 Scope of the Study

In the 1990s, developing countries start invested in ICT at faster rates and some notably in Asia (UNCTAD, 2009). With the pretty much attention to importance of ICT, the public and private sector use ICT in various economic activities in order to maximize their interests and benefits. It is questionable whether ICT really yields the growth and productivity of the economy. Therefore, with the purpose of studying the impact of ICT capital deepening on productivity in Thailand, the study will explore the relationship between ICT capital deepening and productivity of Thailand from 1991 to 2005.

In order to be able to analyze, the study will explore the existing literature on ICT and labour productivity. Based on the secondary data published from various sources such as National Economic and Social Development Board (NESDB), National Statistical Office (NSO) of Thailand, World Development Indicators by World Bank, International Telecommunication Union (ITU) and World Information and Technology Service Alliance (WITSA), and the study will examine the impact of

ICT capital deepening on productivity and growth by using growth accounting method.

1.3.1 Definitions

Real Gross Domestic Product Growth (Output Growth Y): Real GDP Growth rate excludes the effects of inflation by taking weighted based year (in this study year 1988 as based year). It is the value of all-final goods and services produced within the geographical boundary of a country by using domestic factors of production within a year. The National Economic and Social Development Board of Thailand (NESDB) provides data series for GDP in real term (constant prices of 1988).

Employed Person (L): Number of employment data can be available from the labour force survey (LFS) has been undertaken by the National Statistical Office (NSO). Since the year 2001, the population aged 15 years and above is classified as total working age population. Prior to 2001, population of aged 13 years and over is accounted for it. However, labour force survey 2008 by NSO has provided the data for number of employed person with 15 years and above since 1988. For the sake of consistency, the study will reveal the minimum working age as 15 years and above. In this study the data for labour employed are taken out as an average of the whole year from different surveys (3 rounds and 4 quarters) of the labour force surveys.

Hours Worked (HW): Hours worked in Thailand means accounting to NSO labour force survey, hours actually worked during the survey week. If a person holds more than a job, the hours worked would be the sum of total hours worked on all jobs. For a person who had a regular job but absent in job would be recorded as zero since 2001. Reliable data on hours worked is available starting from 1985. However, there is a major revision in 2001, total hours worked structurally shifted downward. In order to have consistency, series after 2001 are adjusted by taking weighted average of total number of hours worked and recalculated back to the total hours worked with the relationship between hours worked and average yearly employment. All analysis with hours worked are based on weighted average series.

Information and Communication Technology (ICT): According to International Telecommunication (ITU), the type of ICT devices and services useful for improving the efficiency of the work includes radio, television, fixed telephone, mobile telephone, personal computer and the internet. The first three are considered as old ICT devices and the latter three are considered as new ICT devices. In term of manufacturing arena, computer aided manufacturing equipments are take in to account as ICT devices.

ICT Expenditure or Spending Series: Since ICT can be categorize into four namely; hardware, software, services and communication, computer hardware spending includes the total value of purchased or leased computers, storage devices, memory upgrades, printers, monitors, scanners, input-output devices, terminals, other peripherals, and bundled operating systems. Computer software spending includes the total value of purchased or leased packaged software such as operating systems, database systems, programming tools, utilities, and applications. It excludes expenditures for internal software development and outsourced custom software development. Computer services spending includes the total value of outsourced services – whether domestic or offshore – such as IT consulting, computer systems integration, outsourced custom software development, outsourced world wide web page design, network systems, network systems integration, office automation, facilities management, equipment maintenance, web hosting, computer disaster recovery, and data processing services.

Communications spending includes the total value of voice and data communications services and equipment. Communications services include local and long distance wire-line telecommunications, wireless telecommunications, paging, satellite telecommunications, internet access, private line services, and other data communications services. Communications equipment includes wire-line and wireless telephone handsets, legacy and IP PBXs, key systems, wired and wireless LAN equipment, WAN equipment, central office equipment, modems, multiplexers, and telephone answering machines and systems. The World Information Technology and Services Alliances (WITSA) published the data on ICT spending for 75 countries by using data provided by Global Insight, Inc. The data was obtained from the three sources: 1) survey of IT spending in 50 countries performed by telephone and in person visits, 2) a vendor supply analysis obtained through interviews and review of financial records; 3) access to official statistical on

GDP, telephone usage and jobs from the World Bank, International Telecommunication Union and OECD.

ICT Capital (Kc): Capital stock is defined to consist of all assets which are durable (with a service life longer than a year), reproducible and tangible (Bhom et al., 2002). One of the most commonly used method of estimating capital stock is the perpetual inventory method which requires a time series of deflated values of capital investment data obtained by dividing the current value of investment by a capital goods price index in order to adjust for changes in the purchasing power of investment dollars' (Anderson and Rigby, 1989). However, national statistical offices in Thailand do not provide information about ICT investment. The lack of data from national statistics can be mitigated by using alternative sources of data under number of assumptions. This study assumed ICT spending or expenditure series as investment series and construct the ICT capital stock series for Thailand by using perpetual inventory method and deflated by using deflator of capital stock prices.

Non ICT Capital (Knc): The capital stock data can be available from the National Statistical Office under the compilation of capital stock of Thailand in 2551 (2008). The capital stock data of both gross and net capital stocks are also provided in term of the constant values in 1988 prices. The *composite index of capital stock* will be formulated by using 75 percent weight on the gross capital stock and 25 percent weight on the net capital stock. As for the non ICT stock, it can be derived from the difference between ICT capital Stock estimated by two different approaches have discussed in the section of ICT capital Stock data and composite index of capital stock.

1.4 Organization of the Study

The paper is broadly divided into 6 sessions. The first chapter is the introduction, background and rationale. . It is followed by second chapter that discusses on the overview of ICT development in Thailand. The third chapter will discuss review of current and recent literature presenting debates concerning the relationship between ICT and productivity growth. The fourth chapter is discussing methodology and description of data used for growth accounting economic analysis. The fifth one is the empirical findings based on applied methodology. Finally, the study will bring the concluding chapter that summarizes the empirical findings and discussion of the ICT contribution to Thailand’s growth and labour productivity.

1.5 Estimated Benefits of the Study

Firstly, the study will generate the estimation of an ICT capital stock series for Thailand with assumed different rates of depreciation, which is never derived before. Then, the study will examine the contribution of ICT capital to growth and productivity at national level. The empirical results obtained from this exercise are also compared with those found in previous studies. It will be able to understand the policy makers on the effect of labour productivity through process of ICT capital deepening. It is expected to be a useful tool to impose some technology policies to drive economy to be more prosperous.

Chapter II

Thailand and ICT

2.1 Introduction

Locating at the heart of the Southeast Asia region, covering an area of 513,115 square kilometers with abundance of natural resources, many recognize Thailand as one of the fastest growing economies in the world. Being a one of the remarkable Asian tigers, Thailand practices long history of liberal trade and investment policies. Thailand’s average annual growth rate of real GDP was about 6.5% per year over the last 50 years since 1951. During the boom period, Thailand’s GDP hit the highest in its history except the lowest GDP growth of 8.1% in the 1992 due to global economic slump. However, it came to an end in 1997 owing to the Asian financial crisis.

Thailand has been refocusing its economic development initiatives in the direction of building an information and knowledge intensive economy after the 1997 crisis. The new direction has been shaped by implementing several IT policies and master plans. In historical perspective, Thailand issued its first national economic master plan referred to as the National Economic and Social Development Plan (1961-1966). The main objective of the plan was to motivate economic growth. The plans were refined over time and more and more pay attention to educational and ICT infrastructures. Thailand's ninth economic and social development plan has finished and currently undergoing the tenth plan. With the continuous efforts to reorient the economy, Thailand has experienced a tremendous change in the past 20 years.

2.2 The Macroeconomic Situation of Thailand

Many scholars believe that Thailand’s modern economic growth and development can be broken down into four sub periods – 1972-1986 (pre boom), 1987-1996 (boom), 1997-1999 (crisis) and 2000- until now. Between 1972 and 1986, Thai economy grew on average of 6.3 % per annum (Sra Chuenchokesan and Don Nakornthab, 2008). With the Investment Promotion Act 1977, later amended in 1991 and 2001, Thailand welcomed foreign investment. Board of Investment (BOI) promotes investment which fulfills the following factors.

- strengthen Thailand's industrial and technological capability
- make use of domestic resources
- create employment opportunities
- develop basic and support industries
- earn foreign exchange
- contribute to economic growth of regions outside Bangkok
- develop infrastructure and conserve natural resources and
- reduce environmental problems.

Privileges were granted to projects which benefited the economy and priority were given to the activities in agricultural products, projects related to technological and human resource development, public utilities and infrastructure, environmental protection and conservation targeted industries. Moreover, BOI ensured the Thailand Investment Policies to be in line with international obligation. As a result, Thailand received enormous amount of investment inflow. From 1990 to 1995, Thailand received around $2 billion with 2.7 percent of total FDI inflow to developing world. The FDI inflow grew up to the peak with $7.4 billion in 1998 which account almost 4 percent of total FDI inflow to developing world even during the crisis period.

However, on the other hand ,country faced a sharp decline in export earning while the country's short term debts and the non-performing loans of financial institutions were pilling up, which resulted in a huge and increasing deficit in the current account balance. While the Bank of Thailand was seen as unlikely to devalue the Thai Baht, speculators attacked the currency. The central bank failed to defend and lost a tremendous amount of the country's international reserves. Then it leads to the financial crisis, on July 2, 1997 the Thai government floated the currency, Baht, triggering a collapse of the financial sector and devastating economic down turn. GDP declined by 1.4 percent in 1997 and by a further 10.5 percent in 1998. Thailand nonetheless has managed to recover after 1998.

The 9th Economic and Social Development Plan was initiated in 2002. With solid economic expansion between 2002 and 2004, the economy back into the track with present day rate of real GDP growth of about 5 percent Table (2.1).

Table 2.1 Output Growth and the Structure of GDP

	1970s	**1980s**	**1990s**	**2000s****
Real GDP Growth* (Percent)	7.8	6.7	7.8	4.8
Real Per Capita GDP* (Baht)	13,143	19,558	34,839	48,159
Ratio of the Domestic Product by Industrial Origin (selected sectors) to GDP (Percent):				
Agriculture	27	20	14	10
Manufacturing	17	23	28	38
Transportation and Communication	7	7	8	10
Wholesale and Retail Trade	18	18	17	14
Services	12	13	12	13
Ratio of Expenditure to GDP (Percent):				
Private Consumption	70	65	57	54
Government Expenditure	11	12	9	9
Fixed Investment	24	28	40	21
Net Export	-4	-6	-8	14

Source: Brookers Group plc and ADB (2009)
* 10-year average of annual real
GDP
** 2000-2008

2.2.1 Employment and Labour Productivity

Thailand with the total population of about 66 million and about 37.62 million (57 percent) are in the labour force. Thailand’s population growth became slower and slower during last 3 decades, the slowdown of the population growth reflects largely the decline in fertility rate. The total fertility rate of the Thailand has been decreasing significantly from 4.9 in 1975 to 2.1 in 1996 and 1.6 in 2006. Almost 98 percent of the labour force (36.86 million) is employed. However, the employment rate has been increasing from 94.19 % in 2000 to 98.19% in 2008 with average of about 97% over the eight years. The agriculture sector took the majority of the employment in the 2000 with 44.20 percentages but the present days, it is losing its labour to other sectors and only remains 39.71 % in 2008. Table (2.3)

The employment growth accounted for more than half of Thailand’s growth during the pre-boom period (1972-1986). Total employment grew by 3.7 percent per annum during the period of fifteen years compared to 2.7 percent of growth in real

GDP per employed person. They also pointed out the major role of labour productivity in the boom period (1987-1996). During that period, the average real GDP per employed person increased 7 percent annually while the real GDP increased in average of 9.5 percent annually. It could be denoted that extraordinary surge in labour productivity that made the story of Thailand's growth in the past twenty years. They mentioned the current period (2000-2007) also has significant contribution of labour to GDP; it is even slightly higher than the corresponding figure during the pre boom period Table (2.2).

Table 2.2 Average Annual Percentage Changes in Real GDP, Total Employment and Labour Productivity in 4 periods (Unit: Percentage)

Sub-period	Real GDP	Total employment	Real GDP per employed person
1972-1986	6.3%	3.7%	2.7%
1987-1996	9.5%	2.4%	7.0%
1997-1999	-2.5%	-0.1%	-2.5%
2000-2007	5.0%	2.0%	3.0%

Note: Simple averages; data for 1972-1986 are for employment age of 11 and above otherwise 15 and above

Source: Chuenchokesan and Nakornthab(2008)

Table 2.3 Employment Share by Sector (2000-2008)

Calendar Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Labour Force (Thousand)	33224	33813	34262	34902	35718	36120	36429	36942	37700
Employed	31293	32104	33061	33841	34729	35245	35686	36249	37017
Agriculture	13830	13621	14042	13880	13634	13617	14171	14306	14699
Agriculture as a percent of employed person	44.20%	42.43%	42.47%	41.02%	39.26%	38.64%	39.71%	39.47%	39.71%
Manufacturing	4650	4927	5052	5299	5476	5588	5504	5619	5453
Manufacturing as a percent of employed person	14.86%	15.35%	15.28%	15.66%	15.77%	15.85%	15.42%	15.50%	14.73%
Mining	45	50	45	47	50	57	58	63	58
Mining as a percent of employed person	0.14%	0.16%	0.14%	0.14%	0.14%	0.16%	0.16%	0.17%	0.16%
Others	12768	13516	13922	14615	15568	15996	15953	16261	16806
Others as a percent of employed person	40.80%	42.10%	42.11%	43.19%	44.83%	45.39%	44.70%	44.86%	45.40%
Unemployed	1194	1124	823	754	739	663	552	508	522
Unemployment rate percent	3.6	3.3	2.4	2.2	2.1	1.8	1.5	1.4	1.4
Labour Force annual change, percent	1.5	1.8	1.3	1.9	2.3	1.1	0.9	1.4	2.1
Labour Force participation rate percent	71.5	71.9	71.9	72.2	72.4	72.5	72.2	72.4	72.6
male	77.1	80.6	80.6	80.8	81.2	81.1	80.9	81.1	81.2
female	60.9	63.3	63.3	63.9	63.8	64.3	64.0	64.2	64.5

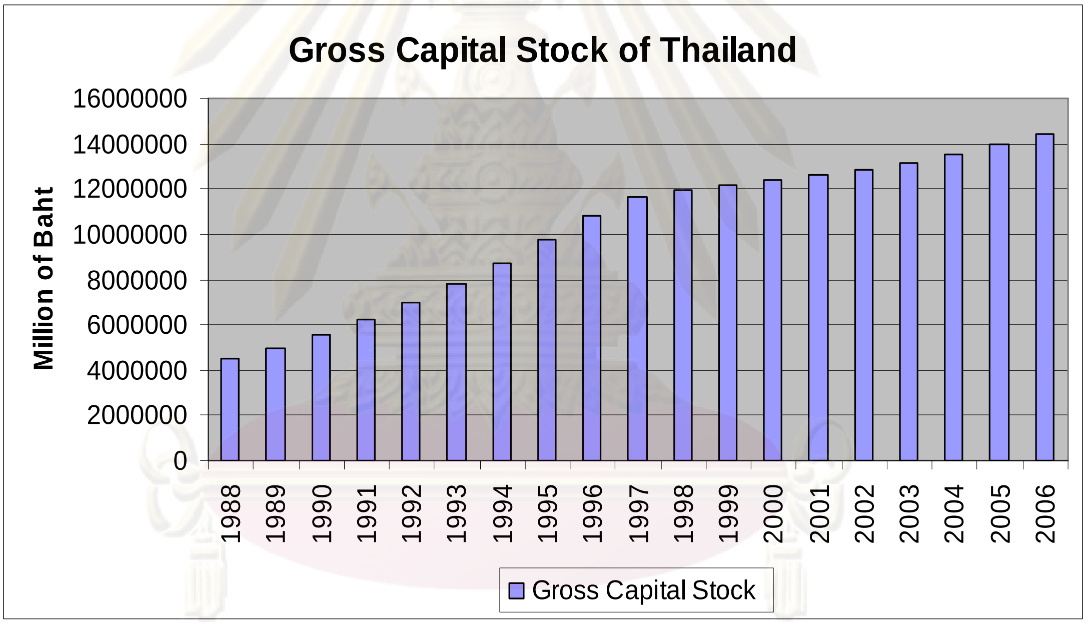
Source: ADB (2008)

11

2.2.2 Capital and Technological Progress of Thailand

Capital plays the crucial role in the economic growth and it recognizes as one of the factor input to the output growth in economic theories. In the same vein, the massive output growth in Thailand during the past few decades has been contributed by capital accumulation. From 1988 to 1996, the capital has increased due to massive inflow of direct investment; the capital stock has increased with the average growth rate of 11.54 percent. It has declined significantly up to average rate of 3.54 percent during 1997-2000 and 2.37 percent during 2001-2005 respectively. Figure (2.1) shows that the growth of gross capital stock in Thailand since 1988.

Figure 2.1 Gross Capital Stock of Thailand (1988-2008)



Source: NESDB (2008)

Only capital and labour cannot bring growth of a country for the long run, technological progress is also needed to be a considerable factor. The Total Factor Productivity (TFP)[1] had little effect on the growth of the Thailand economy in the past. However, during the ninth social and economic plan (2002-2006), TFP plays major role for Thailand economic growth, which accounts almost 58% of the average GDP growth rate of 5.69 during 2002 to 2006 (Table 2.4).

[1] Many economic theories regard TFP as one of the growth factors comes from progress in technology.

Table 2.4 Growth Rate of GDP and Sources of Growth (1987-2008)

(Unit: percentage)

	6th Plan	7th Plan	8th Plan	9th Plan						10th Plan		
	Average	Average	Average	Average						Average		
	1987-1991	1992-1996	1997-2001	2002-2006	2002	2003	2004	2005	2006	2007-2008	2007	2008
GDP Growth	10.94	8.09	-0.10	5.69	5.32	7.14	6.34	4.53	5.11	3.75	4.93	2.58
Source of Growth												
Labour	0.86	0.37	0.26	0.72	1.01	0.79	0.87	0.50	0.41	0.59	0.51	0.68
Land	0.01	0.01	0.01	0.02	0.03	-0.02	0.01	0.04	0.04	0.04	0.03	0.04
Capital	7.69	7.74	1.37	1.65	0.91	1.29	1.81	1.96	2.31	2.16	2.28	2.04
TFP	2.38	-0.03	-1.74	3.30	3.36	5.08	3.66	2.03	2.36	0.96	2.10	-0.18

Source: NESDB, Capital Stock of Thailand (2008)

To a large extent gains in TFP have come from reallocation of factors from agriculture to industry and services, whereas within-sector contributions to TFP are low (NESDB, 2008). Among them industrial (mostly manufacturing) sector has highest TFP contribution. This is followed by agriculture and the services sector in which the TFP contribution has been almost zero. TFP in agriculture has reached its peak in 1991 and 1997-98 crises has not largely affected to it. The estimates of factor shares and thus the relative importance of capital and labour of growth are not accurate enough to decompose the sources of growth for agriculture sector in Thailand. As for the industry and its sub sector of manufacturing, TFP did not return to pre-crisis level until 2004. The growth rate of service sector was slower than that of industry. The TFP growth in services turned to negative after 1997 and the average growth rate of TFP is small and only 0.5 percent per year from 1977 to 1996. As mentioned above, most of the TFP growth of the past came from reallocation of labour from low productivity to higher productivity sector, Thailand, whose agriculture sector employment is still around 40%, must move from labour intensive to more technology intensive sector. For this purpose, Thailand's technological performance has to improve substantially. The regional comparison of Thailand with East Asia countries can be seen in Table (2.5). According to Table (2.5), Thailand can be regarded as middle among them in terms of both labour productivity and TFP.

Table 2.5 Sources of Growth in East Asian Economies (1975-2000)

(Unit: Average Annual Percentage Change)

Country	Output	Output per worker	Physical Capital	Education	Factor Productivity
China	8.8	6.9	2.5	0.4	3.9
Indonesia	5.8	3	2.4	0.5	0
Korea	7.3	4.8	3	0.7	1.1
Malaysia	6.9	3.7	2.2	0.6	0.9
Philippines	3	0.2	0.8	0.4	-0.9
Singapore	7.7	4.4	2.1	0.5	1.8
Thailand	6.5	4.1	2.1	0.5	1.4
Taiwan(China)	7.8	5.5	2.6	0.4	2.4

Source: Bosworth and Collins (2003)

World Bank's benchmarking system "Knowledge Assessment Methodology" enables a country's technological innovation with Knowledge Economy Index. The methodology uses 81 variables to cover four areas, economic incentive regime, innovation, education, and ICTs, of a knowledge economy. Thailand's index has increased from 4.28 out of 10 in 1995 to 4.88 out of 10 in 2006. Though Thailand is still higher than Indonesia, Philippines and Vietnam, it is still under the average of East Asia countries (Table 2.6).

Table 2.6 Knowledge Economy Index (1995 and 2006)

	Knowledge Economy Index	
Country	1995	2006
East Asia	4.33	6.03
Singapore	7.42	8.20
Taiwan (China)	6.37	8.12
HongKong (china)	7.20	7.85
Korea	5.87	7.60
Malaysia	4.79	5.69
Thailand	4.26	4.88
Philippines	2.99	4.03
Indonesia	2.34	2.96
Vietnam	1.49	2.69

Source: World Bank, K4D program

2.3 ICT Development in Thailand

The Thai government recognizes the important role of information and communication technology (ICT) in the enhancement of economic productivity as well as in the transformation of Thai society into a knowledge based society. Thailand has set the aggressive goal to accelerate the technological growth and development to compete with other developed countries by the year 2020 (Wonglimpiyarrat, 2006). The importance of information and communication technology has been recognized for the development of Thai economy and society since 1990s. The National Information Technology Committee (NITC) was formed in 1992 and the Ministry of ICT was established in 2002. Again, NITC was restructured as a National Committee on Information Technology (NCIT) and Communication in order to represent the newly formed Ministry of ICT and to govern the national IT policies. Over the years government enforced the institutional infrastructure of ICT by forming National Electronics and Computer Technology Center (NECTEC) to facilitate policy implementation. In addition, many sub committee of NCIT/NECTEC have worked on many areas of drafting electronic transaction and computer crime laws, digital divide issues; utilization of ICT in public sector; human resources development; and Internet policy. The first national IT policy (IT 2000) covered the period 1996-2000 and focused on 3 agenda: investment in information infrastructure; investment in people to build a literate populace and an adequate technology human resource base; and investment in good governance to ensure that IT will result in narrowing of social and economic gaps.

In addition, IT- 2010 was drafted and approved by the cabinet in 2002. The focus of IT 2010 has not been only on the technology but also to facilitate the transaction of Thailand into knowledge based economy and society. Since ICT is the critical backbone of the information economy, goals are set to increase ICT adoption and usages across the Thailand. The ICT usage is classified into five areas including e- government, e-commerce, e-industry, e-education, and e-society. To quantify the goals

- To increase the technological capability with the goal to shift the country from being in the dynamic adopters category in which innovation diffusion is slow to the potential leader category in which a country has highly skilled human resources and wide technology diffusion, according to the UNDP technology achievement index.

- To increase the proportion of "knowledge workers" from 12% in 2001 to 30% in 2010.
- To increase the proportion of "knowledge based industries" to 50% of the overall economy of the country.

The IT 2010 policy framework has been transformed into strategic plan; Thailand also developed the first five year medium-term plan (2002-2006). The First ICT Master Plan has clearly set forth a vision, missions, objectives, strategies, work-plans and activities, with the key goal as follows:

- Development and upgrade the economy by using ICT;
- Enhance of the competitiveness of the ICT industry;
- Developing of human resources by increasing the application of ICT in education and training
- Strengthening of rural communalities for sustainable development.

In order to achieve these ICT development goals, the First ICT Master Plan has devised seven key strategies, namely 1) development of the ICT industry into a regional leader; 2) utilization of ICT to enhance the quality of life and society; 3) reform and enhancement of capacity for ICT research and development; 4) reinforcement of social capacity for future competition; 5) development of entrepreneurial capacity for future competition; 6) utilization of ICT in small and medium enterprises; and 7) utilization of ICT in government administration and services. In order to reach the goal, Thailand has paid much attention in science and technology development especially the investment has skyrocketed from less than 500 million Baht in 1992 to about 2.4 billion Baht in 2008 (Huang et.al, 2007).

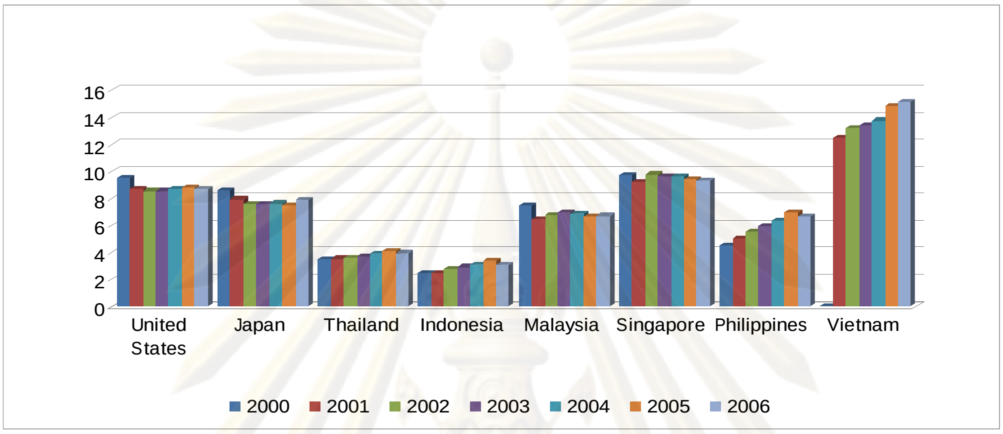
On 11 September 2007, the Cabinet called for an extension of the First ICT Master Plan. The ICT Ministry, with the collaboration of NECTEC, accelerated the development of the Second Master Plan for 2009-2012. The 2nd Master Plan seeks to ensure the continuity within the policy framework of IT 2010 and the 1st Master Plan by continuing to emphasize the development and application of ICT for e-Commerce and e-industry, e-Education and e-Society and e-Government. The 2nd plan also emphasizes two areas of the developing people who are smart and information literate and managing ICT at national level in accordance with the principles of good governance. The 2nd plan set the objectives to develop ICT professional with adequate quality and quantity to meet market demand in order to develop Thailand into knowledge and innovation based society and economy that are sustainable and stable. Moreover, 2nd plan has intension to support economic sector restructuring for value creation of goods and services on the basis of knowledge and innovation by using ICT. Again, it also needs to build capacity of business and industries by emphasizing on increased domestic value-added, research and development and the use of local wisdom, Thai culture and Thai identity, in order to develop Thailand into a knowledge-and innovation-based society and economy that are sustainable and stable. The goals of 2nd ICT Master Plan are;

1. Ensure that at least 50 percent of the population will have the knowledge and capacity to access, create and use information in an information-literate way in order to benefit education, work and everyday life.
2. Raise the ICT readiness ranking of the country by 15 places in the Networked Readiness Ranking by 2013.
3. Enhance the role and importance of the ICT industry in the national economy, by increasing its share of GDP to at least 20 percent by 2013.

The current Tenth National Economic and Social Development Plan's (2007-2011), a primary plan directing social and economic development in Thailand, one of the strategies is improving the quality of Thai people and society through the development of a knowledge-based society and plan refers to reinforcing and promoting ICT in various aspects. The current period is approaching to the end of IT 2010 plan and there are some outcomes from the IT 2010 plan.

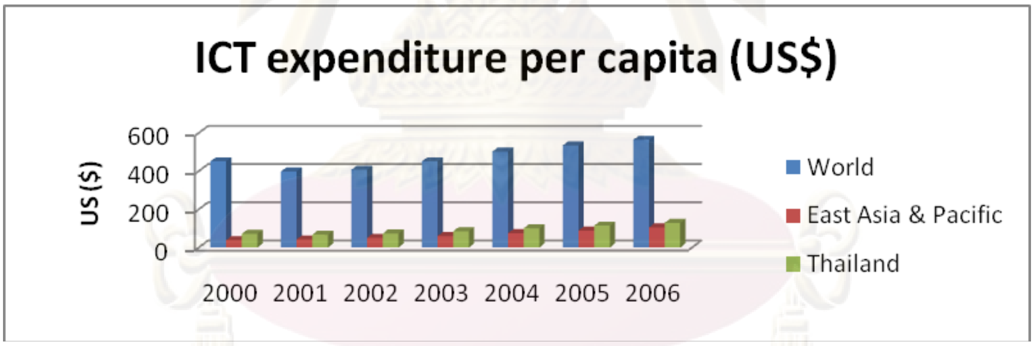
With the population of over 60 million, as a result, the penetration rate of personal computer and internet is growing with the faster rate becomes the factor for attracting the investment in the industry. Thailand is also becoming increasingly affluent and income area also growing. This has resulted in increased on the expenditure of IT products. The ICT expenditure per capita for Thailand increased around 1.8 times from 72 US$ in 2000 to around 130 US$ in 2006. The per capita ICT expenditure of Thailand was higher than the average of East Asia and Pacific region can be clearly seen in the Figure (2.3)

Figure 2.2 ICT Expenditure as a Percentage of GDP



Source: WITSA (2008)

Figure 2.3 ICT Expenditure Per Capita



Source: ITU (2008)

The ICT market in Thailand has been continuously growing. This is due to increase in ICT usage in the society, which in turns influenced by the rapid change and impressive development of technology. The total ICT market has grown from 42.64 billion in 1997 to 103.2 billion in 2004. Hardware sector represented the largest share as well as highest growth rate in the market up to 2004. According to Software Industry Promotion Agency (SIPA), the total ICT market valued was 421 Billion Baht in 2005, since communication has taken into account for the ICT market. The hardware market has grown by 21 percent between 1997 and 2004 and the major market share was PC and peripherals market.

Software development receives high priority within the government agenda. The National ICT Master Plan (2002-2006) put much emphasis on the development of software industry. In 1999, Software Park Thailand was set up in order to stimulate the development of the Thai software industry. By providing world class infrastructure, tools and consultancy services, local and international software developers are attracted to establish a critical mass of software related business. As a result, the software market has also grown by 17% from 1997 to 2004 (Table 2.7). According to SIPA, the internet market of Thailand was valued at 7.6 billion Baht and internet services were being provided by almost twenty local internet service providers. The internet penetration rate was 12 percent in 2005 and it is expected to grow over 30% in the near future.

Table 2.7 Thailand IT Market by Category (1997-2004) (Unit: Million Baht)

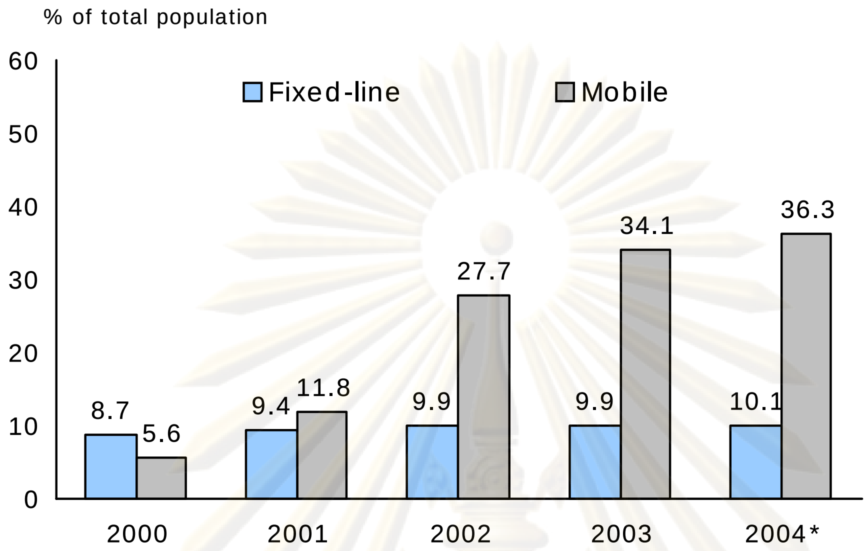
Category	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average Growth Rate**
Hardware	27596	13597	20110	31275	35819	48879	50331	67193	21%
Software	6851	5126	6289	8378	10125	12530	14129	17934	17%
IT Services	8200	7229	8738	9486	10993	12501	15260	18069	12%
Total	42647	25952	35137	49139	56937	73910	79720	103196	15%

Source: NECTEC (2005)

2.3.1 Current Status of ICT Diffusion in Thailand

As telecommunication infrastructure development is one of the determinants of ICT development, Thailand has extraordinary growth of mobile phone market. The mobile phone penetration has increased from 5.6 percent in 2000 to 36.3 percent in 2004 by surpassing that of fixed-line figure (2.4).

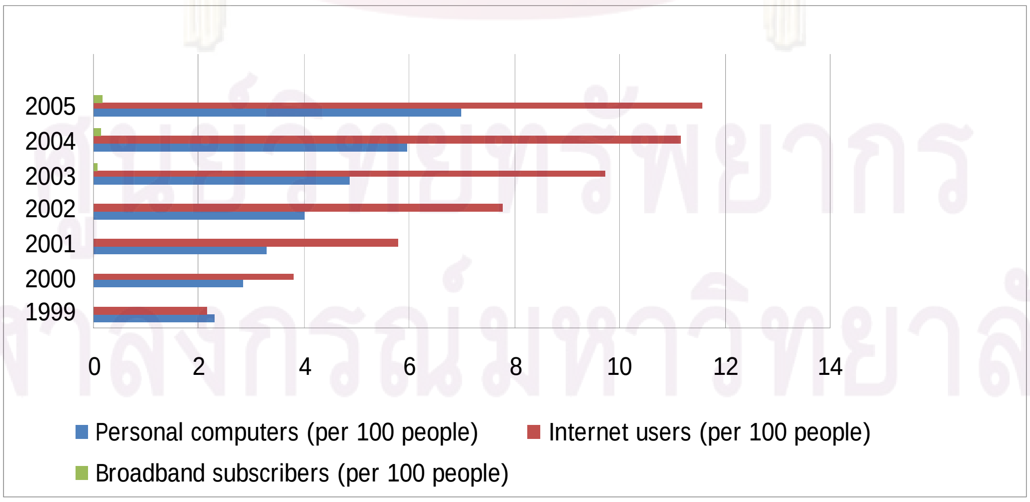
Figure 2.4 Fixed-Line and Mobile Phone Penetration Rate (2000-2004)



Source: TOT Corporation Plc. and CAT-Telecom Plc.
Remarks: * as of March 2004

With the government policy of promoting low cost internet Broadband for Thai People, the ADSL technology was introduced to the Thai internet market. The number of ADSL subscribers is also increasing with speedy rate. With huge price reduction, the technology shifts to broadband is spreading rapidly in urban areas. The overall broadband penetration rate is increased from 3 people per 1000 population in 2001 to 170 people per 1000 population in 2005 (Figure 2.5).

Figure 2.5 Personal Computer, Internet and Broadband Subscribers per 100 Populations



Source: ITU (2008)

With regards to computer diffusion, Thailand's PC penetration has increased from 2.3 PC per 100 populations in 1999 to 7.0 PC per 100 populations in 2005 (Figure 2.5). In 2003, Thai government put effort on the availability of PCs and software at affordable price to general public under the name of low cost PC initiatives. The Ministry of ICT offered low cost PC (US$ 250 per a desktop PC, and US$500 per laptop PC) and there were more than 150,000 orders received by the Ministry of ICT at that time (Chadamas Thuvasethakul and Kasititorn Pooparadai, 2003). Table (2.6) shows the percentage of households with computers from 2001 to 2004. According to Table (2.8), households in Bangkok have better access to PC as compare to other regions and its penetration rate is 2 times higher than that of Central region and more than 3 times higher that of others.

Table 2.8 Percentage of Households with Computer (2001-2004)

	2001	2003	2004
Overall	5.1	8.2	11.1
Bangkok	19.8	24	28.1
Central	5.1	7.5	11.6
North	2.8	6.1	9.0
Northeast	2.0	4.5	6.3
South	2.3	6.1	8.6

Source: National Statistical Office

In terms of internet usage, the number of internet users has reached about seven million or 11.9 users per 100 populations in 2004. There was apparently difference in the diffusion of internet around Thailand, about 26.6% of people who live in Bangkok uses internet, compared to 7.7% for those residing in the Northeast in 2004 Table (2.9).

Table 2.9 Internet Penetration by Location (2001-2004)

Region	No. of users (Million persons)			Users per 100 inhabitants (Percentage)		
	2001	2003	2004	2001	2003	2004
Whole kingdom	3.53	6.03	6.97	5.6	10.4	11.9
- Bangkok*	1.23	2.01	2.00	16.0	26.9	26.6
- North	0.52	1.34	1.52	4.6	10.1	11.2
- Central	0.83	1.00	1.21	5.9	9.7	11.4
- Northeast	0.56	1.07	1.49	2.6	5.6	7.7
- South	0.39	0.62	0.76	4.7	8.2	9.9

Source: National Statistical Office
Remarks: * Vicinity includes Pathumthani, Nonthaburi, Samut Prakarn, Samut Sakhon, and Nakhon Pathom

Regarding to ICT skills, according to labour force survey conducted by NSO in 2003, there were approximately 320,048 ICT personnel in Thailand or about 10 ICT personnel per 1000 workforce. It seems to be high number 1 out of every 100 workforce; however, 75.8 % of them are low skilled jobs mean electrical and electronic technicians. The SIPA estimated there were 30,000 software personnel in the market. The demand for software personnel were estimated to be 100,000 in 2008 while the educational institutions were expected to be able to deliver approximately 40,000. Somchai Sukiriserekul (2004) compared the shortage of ICT manpower between 1994 and 2006 can be seen in the Table (2.10)[2].

Table 2.10 Comparison Between the Demand and Supply of ICT Manpower in (1994-2006)

Year	Demand	Supply	Balance
1994	32544	12501	-20043
1995	37217	14953	-22264
1996	42293	18811	-23482
1997	47692	22126	-25566
1998	53517	24867	-28650
1999	59928	NA	NA
2000	67072	NA	NA
2001	74640	NA	NA
2002	92091	70386	-21705
2003	106992	82986	-24006
2004	122670	97030	-25640
2005	139154	112975	-26179
2006	156546	130502	-26044

Source: Somchai Suksiriserekul (2004)

[2] Somchai Sukiriserekul's comparison were based on the two previous survey on ICT workers conducted by Durungawarol et al. (1995) and Puntasen et al (2001).

Moreover, there is no specific indicator for the ICT skills and the capacity to utilize ICT effectively in Thailand that there is a good proxy to measure by using the level of education and literacy[3]. International Telecommunication Union (ITU) also suggested with the increase in the inclusion of ICT in to school curricula, school attendance can provide an acceptable proxy for students' exposure to computers or the internet. Adult literacy rate in Thailand has quite high and male adult literacy rate is bit higher than that of female (Table 2.11). Secondary enrollment in Thailand has increased from 66.6 percent in 2001 to 78.08 percent in 2006. Similarly tertiary enrollment also increases from 33.01 percent in 1999 to almost 46 percent in 2006 (Table 2.12).

Table 2.11 Adult Literacy Rate of Thailand (Unit: Percentage)

	1990	2000	2002	2004	2007
Male	95.6	97.2	94.9	98.1	95.9
Female	91.2	94	90.5	97.8	92.6

Source: www.aseansec.org

Table 2.12 Gross School Enrollment Ratio in Secondary and Tertiary

	1999	2000	2001	2002	2003	2004	2005	2006
School enrollment, secondary (% gross)	-	-	66.63	68.39	68.69	71.58	77.21	78.08
School enrollment, tertiary (% gross)	33.01	35.17	39.37	40.98	42.34	43.56	45.97	45.90

Source: www.aseansec.org

Alternatively, we can take into account the human capital as a proxy for ICT skills of a specific country or a region. Human capital in theory discussed as a "the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity" (OECD,1988). Dearden (1998) discussed that individuals who completed schooling with some formal qualification have significantly larger returns than individuals with same amount of schooling without any formal qualification. ICT also need specific skill or capacity to use effectively that level of human capital will take into account as ICT skills in general.

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[3] ITU also suggested using the education and literacy indicators for the development of ICT skills in the country or the region.

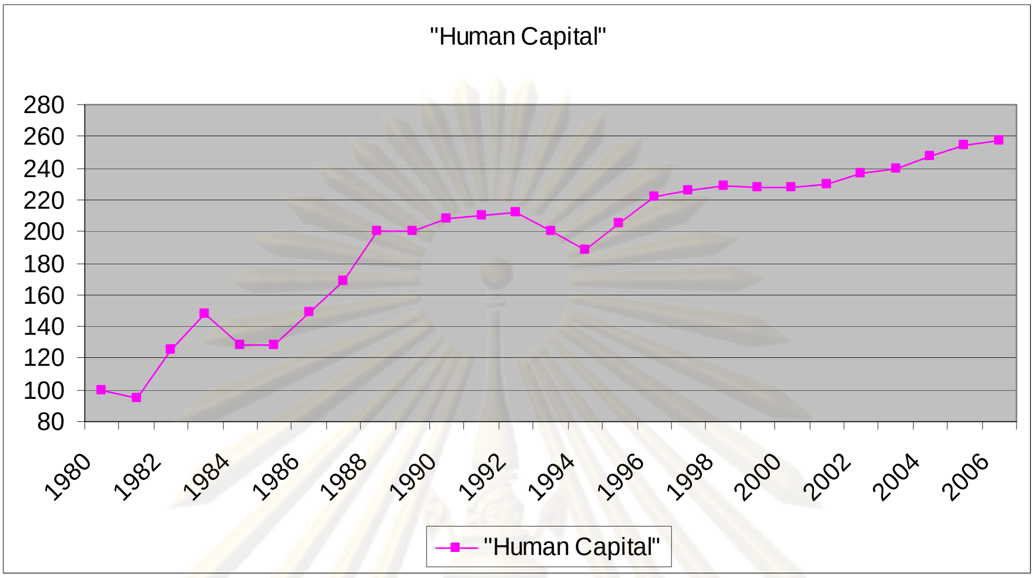
Improving the quality of human capital is one of the major concerned in the national development strategy of Thailand. Thailand has expressed its attention to human capital development by improving the quality of education and providing educational access to more of nation's school-age children in its 9th five year plan (2002-2006). Thailand also spent on education about 20 percent of national budget was equal to about 4 percent of total GDP since late 1970s (Wangudom, 2001). The National Education Act of 1999 demonstrates the Government's commitment to education by promising 12 years of quality education for all Thais, free of charge by 2004.

Many scholars have studied the human capital development in Thailand, Barro and Lee applied their average year of schooling in the international database. Their study found out that Thailand average year of schooling has increased about 47% over the 20 years. Wongudom (2001) has applied three approaches namely; *average year of schooling, labour income without experiences and labour income with experiences*. Wongudom's study also proved that human capital for Thailand also increased in all three methods. The growth rate of human capital by using average year of schooling is 3.9 percent per annum, whereas human capital by using labour income method with and without experience is 3.6 per annum (Wangudom, 2001). Ichayaprugs (2003) also exhibited that human capital of Thailand has increased almost 89 % from 1980 to 1999.

Ruttiya Bhula-or (2009) reexamined the human capital of the Thailand by using different methodology[4]. Her study also captured human capital in accordance with the characteristic of labour market in Thailand by allowing wage differences different regions, different level and type of education and different occupation that it has the highest possibility to reflect the actual human capital of the Thailand among different studies discussed in above. Figure (2.5) clearly states that human capital in Thailand increased with the average growth rate of 4 percent per year since 1980. Moreover, human capital accumulation in Thailand has increased at about 24 percent from 1990 to 2006.

[4] Her methodology detail will be appeared in Chapter (4) Methodology under Human Capital proxy for ICT Development section.

Figure 2.6 Human Capital of Thailand (1980-2006) (Based year 1980=100)



Source: Ruttiya Bhula-or (2009)

In general, Thailand has made great progress in infrastructure development. World Economic Forum ranked Thailand as 34th for network readiness in 2005 and ITU ranked it as 60th among 154 countries for the ICT development index in 2007. Thailand could be regarded as moderately successful in effective use of ICT for development, enhancing competitiveness and productivity and stimulating the growth. However there are still many challenges to be able to utilize ICT in full range. The disparity of PC and internet penetration among different regions is one of it. Since English is the standard language for most of the commonly use software that localization of software is also essential factor for Thailand. Moreover, putting more Thai language content on the Web, expanding broadband coverage and lowering broadband prices is also necessary. Therefore, internet penetration especially broadband and knowledge divide are still big challenges to move Thailand toward a knowledge based society.

Chapter III

Growth, Productivity and ICT: Theories and Empirical Studies

3.1 Introduction

Today, the age of globalization brought the word "*New Economy*". Salvadore (2003) refers the *New Economy* to "the rapid improvements and spread in the use ICT based on computers, software and communication systems." Lipsey (2004) uses the term *New Economy* to refer the social, economic and political changes brought about by the current revolution of ICTs- the revolution that is driven by computers, lasers, satellite, fiber-optics, the internet and other communication related technologies. Technological advancement brings high computing power in the small or portable sizes with a cheap or affordable price. It is facilitated by high bandwidth rate of internet and newly advanced software applications that ICT can be denoted to General Purpose Technology (GPT). The economic impact of ICT is growing over the recent years. In this chapter, the study will examine the theoretical point of views and some empirical studies of ICT contribution to economic growth and labour productivity.

3.2 ICT and Firm level Productivity

The widespread use of computer and internet around the globe in 1990s could be able to say as "Third Industrial Revolution". The ICT revolution has many impacts on the world economy by improving production technology or changing consumer behaviours. For example, with the intensive use of ICT, on one hand, online shopping through e-commerce technology brings time and cost savings to consumers for the right and cheap product, on the other hand the producers can improve productivity with the help of ICT enable production technology or tremendous growth in sale brings by ecommerce technology. The more use of ICT enable devices or technologies means the more investment in computers and computer aided machinery, softwares and systems. Therefore, it is generally to say that investment in and use of ICT play crucial role in generating output growth.

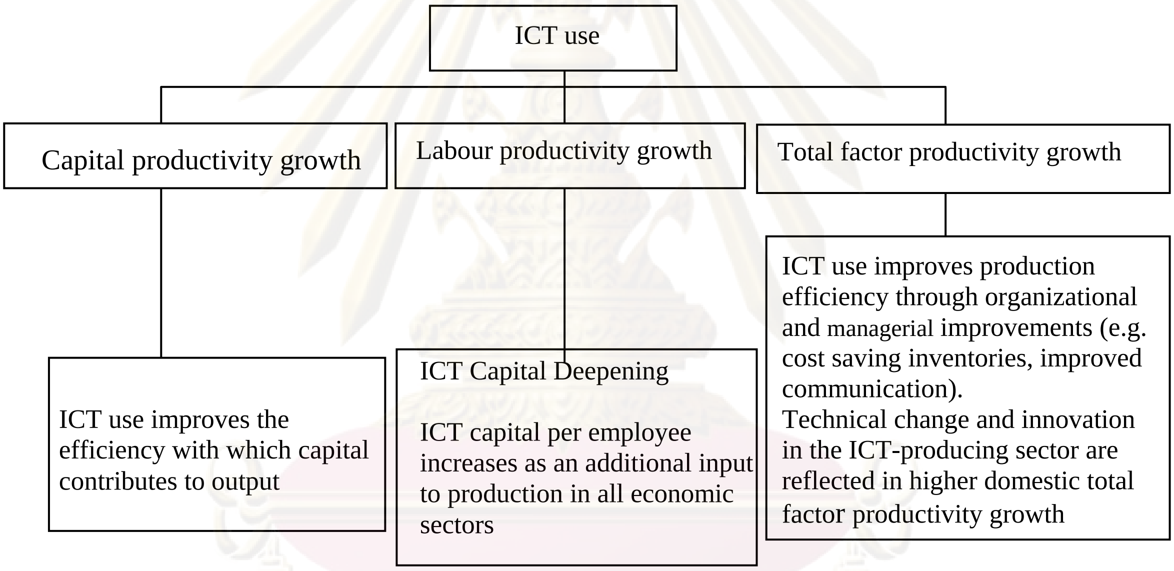
Firms generally can benefit from ICT investment through adaptation and innovation in their work process (OECD, 2004). Oz (2005) also discusses if a firm adopt a new technology (specifically ICT) which may be an innovative hardware equipment or software application, its productivity as well as income and profit increase as the new technology enables the firm to produce the same goods or services more efficiently or to produce better goods or services, then the firm can benefit from either increasing efficiency or economy of scale. Later on, in term of spillover effects, all firms in the industry may successfully adopt the same technology then it becomes the standard one over time. With the increase in productivity of the entire industry, all firms are now able to produce their goods and services with better quality with low prices.

The study done by Atzeni and Carboni in 2006 found that the returns of ICT investment is more than eight times higher than non ICT one. The study has done for Italian manufacturing sector and ICT investment accounted for 12 percent of total investment and 34 percent of total investment growth respectively yields 0.8 percent of return compared to 0.1 percent of non ICT. Oliner and Sichel (2000) and Council of Economic Adviser (2000) also indicated that the contribution of ICT is growing in all IT using sector in the United States. Their study also reflects Oz's (2005) discussion that group of companies or industrial sector show high return to investment in IT does not mean that productivity improvement at the national level but impacts are mostly redistributional with the gains of some firms or industries coming at the expense of others as restructuring occurs in the national economy. However, as for global economy, every nation could benefits from IT investments just by making their firms more competitive against foreign firms. It means that country can benefit by increasing their investment in IT, while others that fail to do so then the latter will only fall further behind economically, so it is important to conduct country level survey (Kraemer and Dedrick, 2002).

3.3 ICT and Productivity: Macroeconomic Perspective

It is seem to be a great interest to both developed and developing world in the age of globalization. Researchers, in recent years, studying the impact of ICTs on growth and productivity used different economic models of interpretation. ICT leads to productivity growth in two ways (Figure 3.1). First, it increases the efficiency of factor inputs (capital and labour) and second, it fosters technological innovation as a source of total factor productivity growth. Labour productivity grows as a result of capital deepening[5] by increasing ICT investment and utilized ICT technology in the production process. As a result, it improves efficiency of labour even without changing technology of production. When, in addition to capital deepening, economic agents are able to relocate resources in a way that improves technological efficiency and better incorporates ICT into their production processes, ICT use can result in total factor productivity gains (UNCTAD, 2009).

Figure 3.1 Channels Through which ICT Contributes to Productivity Growth



Source: UNCTAD (2009)

No one can deny that an economy gains while there is overall improvement in productivity across the country. Investing in ICT means networking among all the firms through out the country will save the transaction cost and time and speed up the newly innovative processes in the economy (OECD, 2004). Timmer and van Ark (2005) mentioned that production of ICT goods increases scales mean productivity in

[5] **Capital deepening** is a term used in economics to describe an economy where capital per worker is increasing; a process of increasing the amount of capital per worker or increase in capital intensity. Capital deepening is often measured by the capital stock per labour hour. Overall, the economy will expand, *and* productivity per worker will increase. (Sullivan, arthur; Steven M. Sheffrin (2003). Economics : Principles in actions) retrieved from http://en.wikipedia.org/wiki/Capital_deepening

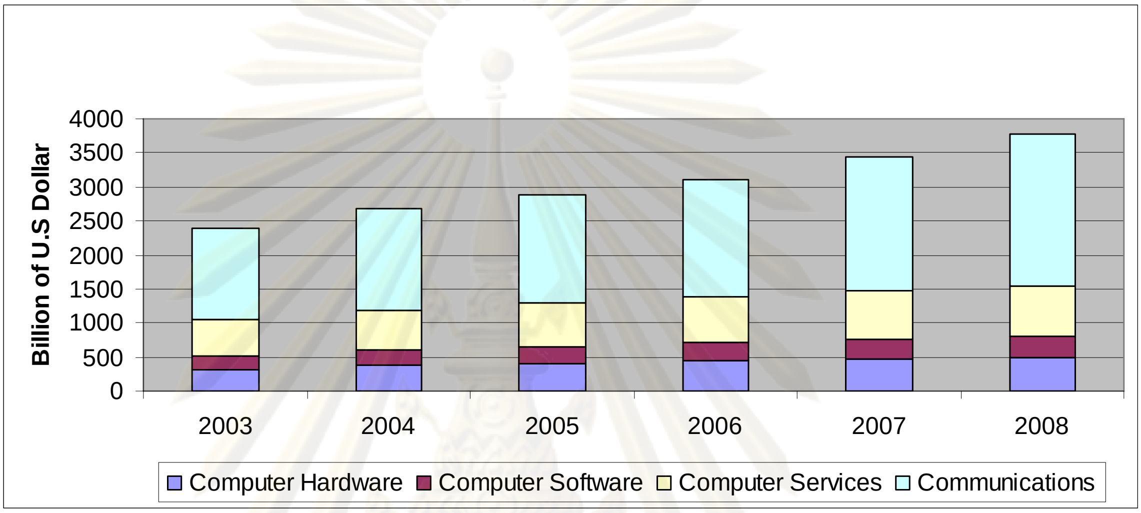
ICT producing industries then it leads to falling in prices of ICT goods. Being General Purpose Technology, ICT facilitates firms to become more efficient organizational forms and subsequently boosting the productivity of the firms. In reality, the relationship between ICT and productivity growth has been that of input substitution between Capital associated to using of ICT (ICT Capital) and non-ICT capital. The more investment in ICT comes from the rapid falling prices of ICT goods. According to McGuckin et al (1997) the prices of computers in the US decreased at more than 17% annually between 1975 and 1996. Jorgenson (2001) discussed that the sharp acceleration in the level of economic activity since 1995 resulted the decline in prices of ICT goods and services turned incentives for the substitution of ICT for other productive inputs.

Although ICT has been widely used in those days, many failed to prove that ICT contributes to productivity. Research estimated the impact of investment in computing equipment on GDP growth in the United Stages in the 1908s found a rather small contribution of just 0.2 percent compared with average GDP growth rate of 2.3 percent (UNCTAD, 2009). Therefore, Robert M. Solow remarked in 1987 that "you can see the computer age everywhere but in the productivity statistics' which came to be known as the Solow paradox or ICT productivity paradox (Pohjola 2002). In facts, gains to productivity from ICT have seemed to be little when ICTs are nascent in the economy. Dedrcik et al. (2003) discussed that it was due to insignificant share of ICT investment to national capital stock to produce substantial economic impact. It was also highlighted in Jorgenson and Stiroh's (1995) study which found that computer investment had reached a sizeable amount in certain specialized sectors, the national level investment of computing equipment accounted for only 0.5 percent of the total capital stock in 1993.

Measuring the amount of capital invested in ICT goods and services is one way of measuring the intensity of ICT uptake in an economy (UNCTAD, 2009). Worldwide ICT spending growth was 6 percent in 2006, down from almost 13 percent in 2004. Information and Communications Technology (ICT) spending made up 6.8 percent of worldwide GDP between 2001 and 2005. The top ten ICT-spending countries remained the same from 2001 to 2005 (in descending order): the U.S., Japan, Germany, the U.K., France, China, Italy, Canada, Brazil, and South Korea.

China is expected to surpass France in 2007 and the U.K. in 2008, while India is expected to replace South Korea in the tenth position in 2007(Britton and McGonegal, 2009). The worldwide ICT spending has increased up to 3.7 trillion in 2008 (Figure 3.2).

Figure 3.2 Worldwide ICT Spending (2003-2009)



Source: Digital Planet 2008 report (WITSA)

There has been increasing in contribution of ICT capital to the economic growth in many world economies. Being world largest investor in ICT, US has proved that significant relationship between ICT capital and growth or productivity. The GDP growth of US between 1973 and 1995 was 2.78 and it was increased to 4.07 in the period of 1995-2000. While the extensive growth has been resulted, ICT capital accounted for 15.1 percent in the former and 24.1 percent in the later period (Table 3.1). During the first half of the 1990s, the share of contribution from ICT capital ranged from 8 percent in the former West Germany to more than 18% in Canada and France (Schreyer, 2000).

Table 3.1 Sources of Growth in GDP in the US (1974-2001) (Unit: Percentage)

	GDP	KICT	KNICT	L	TFP
1973-95	2.78	0.42	0.98	1.12	0.26
	(100)	(15.1)	(35.3)	(40.3)	(9.4)
1995-00	4.07	0.98	1.10	1.37	0.62
	(100)	(24.1)	(27.0)	(33.7)	(15.2)
1995-01	3.55	0.93	1.10	1.12	0.40
	(100)	(26.2)	(31.0)	(31.5)	(11.3)

Note: Figures in parentheses are the share of each factor growth
KICT = ICT capital, KNICT = Non ICT Capital, L =Labour
Source: Jorgenson, Ho and Stiroh (2003)

The falling in prices of ICT goods after 1995 brought the massive improvement in the ICT investment of the world economies especially in the developing economies. Jorgenson and Vu analyzed the impact of ICT investment (including equipment and software) on the growth of the world economy, as well as growth for each of the seven regions and 14 major economies (i.e. seven countries of the G7 and seven major developing economies) in 2005. The US data was revised and updated since the earlier work of Jorgenson in 2001. The contribution of ICT to world economic growth increased from 10.8 percent in 1989-1995 to 15.4 percent in 1995-2003; for the US, it rose from 20.2 to 24.6 percent for the G7 as a whole, the contribution jumped from 17.4 percent to 27 percent. Empirical findings for the developing economies also showed a general increase in the contribution of ICT to economic growth between 1989 - 1995 and 1995 - 2003, except for Sub Sahara Africa. For instance, the contribution of ICT to economic growth increased from 2 percent to 7.7 percent in the 16 countries of developing Asia; from 15.8 percent to 16.3 percent in the 15 countries of non-G7; from 5.2 percent to 18.5 percent in Latin America; from -1.4 percent to 8 percent in Eastern Europe; from 10.7 percent to 10.1 percent in Sub-Sahara Africa and from 3.4 percent to 9.8 percent in North Africa and Middle East. Each of the seven major developing economies, except Mexico, has experienced a rising tend in the share of ICT to economic growth. The findings are as follows: from 4.6 percent to 23.7 percent in Brazil; from 1.8 percent to 4.2 percent in India, from 1.5 percent to 3.7 percent in Indonesia, from 11 percent to 6.5 percent in Mexico, form -0.8 percent to 3.1 percent in Russia and 3.9 percent to 11.2 percent in South Korea (Wong, 2004). As for the Asian developing countries, lee and Khatri found in 2003 that the contribution of ICT to growth accounted as 56 percent in Hong Kong, 25 percent in Singapore and 19 percent in South Korea respectively for the period of 1995 to 1999.

3.4 ICT and Labour Productivity

Within the neoclassical growth accounting framework, ICT investment is assumed to contribute to labour productivity through capital deepening, this assumption being consistent with the logic that workers who have more computing and communication equipment are more efficient than workers who have only ordinary capital. This ICT capital contributes to GDP per capita growth as an additional input to the production function. This theoretical framework does not account for the contribution of ICT to total factor productivity arising from an ICT-enabled innovative reallocation and reorganization of production (such as the substitution of ICT capital for ordinary capital (UNCTAD, 2009). Several studies conducted the growth accounting exercises over different periods of time to estimate the contribution of ICT capital to GDP. However there is not much empirical work on ICT contribution to average labour productivity (ALP) growth than that of GDP growth. The countries which have been examined are the US (Jorgenson et al., 2003, Oliner and Sichel, 2003), Canada (Robidoux and Wong, 2003), Australia (Parham et al., 2001), Finland (Jalava and Pohjola, 2001), selected transition countries (Piatkowski, 2003) and ten Asia-Pacific counties (Lee and Khartri, 2003).

The ICT capital deepening contributes to ALP growth in US increased from about 30 percent in the period of 1991 – 1995 to 42 percent during 1996 to 2001 (Table 3.2). Similarly Singapore and Korea has proved that 38 percent and 9.3 percent respectively during 1995 to 1999. Oliner and Sichel (2003) also observed that the share of ICT contribution to labour productivity has risen from 30 percent in the period of 1974 -1995 to 42 percent in 1996-2001. They also projected growth in labour productivity of about 2 percent per year in United State. They also concluded that future increases in labour productivity will depend significantly on the pace of technological advance in the semiconductor industry and on the extent to which products embodying these advances diffuse through the economy. Apart from US, Parha found that ICT capital has contributed in the Australia's ALP growth for about 35 percent in 2003. Similarly, Oulton and Srinivason found that United Kingdom's ALP growth of average of 3 percent from 1995 to 2000 has been resulted from 47 percent of contribution of ICT capital.

Table 3.2 Average Labour Productivity in the US (1974-2001) (Unit: Percentage)

	ALP	KICT	KNICT	L	TFP
1974-90	1.36	0.41	0.37	0.22	0.37
	(100)	(30.1)	(27.2)	(16.2)	(27.2)
1991-95	1.54	0.46	0.06	0.45	0.58
	(100)	(29.9)	(3.9)	(29.2)	(37.7)
1996-01	2.43	1.02	0.17	0.25	0.99
	(100)	(42.0)	(7.0)	(10.3)	(40.7)

Note: Figures in parentheses are the share of each factor growth
KICT = ICT capital, KNICT = Non ICT Capital, L =Labour
Source: Oliner and Sichel (2000,2003)

As for the developing world, Piatkowski (2003) also found out in the study of selected transition economies[6] that the contribution of ICT capital to labour productivity growth was high; Czech Republic, Hungary and Poland recorded the highest contribution in absolute term. For Asia, China, India and Korea had an increase in ALP growth between 1990 - 1994 and 1995 - 1999. However, Hong Kong and Indonesia had experienced negative share of the corresponding contribution to ALP growth although they had positive contribution of ICT to GDP growth. Other Asian NIEs and developing countries including Thailand have less than 15 percent share of contribution form ICT capital deepening to ALP growth (Lee and Khatri) (Table 3.3). Therefore, it is observed that ICT capital deepening has played an important role in improving labour productivity since the days of mid 1990s. The empirical findings relating to the contribution of ICT to labour productivity growth can be summarized in the Table (3.4)

As we have seen in the figure (3.1), ICT can affect total factor productivity also. ICT use improves production efficiency through organizational and managerial improvements (e.g. cost saving inventories, improved communication). Some literature finds that ICT producing industries contribute to labour productivity through increased TFP, while ICT-using industries contribute to labour productivity through increased capital deepening (Wong, 2004). Stiroh (1998) conducted the study on ICT and economic growth for period of 1947 to 1991 and found that the computer producing sector showed strong TFP and it is resulted a large substitution to other sectors (computer-using sectors). Similarly, Jorgenson et al (2003) has examined that

[6] Bulgaria, Czech Rep, Hungary, Poland, Romania, Russia, Slovakia, Slovenia

TFP growth in US has resulted more than 70 percent since 1995. Again, for Japan, Jorgenson and Motohashi (2005) found that the ICT contribution to TFP growth became twice before and after 1995 (Table 3.5).

Table 3.3 Decomposition of TFP Growth in Japan (1990-2003)

(Unit: Percentage)

	1990-1995	1995-2000
TFP	0.80	0.45
ICT	0.23	0.36
	(14.6)	(80.0)
Non-ICT	0.48	0.10
	(60.0)	(22.2)

Note figure in parentheses are the shares of TFP growth

Source Jorgenson and Motohashi (2005)

Table 3.4 Contribution of ICT to ALP Growth in Ten Asian Economies, 1990-99 (Unit: Percentage)

	1990-94					1995-99				
	ALP	KICT	KNICT	L	TFP	ALP	KICT	KNICT	L	TFP
China	6.63	0.10	2.16	1.10	3.27	7.41	0.21	2.92	0.65	3.63
	(100)	(1.5)	(32.6)	(16.6)	(49.3)	(100)	(2.8)	(39.4)	(8.8)	(49.0)
Hongkong	3.81	0.73	0.8	1.79	0.5	-0.49	0.9	0.33	0.54	-2.26
	(100)	(19.2)	(21.0)	(47.0)	(13.1)	(100)	(-183.7)	(-67.3)	(-110.2)	(-461.2)
India	4.09	0.05	1.35	2.01	0.68	5.82	0.09	1.34	2.34	2.05
	(100)	(1.2)	(33.0)	(49.1)	(16.6)	(100)	(1.5)	(23.0)	(40.2)	(35.2)
Indonesia	6.70	0.12	2.78	1.82	1.98	-0.69	0.15	1.30	2.38	-4.52
	(100)	(1.8)	(41.5)	(27.2)	(29.6)	(100)	(-21.7)	(-188.4)	(-344.9)	(655.1)
Korea	5.13	0.69	0.80	1.64	2.01	5.21	0.94	0.61	0.76	2.91
	(100)	(13.5)	(15.6)	(32.0)	(39.2)	(100)	(18.0)	(11.7)	(14.6)	(55.9)
Malaysia	5.31	0.29	2.58	4.23	-1.79	1.78	0.41	1.39	1.16	-1.18
	(100)	(5.5)	(48.6)	(79.7)	-(33.7)	(100)	(23.0)	(78.1)	(65.2)	(-66.3)
Philippines	-0.12	0.13	0.15	0.66	-1.07	2.12	0.23	0.19	0.61	1.09
	(100)	(-108.3)	(-125.0)	(-550.0)	(891.7)	(100)	(38.1)	(13.1)	(58.2)	(-9.0)
Singapore	5.04	0.66	0.58	5.58	-1.78	2.68	1.02	0.35	1.56	-0.24
	(100)	(13.1)	(11.5)	(110.7)	(-35.3)	(100)	(9.3)	(26.8)	(19.6)	(44.2)
Taiwan	5.17	0.33	1.50	1.22	2.12	5.04	0.47	1.35	0.99	2.23
	(100)	(6.4)	(29.0)	(23.6)	(41.0)	(100)	(9.3)	(26.8)	(19.6)	(44.2)
Thailand	7.80	0.19	2.38	1.20	4.04	1.21	0.19	0.99	0.95	-0.93
	(100)	(2.4)	(30.5)	(15.4)	(51.8)	(100)	(15.7)	(81.8)	(78.5)	(-76.9)

Note: Figures in parentheses are the share of each factor growth

KICT = ICT capital KNICT = Non-ICT capital

L = Labour TFP = Total Factor Productivity

Source: Lee and Khatri (2003)

35

Table 3.5 Contributions to ALP Growth: Single Country Study (Unit: Percentage)

Author	year of study	Country	Period	ALP	KICT	KNICT	L	TFP	Other Variable
Oliner and Sichel	2000	US	1996-99	2.57	0.96	0.14	0.31	0.16	
				(100)	(37.4)	(5.4)	(12.1)	(45.1)	
Jorgenson	2001	US	1995-99	2.11	0.89	0.35	0.12	0.75	
				(100)	(42.2)	(16.6)	(5.7)	35.5)	
Jorgenson, Ho and Stiroh	2003a	US	1995-2000	2.07	0.87	0.37	0.21	0.62	
				(100)	(42.0)	(17.9)	(10.1)	(30.0)	
			1995-2001	2.02	0.85	0.54	0.22	0.4	
				(100)	(42.1)	(26.7)	(10.9)	(19.8)	
Oliner and Sichel	2003	US	1995-2001	2.43	1.02	0.17	0.25	0.99	0.42*
				(100)	(42.0)	(7.0)	(10.3)	(40.7)	(17.3)
Parham et al	2001	Australia	1995-2000	3.7	1.3	0.4			
				(100)	(35.1)	(10.8)			
Jalaba and Pohjola	2001	Finland	1995-99	3.5	0.6	-1.4	0.2	4.1	
				(100)	(17.1)	(-40.0)	(5.7)	(117.1)	
Harchaoui et al	2003	Canada	1995-2000	1.7	0.4	0	0.3	1.0	
				(100)	(23.5)	-	(17.6)	(58.8)	
Robidoux and Wong	2003	Canada	1996-2001	1.8	0.6	0.3	-	1.0	
				(100)	(33.3)	(16.7)		(55.6)	
Oulton and Srinivasan	2005	UK	1995-2000	2.93	1.37	0.79	0.45	0.32	
				(100)	(46.8)	(27.0)	(15.4)	(10.9)	

Note: Figures in parentheses are the share of each factor growth
KICT = ICT capital, KNICT = Non ICT Capital, L =Labour
* semiconductor
Source: Wong (2004)

36

3.5 Thailand and Impact of ICT on Productivity

There is only few studies have been conducted in this field of ICT and productivity in Thailand. They are Lee and Khatri (2003), Fiscal Policy Research Institute (2004) and joint study of UNCTAD and NSO of Thailand. For Lee and Khatri, as discussed in the previous sections, it is done for major Asian countries for the period of 1990 to 1999. Fiscal Policy Research Institute has conducted the study for 1993 to 2002 and also projected for the economic growth of 2004 to 2008. UNCTAD and NSO study is different from the others. It is measuring the impact of ICT in Thai manufacturing firms.

Lee and Khatri (2003) have examined the impact of ICT on both GDP and labour productivity. Their study found out that contribution of ICT capital has increased significantly from 2.3 percent to 12.2 percent between the periods of 1990-94 to 1995-99. Fiscal Policy Research Institute (FPRI) report was carried out in 2004. The study recognized the special role of high technology capital by separating computers from other form of capital in a production framework that incorporates constant returns to scale and two types of capital. However, the study incorporates a more restricted production function framework on fixed coefficients with no allowance for a secular component of TFP growth. The result for the aggregate economy is a relationship that assigns a weight of 0.51 to non-IT capital, 0.13 to capital and 0.36 to labor (Bosworth, 2006).

Table 3.6 ICT Capital Contribution in Thailand (1993-2002) (Unit: Percentage)

	Contribution of		
Sector	Non ICT capital	ICT capital	Labour
Total Economy	0.51	0.13	0.36
Agriculture	0.54	0.08	0.39
Industry	0.61	0.23	0.16
Services	0.67	0.17	0.16

Definitions: Non ICT and ICT capital services are measured by depreciation of the capital stocks. The labour input is total hours multiplied by a quality index equal to the average years of schooling and average age of work force

Source: FPRI (2004)

Using firm-level data set[7] of combined ICT uptake and several economic variables, NSO and UNCTAD have conducted a joint research project. A well known empirical model (the Cobb-Douglas production function) was used to access the relationship between ICT use and productivity of Thai manufacturers (UNCTAD and NSO, 2008). The sale per employee (labour productivity) has positive relationship with ICT usage, among three ICT considered, computers contributed with 14 percent, internet access with 3 percent and web present with 4 percent on sale per employee of the firms regardless of other economic characteristics. Again the study has conducted by taking into account the size of firms, internet access is more to labour productivity in small firms and computer presence correlates with high productivity in middle size whole what makes a difference in large firms is web presence. The link between ICT use and labour productivity is stronger in large and middle sized firms, with high contribution from the presence of computers (UNCTAD and NSO, 2008). The study has also tried for different regions and the study has proved that the positive relationship between ICT and labour productivity (here sale per employee) Table (3.7).

Table 3.7 Regression Analysis for the ICT Contribution to Thai Manufacturing Firms by Different Regions

Dependent Variable: Log (sales per employee)			
	R-squared =0.924005		
	Computer presence	Internet access	Web Presence
Bangkok	0.2198***	0.0892*	0.0254
Vicinity	0.1411***	0.0511	0.0731*
Central	0.1553***	0.0121	0.1533**
North	0.1921***	0.0302	-0.1729*
North-east	0.1187***	0.0669	-0.0101
South	0.1436***	0.0236	0.0400

Note: The regression included controls for employment size, capital, costs incurred with materials, foreign capital participation, multi-unit firms and industry and region specific characteristics (level of significance at *** 1 percent, ** 5 percent, * 10 percent)

Source: UNCTAD and NSO (2008)

[7] ICT survey (2004, 2005), Manufacturing Industry Survey (1999, 2000,2003) and the Business Service Survey (1999,2003)

Many literature reviews have found out that the ICT has a positive impact on labour productivity and growth in both in developed and some of the developing countries regardless of firm, industry or national level. As we have seen, the stronger contribution has found in developed world such as US, UK, Canada, and Australia where most of the ICT production has initiated. The contribution of ICT to growth and productivity has vividly found during the 1990s especially before and after of 1995 where the ICT revolution brought the declination of prices on ICT goods and services. Thailand, one of the developing countries, also seems to be resulted from ICT production and usage and the current study has expected to be able to explain how ICT would have resulted in the current period.

Chapter IV

Methodology of the Study

4.1 Introduction

Since productivity is an indicator of the efficiency while inputs are processed to produce the output, this study will explore the productivity and the capital deepening of the ICT Capital in Thailand. Growth accounting breaks down the output growth and productivity into associated with changes in factor inputs. The basic of growth accounting were presented especially in Solow (1957), Kendrick (1961), Denison (1962) and Jorgenson and Griliches (1967). Moreover, the contribution of Information Communication and Technology (ICT) to growth is also examining by many scholars including Oliner and Sichel (2000) for United States, Goldman Saches (2000), Daveri (2000) and Cardarelli (2001) for Europe, Japan and Australia. Again, labour productivity can be augmented through accumulation of ICT capital stock. The direct impact of ICT on productivity is able to investigate in a simply augmented growth accounting framework. . The study also would like to explore the nature of ICT contribution to growth and productivity in Thailand and this chapter is going to discuss the detail methodologies of how ICT capital deepening can effect to growth and productivity of Thailand in the growth accounting framework.

4.2 Output Growth and ICT Capital

A typical neoclassical production function in its simplest form can be expressed as

$$Y = A_{(t)}(K, L) \qquad (4.1)$$

Where Y= The unit of output

L = The labour input

K= The capital input

A= Hicks-neutral (or output –augmenting) level of technology or TFP

The growth rate of the output can be partitioned into components associated with the factor accumulation and technological progress. Differentiation of equation (4.1) with respect to time then after division by Y and rearrangement of terms;

$$\frac{\dot{Y}}{Y} = g + (\frac{F_K K}{Y}).(\frac{\dot{K}}{K}) + (\frac{F_L L}{Y})\frac{\dot{L}}{L} \qquad (4.2)$$

Where F_K and F_L are the factor (social) marginal products and g- the growth due to technological change is given by

$$g \equiv \frac{F_A A}{Y}.(\frac{\dot{A}}{A}) \qquad (4.3)$$

If the technology factor appears in Hicks-neutral way, so that F (A, K, L) = A. $\bar{F}$ (K, L) then g = $(\frac{\dot{A}}{A})$. The rate of technological progress g, can be calculated from equation (4.2) as a residual.

$$g = \frac{\dot{Y}}{Y} - (\frac{F_K K}{Y}).(\frac{\dot{K}}{K}) - (\frac{F_L L}{Y})\frac{\dot{L}}{L} \qquad (4.4)$$

Where AF_K is the marginal product of capital, if factors are paid their social marginal products, then F_K= r = R (the rental price of capital); and AF_L=w (the wage rate), then the equation on estimation of the rate of technological progress follows from the above can be express as

$$\dot{g} = \frac{\dot{Y}}{Y} - s_K.(\frac{\dot{K}}{K}) - s_L\frac{\dot{L}}{L} \qquad (4.5)$$

Where $s_K \equiv \frac{RK}{Y}$ and $s_L \equiv \frac{wL}{Y}$ are the respective share of each factor payment in total product. The value $\dot{g}$ is often described as an estimate of total factor productivity (TFP) growth or the Solow residual. The condition of $s_K + s_L = 1$ or Y = RK + wL which hold all the income associated with the gross domestic product, Y, is attributed to one of the factors, restricted here to capital and labour.

To access contribution of each determinant of productivity growth, needs to have estimates of growth rates of A, K, L and the parameters s_K and s_L. Estimation of growth rate of A or TFP growth comes first. There are two approaches and first is the most popular approach, growth accounting. Growth accounting is a procedure used in economics to measure the contribution of different factors to economic growth and indirectly compute the rate of technological progress, measure as a residual in an economy. Growth accounting thus provides a mechanical way to derive TFP growth.

The second approach is direct econometric estimation of the aggregate production function. The main advantage of this approach is that it dispenses with the assumption that the factor of social marginal products coincide with the observable factor prices, that is, the factor (social) marginal products equal to the rental price of capital and the wage rate. The disadvantages of the regression approach are several factors. The variable of capital growth ($\frac{\dot{K}}{K}$) and labour growth ($\frac{\dot{L}}{L}$) cannot be regarded as exogenous with respect to variations in growth due to technology change, in particular, the factor growth rate would receive credit for correlated variations in unobservable technological change. Moreover, if capital growth ($\frac{\dot{K}}{K}$) and labour growth ($\frac{\dot{L}}{L}$) are measure with error, then standard estimates of the coefficients of these variables would deliver inconsistent estimates of respective shares. This problem is likely to be especially serious for the growth rate of capital input, where the measured capital stock is unlikely to correspond well to the stock currently utilized in production. This problem often leads to low estimates of the contribution of capital accumulation to economic growth when high frequency data are employed. Again, the regression framework has to be extended for its usual form to allow for time variations in factor share and the TFP growth rate. Owing to these drawbacks, most of the study prefers non-econometric estimation one (Barro, 1998).

Here, in this study, the methodology of measuring the contribution of ICT capital to growth and productivity is based on original work by Solow (1957) and Jorgenson and Griliches (1968). It is extended by Oliner and Sichel (2000) and Jorgenson and Stiroh (2000). The contribution of productivity gains in economic growth can best described in the context of aggregate production function in the following form.[8]

$$Y_t = A_t F(Kc_t Knc_t L_t) \qquad (4.6)$$

Where at given time t , Y = real GDP

Kc = ICT Capital input

Knc = Non ICT Capital input

L = Labour input

A = the technological residual (TFP)

Assuming that constant return to scale, all the production factors are came along with their marginal products, equation (4.7) can be expressed as follow:

$$\hat{Y} = v_c \hat{Kc} + v_{nc} \hat{Knc} + v_l \hat{L} + \hat{A} \qquad (4.7)$$

Where, symbol Λ indicates here the rate of change and time index t has been suppressed for the simplicity of exposition. The weights sum to one similarly as the weights v_c, v_{nc} and v_l all correspond to the nominal share of ICT capital, non-ICT capital and labour respectively. Again, total factor productivity is presented in the form of Hicks neutral with symbol A.

4.3 Labour Productivity and Capital Deepening

The calculation of labour productivity is derived for the production function approach outlined in above equation and labour productivity can be defined as the ratio of output to hours worked. Since labour productivity: y = Y/H, then y denotes output (Y) per hour (H). Given the above production function, labour productivity can be expressed as

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + s_k \frac{\dot{k}}{k} + s_l \frac{\dot{l}}{l} \qquad (4.8)$$

[8] The following section is largely based on Marcin Piatkowski (2002)

Where $\frac{\dot{y}}{y} = \frac{\dot{Y}}{Y} - \frac{\dot{H}}{H}$, $\frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{H}}{H}$, $\frac{\dot{l}}{l} = \frac{\dot{L}}{L} - \frac{\dot{H}}{H}$ and the ratio of capital services to hours worked (K/H) and its change are commonly referred to as capital intensity and capital depending, respectively. The ratio of labour input to hours worked (L/H) is referred to as labor composition or labour quality. According to the equation, labour productivity growth comes from three main sources, capital deepening, growth in labour quality, and TFP growth. Here, TFP growth is able to capture all the spillover benefits of efficient resource allocations through organizational and management improvements in addition to pure technological improvement. Moreover, TFP also reflects the weakness in measurement (measurement error) as well as anything not able to capture in the defining in inputs used. For example, if labour input is measured in terms of total hours worked, then estimated TFP will pick up the effect of the changes in labour quality (Chuenchokesan and Don Nakornthab, 2008). Again, Jorgenson and Griliches (1967) and Jorgenson, Gollop and Fraumeni (1987) demonstrate the importance of disaggregating inputs by quality classes.[9] Then, the study will consider the labour quality and the labour productivity function can be rewritten in linear form as;

$$\hat{y} = v_c \hat{k}_c + v_{nc} \hat{k}_{nc} + v_l \hat{hc} + \hat{A} \qquad (4.9)$$

Where, v_c, v_{nc} and v_l denote the respective factor shares of output, whereas k_c and k_{nc} reflect changes in the respective use of ICT and non-ICT capital per hour, or capital deepening, The above equation (9) indicates that labour growth comprises three components: (i) capital deepening, which defines as “the contribution of capital services per hour and allocated between ICT and non-ICT components”. It enhances the efficiency of labour by increasing capital per hour in proportion to the capital share (that is, increase in the capital-hour ratio); (ii) human capital (hc) which is defined as “the contribution of increases in human capital per hour input and (iii) TFP, which augments factor accumulation.

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[9] For example, L can be viewed as a vector that specifies the quantities of labor of various kinds, categorized by school attainment, age, sex and so on.

4.3.1 Human Capital Proxies for ICT Development

Again, in the context of labour quality, theories of endogenous growth are suggesting positive effect of human capital on economic growth and productivity. Human capital can be considered in different forms – knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity (OECD, 1988). Different measures of human capital has discussed by many scholars. One of them is income based approach by assuming the concept of income can be regarded as a reflection of human ability. Mincer (1974) discussed that the logarithm of earning was linearly related to individual's year of schooling as human capital. Dearden (1998) discussed individual who completed schooling with some formal qualification have significantly larger returns than individuals with same amount of schooling but without any formal qualification. As the study has mentioned in Chapter (2), ICT also need specific skill or capacity to use effectively that level of human capital will take into account as ICT skills in general. Therefore, in the framework of growth accounting, the study will adopt the human capital calculated by Ruttia Bhula-or to proxy the labour quality with ICT skill.

As for Thialand's human capital, Ruttia Bhula-or's applied the model of Mulligan and Sala-i-Martin (1997), in order to reflect the human capital in accordance with the characteristic of labor market in Thailand. Her study deducts the wage differential effect between genders and captures regional earning differences, and the difference type of education.[10] The study incorporated the possible effect of increase in intra occupation productivities into the equation, as the difference in earning in occupation may be varying the productivity index. Then, the human capital of the whole country is yield by the summation of human capital of each occupation as demonstrate in equation (4.10).

[10] This issue is discussed concerning rate of return on gender. It is found that the earnings of women are considerably lower than those of men. It is also found that the average wages are varies among region.

$$HC_t = \sum_{oc} hc_i^{oc} \tag{4.10}$$

Where HC_t^{oc} = Human capital in Thailand at time t

$$hc_t^{oc_i} = \sum_a \sum_s \sum_n \frac{w_{t,a,s,n}^{s,oc_i}}{w_{t,a,s,n}^{0,oc_i}} \eta_{t,a,s,n}^{oc_i} \tag{4.11}$$

$hc_t^{oc_i}$ = Human capital in occupation i at time t

$w_{t,a,s,n}^{s,oc_i}$ = Wage of high skilled workers in occupation i at time t in region at n highest level of education and sex s.

$w_{t,a,s,n}^{o,oc_i}$ = Wage of workers with no experience and education in occupation i at time t in region a at n highest level of education.

$\eta_{t,a,s,n}^{oc_i}$ = Share of workers in occupation i at time t in region a at n highest level of education and sex s.

$w_{t,a,s,n}^{s,oc_i}$ is represented by the average earning of the university graduates with and without experiences.[11]

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[11] Wage of workers with no experience can be calculated by the Mincerian earning equation. The study disaggregates the gender and region effect by the following equation.

$$\ln W_i = \beta_0 + \beta_1 S_i + \beta_2 Ex_i + \beta_3 Ex_i^2 + \alpha_1 gen_i + \alpha_2 region_i$$

W_i denotes the wage of individual i, β_0 represents the earning of worker without schooling and experience, S_i represents the years of schooling, X_i is a measure of work experience. Gen_i and $region_i$ are responsible for the dummy variable. β_0 with the effects of Gen_i and $region_i$ is $w_{t,a,s,n}^{o,oc_i}$

In the frame work of ICT capital contribution to growth and productivity, the lack of data such as ICT capital and income share of ICT in total income can be regarded as constraints for this study. However, these shortcomings in data can be overcome. The following sections will discuss the specific data problem together with methodologies and assumption to estimate the required data for the study. In addition, the following section will also explore all the data used for this study.

4.4 Data Employed for the Study

4.4.1 Estimating ICT Capital Stock and its Capital Services

Since ICT capital stock data is not readily available for many countries except US, Canada and OECD countries. Perpetual Inventory Method (PIM) is one of the ways of estimating capital stock. It is applied for many studies such as Joregenson in 1989 for US, Levtchenkova and Petchey in 2000 and Diewert and Lawrence in 2005 for Australia, Timmer and Van in 2005 for EU, Brilhault in 2000, Shinjo and Zhang in 2003, Miyagawa, Ito and Harad in 2004, Jorgenson and Motohashi in 2005 for Japan, Hall and Basdevant in 2003 for Russia, Mas Perez and Uriel in 2000 for Spain and Piatkowski in 2002 and 2003 for Poland and some transition economies. It requires capital investment data in deflated time series. The capital estimation of capital stock can be derived from the following equation.

$$K_{C,\,t} = (1-\delta)\, K_{C,t-1} + \Delta K_{C,\,t} \qquad (4.12)$$

Where $K_{C,\,t}$ is the real value of ICT capital stock in the t^{th} year, given rate of depreciation, δ and $\Delta K_{C,\,t}$ is the value of incremental capital stock, the investment for ICT in t^{th} year. Moreover, in order to get the $K_{ICT,\,t}$ ***initial valued approach*** is also going to apply. This initial valued approached also applied by many scholars including Shinjo and Zhang in 2003 for US, Miyagawa et al in 2004 for Japan, Nadiri and Prucha in 1996 and Reignsdorf and Cover in 2005 for Central American countries. The formula to derive the initial capital stock is as follow.

$$K_0 = \frac{I_{ICT,1}}{(\delta + \gamma)} \quad (4.13)$$

K_0 = the value of ICT Capital Stock in the initial year

I_{ICT} = the level of ICT investment in the first year of series available

δ = assumed depreciation rate

γ = average growth rate of ICT investment over a period of time

From the above equation unavailability of depreciation rate for ICT Capital Stock is seem to be hindered the estimation of initial ICT capital stock. Actually, depreciation depends on the cost as well as life span (usages) of the asset. Jorgenson (2001) pointed out the unit cost of using a computer for a specific period of time determines its rental price. Fraumeni (1997) estimated the depreciation for US computing equipments. He employed the formula of the estimated declining-balance rate over the average asset service life in order to get the depreciation of ICT capital stock for before and after of 1978 in US. However it is hard to define the average asset service life span. The reason is that the depreciation rate of ICT capital highly depends on how fast in obsolescence of ICT equipment means newly innovative ICT equipments may shorten the average life span of current ICT equipments. Different studies different depreciation rates for the ICT capital estimation. Jorgenson (1989) employed 27 percent of deprecation rates for office, computing and accounting machinery in 1997. Fraumeni (1997) applied 2 different rates of depreciation for Office and computing and accounting machinery for before 1978 and after. He used 27 percent for the former and 31 percent for the latter. Similarly, Kim (2002) used depreciation rate of 13 percent to 1970-1977 and 14 percent to 1977-2000 for ICT capital of Korea. Wong (2004) also assumed the depreciation rate of 15 percent for ICT capital in China. Therefore, it can be assumed that the depreciation rate of ICT capital can be lie within 10 to 31 percents. The following table describes the different rates of deprecation of ICT capital for different studies.

Table 4.1 Depreciation Rates of ICT Equipments

Authors	Category of equipment	Depreciation rate (%)
Jorgens on (1989)	Office, computing and accounting machinery 1977	27
Fraumeni (1997)	Office, computing and accounting machinery	
	Before 1978	27
	1978 and later	31
Kim (2002)	ICT Capital (Korea)	
	1970-1977	13
	1977-2000	14
Miyagawa, Ito and Harada (2004)	ICT Capital (Japan)	
	Before 1978	27
	- 1978 and later	31

Source: Wong (2004)

Again, regarding to the ICT investment, there is no adequate data series for ICT investment in Thailand. In order to proxy, ICT spending data is available form World development Indicators 2008 of World Bank publication based on Digital Planet report 2006 of World Information Technology Service Alliances (WITSA). Many studies used WITSA data in order to study ICT and Productivity. Lee and Khatri (2003) employed the ICT spending data from WITSA in order to examine the Information Technology and Productivity Growth in Asia. Piatkowski used ICT spending data of WITSA in 2002 and 2003 for the study on ICT investment versus growth and labour productivity in Poland and eight transition economies[12]. The data provided for ICT spending is as a percentage of GDP. The IT spending data available is available from year 2000 onwards; therefore, the study will use the relationship between ICT spending flows and pet capita income for estimating ICT investment series of Thailand.

[12] Bulgaria, Czech Republic, Hungary, Poland, Russia, Slovakia and Slovenia

Firstly, to project WITSA spending series for the years prior to 2000, the study applied ***OLS log-log backward projection model***[13]. The model is as followed:

$$\ln(Ec_{t-1}) = \beta_0 + \beta_1 \ln(Ec_t) + \beta_2 \ln(Y_{t-1}) + \varepsilon \qquad (4.14)$$

Where Ec represents expenditure on ICT, Y is GDP per capita[14], ε is the error term. The model specifies that the spending on ICT in the year t-1 can be derived from GDP per capita in that year and the spending of the asset in period t. The model above will be used to estimate the expenditure series of information technology.

By using the data available from year 2000 to 2006, the above model has generated the value of β_0, β_1 and β_2. Based on the parameters values of β_0, β_1 and β_2 and GDP per capita of the respective years, the study will be able to estimate back the investment series of ICT up to 1990. In order to estimate the ICT capital stock, the study will estimate back to 1990 by using the equation (4.13), and, the study has also estimated different depreciation rates of (13%, 15%, 20%, 25% and 30%) based on previous empirical studies as discussed above to testify the robustness of the estimation result. Appendix (A) has shown series of ICT Stock with different depreciation rates. However, for the depreciation of ICT capital stock in this study, depreciation rate of 13 percent[15] has applied.

In order to obtain an estimate of the contribution of ICT Capital stock to growth, the share of ICT in total nominal income v_c as shown in equation (4.15) needs to derived by multiplying the nominal ICT Capital Stock (K_c) by the gross rate of return on investment in ICT (R_c) and dividing by norminal total income (I).

$$v_c = \frac{R_c K_c}{I} \qquad (4.15)$$

[13] Vu (2005) applied this methodology in order to conduct backward projection of ICT investment for 50 major ICT-spending countries.
[14] Per Capita GDP (in 1988 constant price) data can be available from national income data (2001) and (2008) published by NESDB.
[15] It is the closest approximation to the study of cooperation between World Bank and NESDB applied for telecommunication sector (12.5%) in Thailand between 1993 and 2006.

Both the value of ICT capital stock, which has derived already in the previous section and total income, is available from national account. R_c is the sum of competitive net rate of return on total investments (RC) and a depreciation rate.

$$Rc = RC + d \qquad (4.16)$$

The competitive net rate of return on total investment (RC) can be arrived by applying the capital asset pricing model (CAPM);

$$RC = R_f + \beta(E_r - R_p) \qquad (4.17)$$

Where the net return on total investment is a sum of a risk free rate (R_f) and a risk premium $\beta(E_r - R_p)$, where β is a particular market share portfolio and E_r is the expected return on specific portfolio. There is data limitation for stock market beta and an expected return on a share of portfolio. Then the competitive rate of return becomes a risk free rate (R_f) and an estimate of a risk premium (R_p)[16]:

$$RC = R_f + R_p \qquad (4.18)$$

Risk free rate in Thailand is about 7.58% based on the 10 year Thai government treasury 6 month forward and as for the premium, according to the Kasikorn Securities (Susheel Narula, 2009). It can be assumed to be around 7 percent from January 1987 to June 2008. The final estimate of RC in Thailand in about 14.58% and income share of ICT can be derived by adding up the depreciation rate and multiply by the ratio of ICT capital stock and real GDP.

4.4.2 Non ICT Capital Stock

The Capital Stock data can be available from the National Statistical Office under the compilation of Capital Stock of Thailand in 2551 (2008). The Capital Stock data of both gross and net capital stocks are also provided in term of the constant values in 1988 prices. The *composite index of capital stock*[17] will be formulated by

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[16] Marcin Ptiakowski (2002) applied same methodologies to derive the share of ICT in total income in Poland.

[17] Bosworth employed the same methodology for capital services in Thailand (2005)

using 75 percent weight on the gross capital stock and 25 percent weight on the net capital stock. As for the Non ICT stock, it can be derived from the difference between ICT Capital Stock estimated in previous section and composite index of capital stock.

4.4.3 Number of Employment (L) and Total Hours Work (H)

Number of employment data can be taken from the labour force survey (LFS) which has been undertaken by the National Statistical Office (NSO). Since the year 2001, the population aged 15 years and above is classified as total working age population. Prior to 2001, population of aged 13 years and over is accounted for it. However, labour force survey 2008 by NSO has provided the data for number of employed person with 15 years and above since 1988. For the sake of consistency, the study will reveal the minimum working age as 15 years and above.

Moreover, as for data consistency again in number of employment, the studies of TDRI and the APO used the August survey when employment is at a seasonal peak but the NESDB and Bosworth used an average of the February and August surveys. Here, in this study the data for labour employed are taken out as an average of the whole year from different surveys (3 rounds and 4 quarters) of the labour force surveys. Hours worked data is able to retrieve from LFS since 1985.

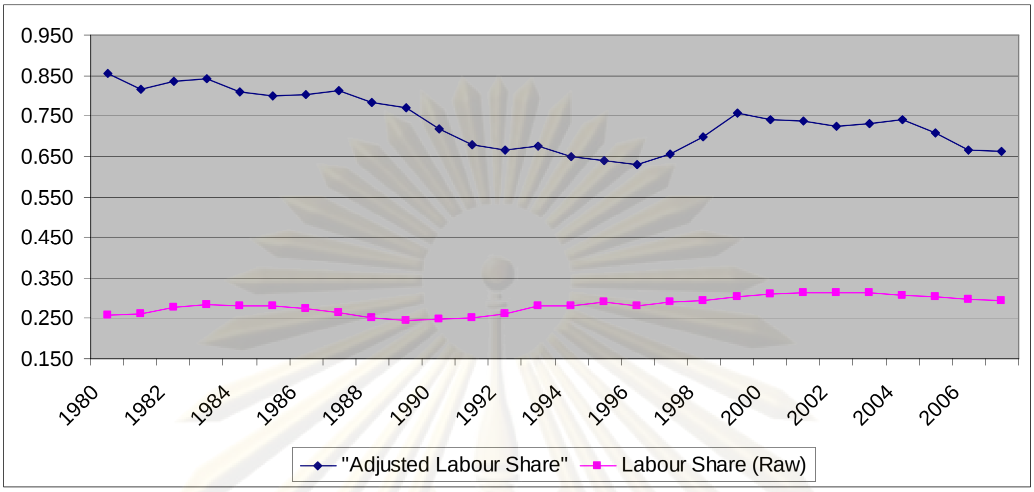
4.4.4 Factor Shares

Factor shares of capital and labour (v_k and v_l) have also been regarded as insights into the shape of the aggregate production function. In Thailand, NESDB take cares of National Income and Product Account (NIPA). NIPA provides the value added in both nominal and real terms and total wage bill in terms of "compensation to employees" which comprises of (1) wages and salaries and (2) employers' contribution of social security, which are workers from formal sector. From the NIPA, the raw labour share of Thailand can be constructed by taking the ratio of the compensation to employees to GDP at factor costs[18]. The series displays a slightly increasing trend, with the mean (0.28), maximum value of (0.31) and minimum value of (0.25) (see Appendix B).

[18] GDP at factor cost = GDP at market price – indirect taxes + subsidies – provision for consumption of fixed capital

Employee compensation, however, differs from the labour income especially in most of the developing countries (Golin, 2002). Labour income also includes some important parts of non wage compensation, rent from particular works, and the return to entrepreneurs. These specific components also comprise in labour income though the people are not wage-labour. In Thailand, quite number of proportion of the total labour force is regard as “own account workers” and “unpaid family workers”. They are not the people who do not receive regular earnings in terms of wages and salaries. NESDB take into account this part of income as “Income from Unincorporated Enterprises (IUE).” The share of IUE corresponds to a mixture of both wages and profits allocated to own account workers, including small firms which are normally operated by households. Therefore, the previous mentioned raw labour share could be some how underestimated. In general, the labour share accounts for two-third of the national income, but the exact figure is quite sensitive to derive from specific methodology. The study applied, here, proposed two approaches by Golin (2002) as adjustment for labour share. Golin’s first approach can be computed as the ratio of sum share in GDP of the compensation of employees and the share of UIE to one minus the share in GDP of indirect taxes and subsidies and provision for consumption of fixed capital. Since this adjustment counts the share of UIE as labour income, the labour share found in this adjustment has a mean of (0.81), declining from (0.92) to (0.70). The second approach is the ratio of the share of compensation of employees in GDP to one minus the share of UIE and minus the share of indirect taxes, subsidies and provision for consumption of fixed capita. By doing so, the adjusted share has resulted with the mean of (0.67) and minimum (0.56) and maximum (0.80) and can be seen in Appendix (B). Since the approach (2) treated UIE as composite of income and profit rates, the labour share of approach (2) should be lower than that of adjustment (1). The study took average outcomes on both approaches with arithmetic mean value of 0.74. The result is comparable to Lee and Khatri’s (2003) labour share with the average of 0.790 from 1990 to 1994 and 0.741 from 1995 to 1999.

Figure 4.1 Adjusted Labour Share of the Thailand (1980-2006)



Source: Author's Calculation

By assuming constant return to scale, share of capital can be derived from one minus labour share here adjusted labour share. Since the ICT capital has derived its own share to income then the non ICT capital can be calculated as one minus adjusted labour share and share of ICT capital.

4.4.5 Real GDP (Y)

Real GDP can be derived from nominal GDP through deflating with CPI. The National Economic and Social Development Board of Thailand (NESDB) provide the data series for GDP in real term (constant prices of 1988).

Chapter V

The Empirical Result

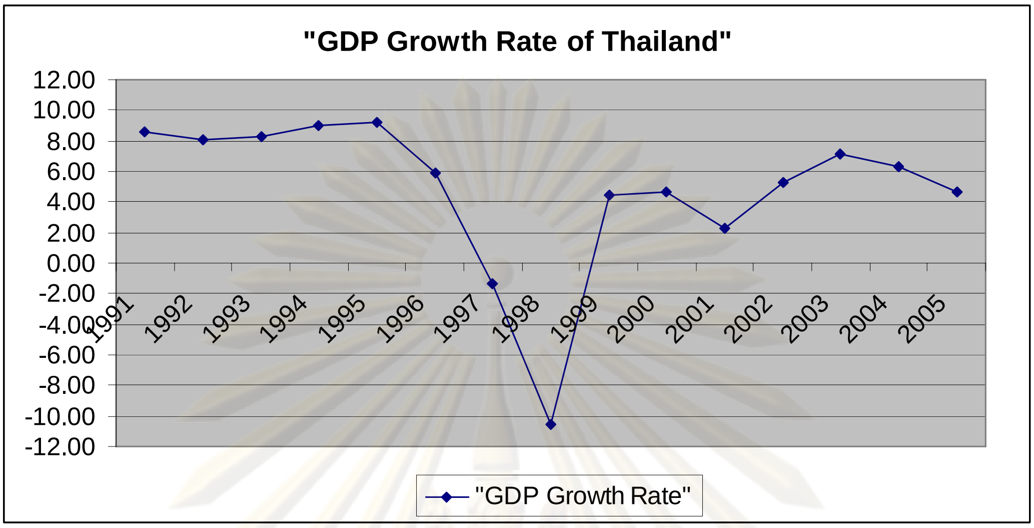
5.1 Introduction

The previous chapters of the study have provided a review on empirical studies relating to the relationship between ICT and economic growth and productivity. Various studies have proved that ICT has positive impact on productivity and growth both in the developed and some developing countries. This chapter will contribute to the literature by focusing on Thailand. It will examine the role of ICT capital in growth and productivity of Thailand. Given Thailand's current economic situation, it will be interesting to investigate how Thailand is similar to or different from the advanced economies with regard to the ICT vs growth and productivity. This chapter will firstly discuss the preliminary analysis of the Thailand's growth and productivity based on the data obtained from Thailand's statistical sources including NESDB, NSO, and capital stock ICT derived in the previous chapter. Then the study will employ growth accounting framework to investigate the contribution of ICT capital and Thailand's growth and productivity. The study will also use different estimation of capital stock series in order to test the robustness of the study. Finally conclusion will be drawn upon the findings of the role of ICT in the Thailand's economic growth and productivity.

5.2 Growth, Productivity and ICT Development in Thailand

Thailand has remarkable growth with the average GDP growth rate of 8.17 percent from 1991 to 1996. By the time of 1997, Thailand has suffered from of the Asian financial Crisis and its GDP growth rate has reached to the trough since the Second World War. The GDP growth rate has declined up to -10.51 in 1998. The recovery process took almost 4-5 years back to normal with average growth rate of 5.14 from 2001 to 2005 (Figure 5.1).

Figure 5.1 GDP Growth Rate of Thailand (1991-2005) (Unit: percentage)



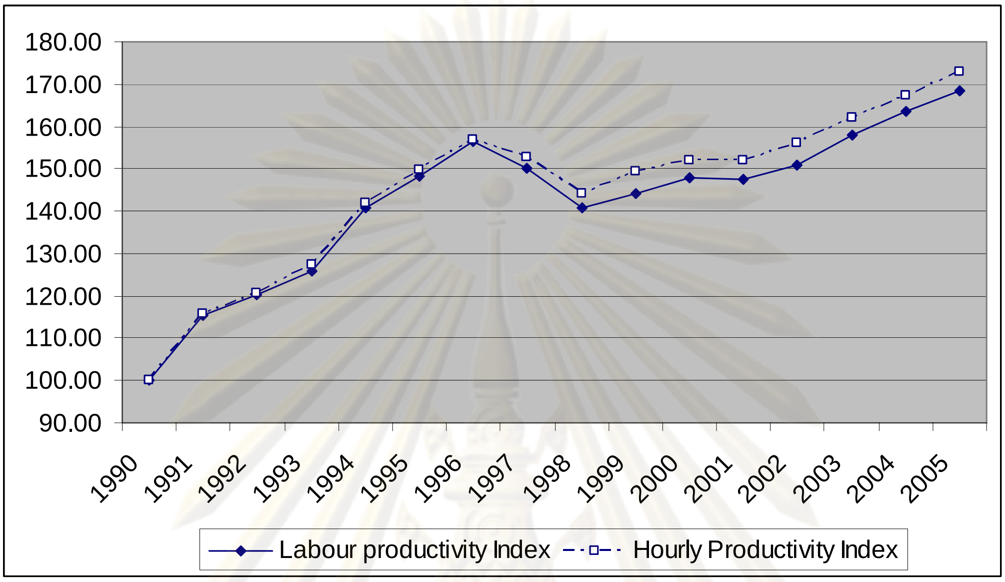
Source: NESDB

Figure (5.2) illustrates the trend of productivity growths, both in terms of labour and hourly, in Thailand from 1990 to 2005. Both labour productivity (measured as GDP per employed person) increased with the average growth rate of 3.67 percent from 1991 to 2005. Labour productivity in pre crisis period, from 1991 to 1996, is the highest with 7.81 percent. During the crisis period (1997-2000), the labour productivity has declined to -1.3 percent but it has backed to 2.66 percent between 2001 and 2005 and the labour productivity of post crisis period is only 35 percent of its pre crisis period.

The average growth rate of average labour productivity (GDP per hour) is slightly higher than growth rate of labour productivity. The possible reason may come from the rate of increase in employee is higher as while the average hours worked per worker is decreased over the time. The growth rate of average labour productivity (GDP per hour) in the pre-crisis period is 7.87 percent and decrease to -0.61 percent during crisis period. After the crisis, it is back to 2.62 percent and the average of the whole study period is 3.84 percent.

Figure 5.2 Labour and Hourly Productivity in Thailand (1990-2005)

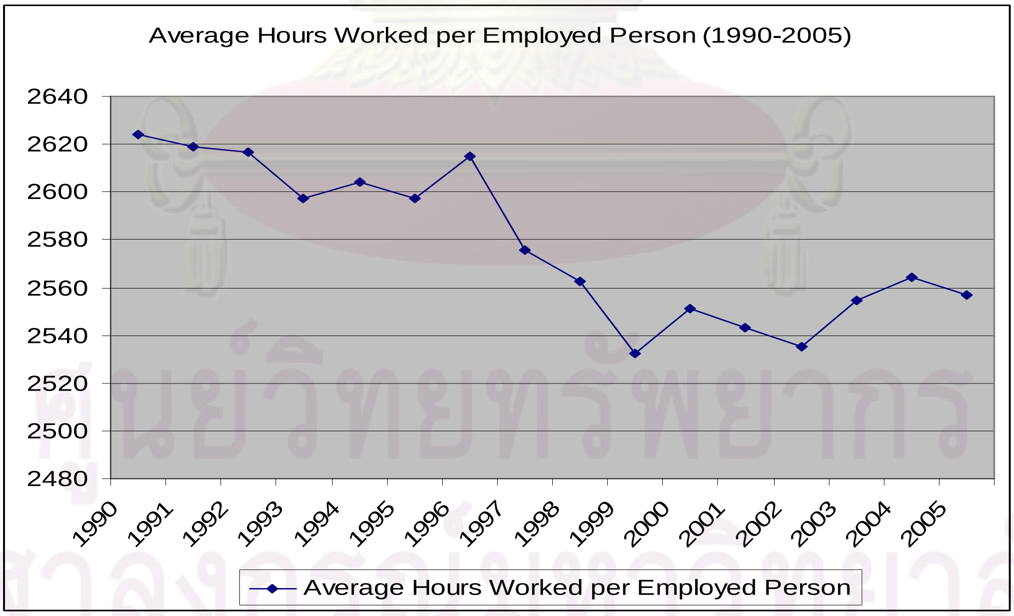
(Based year1990=100)



Source LFS, NESDB and author's calculation

Figure 5.3 Average Hours Worked per Employed Person (1990-2005)

(Unit: Hours)



Source: LFS, author's calculation

Table 5.1 Growth Rates of Sources of Growth (1991-2005)

	EMP Growth Rates	HW Growth Rates	Kc Growth Rates	Knc Growth Rates	HC Growth Rates	Kc per Hour Growth Rates	Knc per Hour Growth Rates	HC per Hour Growth Rates
1991-1996	0.47%	0.41%	7.80%	12.00%	1.26%	7.47%	11.70%	0.92%
1997-2000	0.53%	-0.09%	5.08%	3.22%	0.67%	5.33%	3.39%	0.86%
2001-2005	2.41%	2.45%	3.91%	2.21%	2.19%	1.43%	-0.23%	-0.25%
1991-2005	1.13%	0.96%	5.78%	6.39%	1.41%	4.88%	5.50%	0.51%

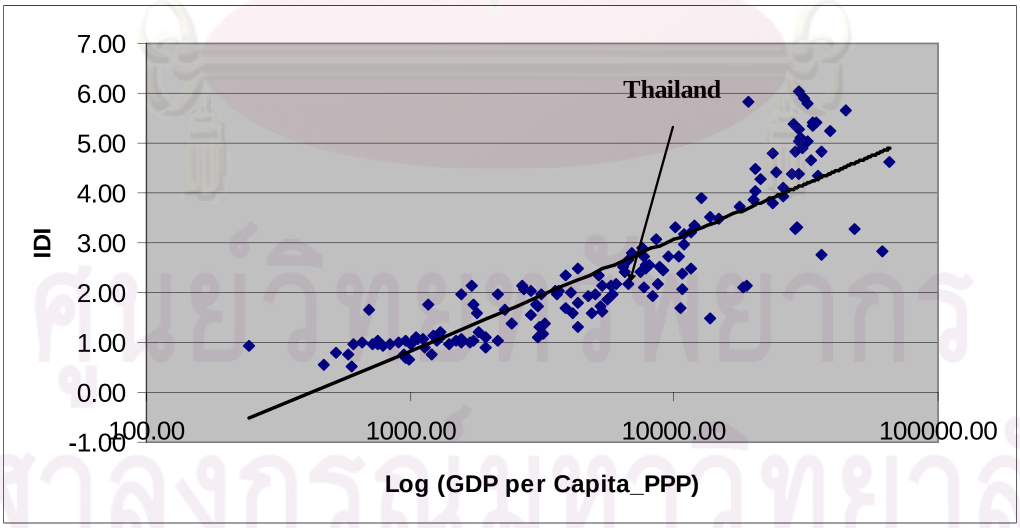
EMP = Employment
HW = Hours Worked
Kc = ICT Capital
Knc = Non-ICT Capital
HC = Human Capital
Source: NESDB, LFS, Ruttiya Bhula-or and author's calculation

One of the determinants of productivity and growth is labour quality or human capital. The employment has increased 1.13 percent during the whole period of 1991-2005. The employment increase in the post crisis period is almost 5 times higher than that of crisis and pre-crisis period while the human capital growth is only 2 times compare to pre-crisis period. As for the human capital, it has increased with the average growth rate of 1.41 percent over the time. 1.26 percent in pre-crisis period, 0.67 percent in crisis period and 2.19 percent in post-crisis period respectively.

Capital deepening also plays important role in growth and productivity. Table (5.1) also shows the rate of growth of ICT capital and non ICT capital in Thailand. ICT capital has increased over the period with the average growth rate of 5.78 percent from 1991 to 2005. Both the ICT and non ICT capital has increased with the enormous rate of 7.8 percent and 12 percent respectively in pre-crisis period. However, the rate of growth of both capitals has declined during the crisis and post crisis period. Especially, rate of growth of non ICT capital in the post crisis period is even lower than that of ICT capital due to slow down in investment activities. As for the capital deepening (capital stock per labour hour), resulting from the decreasing trend of both ICT and non ICT capital, the growth rates of capital intensity have declined dramatically from 7.47 percent and 11.70 percent in pre-crisis period to 1.43 and -0.23 percent in post-crisis period respectively.

The study firstly would like to construct ICT development Index or Indicator (IDI) in order to identify the level of ICT development in Thailand. Since ICT has been increasing over the time, the ICT related indicators are becoming more and more important to measure the overall ability of individuals in a country to access and use of ICT. International Telecommunication Union (ITU) has suggested unique framework to measure ICT *readiness* which reflects the level of network infrastructure access to ICT, *intensity* which reflects the level of ICT use in the society and *impact* which reflects the results of efficient and effective ICT use in 2009. In order to define the level of ICT development, to construct ICT development indicator, ITU has proposed three sub indices, namely ICT infrastructure and access, ICT use and ICT skill[19]. By doing so, the ITU has published the ICT development Index (IDI) for 154 countries for year 2002 and 2007 (see Appendix (5.1)). ITU ranked Thailand as 70th among 154 countries for the ICT development index in 2002.

Figure 5.4 ICT Development Index and GDP per Capita (2002)



Sources: ITU and World Bank

[19]There is no adequate data to construct for a unique index not only for the developed world but also for the developing one such as ICT skill of the society or a country. In this situation, ITU has suggested to proxy human capital on ICT skill with the level of education such as adult literacy, secondary gross enrollment and tertiary gross enrollment. See detail for ICT Development Index (2009), ITU

According to Figure (5.4), the ICT development index has increased along with per capita GDP means the higher the income level of the country the more ICT has adopted. With the purpose of constructing IDI for long series in Thailand, the study has applied the regression analysis by utilizing ITU's IDI and ICT access, infrastructure and skills for 210 countries around the world. The study used internet penetration (per 100 populations) and pc penetration (per 100 populations) to proxy the ICT access, GDP per capita for infrastructure development, composite index of secondary gross enrollment and tertiary gross enrollment for skill and capacity of a specific country[20]. The regression result yields respective elasticity values for the construction of ICT Development Index in Thailand as follow:

IDI = 0.60 + 0.019*(Hc) + 0.035*INTUSER + 0.017*PCUSER + 1.17e-005*GDP_PPP (5.1)

(11.05)*** (6.97)*** (3.55)*** (3.32)***

R^2 = 0.958 Adj. R^2 = 0.956 dw = 1.41

By using the equation (5.1), the study has constructed the ICT Development Index by using data of Human Capital[21], Internet penetration rate per 100 population, PC penetration per 100 population and per capita GDP in purchasing power parity (2005 constant)[22]. The figure (5.5) shows the ICT development Index for Thailand from 1990 to 2005. ICT growth has resulted with the average of 2.31 percent over 15 years. The rate of growth of ICT in Thailand during the pre-crisis period is about 1.28 percent per year and it increases to 2.15 percent per year even in the crisis period. The post crisis period has the growth rate of ICT development with average of 4.05 percent per year. According to figure (5.6) Thailand's labour productivity (GDP per worker) is positively correlated with ICT capital per worker.[23] Therefore, it is

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[20] All the data required are available from the World Development Indicator CD Rom (2008)

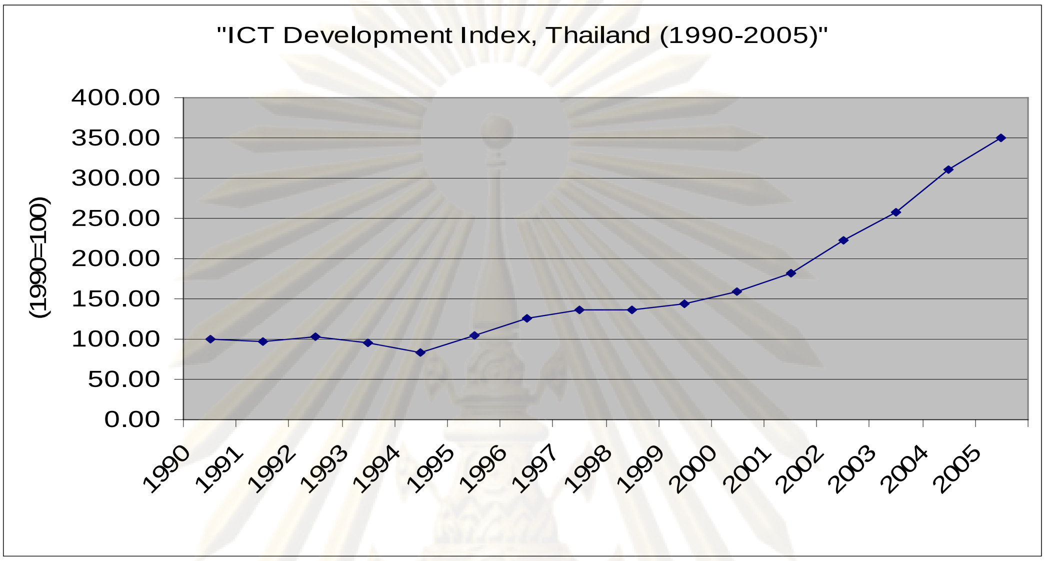
[21] The study adopted the Human Capital Index of Ruttiya Bhula-or (2009 which discussed in Chapter (2).

[22] All the data required except Human Capital are available from the World Development Indicator CD Rom (2008)

[23] Labour productivity is positively correlated with ICT capital per worker with R-squared value of 0.78. The equation is log (GDP per worker) = 2.53 + 0.58 (ICT capital per worker).

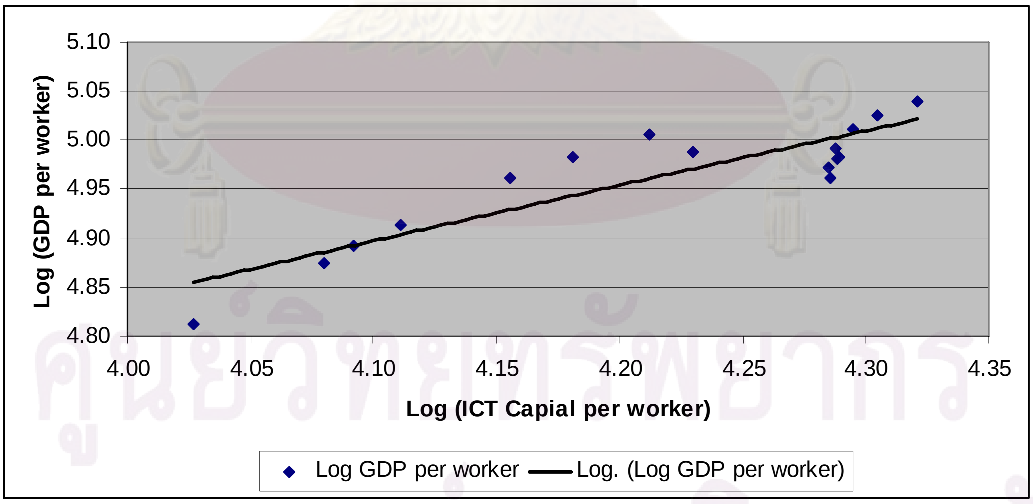
important to study the contribution of ICT on growth and labour productivity in Thailand.

Figure 5.5 The ICT Development Index (1990-2005)



Source: Author's calculation based on equation (5.1)

Figure 5.6 GDP per Capita and ICT Capital per Worker (1990-2005)



5.3 Empirical Results of the Growth Accounting

Therefore, the core objective of this chapter is to examine the sources of economic growth and productivity of Thailand by taking into account the role of ICT capital that the chapter employs the production model which segregates the ICT capital from other forms of physical capital inputs. Moreover, the model in the study considers the role human capital as well. Technological progress or TFP is derived as the residual of a production function. The production function in its simplest form as express as in equation (4.7) and equation (4.9) of Chapter (4) has used in order to derive the following results.

The growth in Thailand has mainly contributed by its capital which accounts for almost 43 percent from 1991 to 2005. Since the capital has decomposed into ICT capital and Non ICT capital, they accounted for growth with 6 percent and 37 percent respectively. As for ICT capital, it accounted for 4 percent in pre-crisis period while the non ICT capital contributed 43 percent in the same period. Both the capitals were negatively contributed to the growth during the crisis period. After the crisis, the increasing rate of investment in ICT related capital goods, contribution of ICT capital has been back to its pre-crisis period while the non ICT capital has not been able to do so (Table 5.2). Moreover, although the ICT capital stock is accountable less than 6 percent of the total capital stock, the contribution to growth after crisis period is more than 30 percent of the total capital stock

Table 5.2 Contribution of Human Capital, ICT Capital and Non-ICT Capital to Growth (1991-2005) (Unit: percentage)

	Growth of				
	Output	ICT Capital	Non ICT Capital	HC	TFP
1991-1996	8.17	0.34 (0.04)	3.50 (0.43)	0.77 (0.09)	3.56 0.44
1997-2000	-0.70	0.27 (-0.38)	0.88 (-1.26)	0.43 (-0.62)	-2.28 (3.27)
2001-2005	5.14	0.21 (0.04)	0.47 (0.09)	1.60 0.31	2.85 (0.55)
1991-2005	4.79	0.28 (0.06)	1.79 (0.37)	0.96 (0.20)	1.77 (0.37)

Figure in the parenthesis are percentage contribution
*HC = Human Capital

Table (5.2) shows that the contribution of human capital has increased from average of 9 percent in pre-crisis to 31 percent after the crisis and it contributes 20 percent as an average during 1991 to 2005. The higher contribution of human capital over time comes from the increasing quality of labour or education of general labour force. TFP accounts for almost 40 percent. The study also highlighted the study of Lee and Khatri (2003) with ICT contribution of about 2.3 percent, 12.5 percent of labour quality and 43 percent of TFP to growth between 1990 to1994. Moreover, the study reflects the contribution of ICT capital has quickly restored back to its pre-crisis[24] level within the short time span. Owing to the factor of declining prices of ICT goods, the same amount of investment in ICT nowadays brings more computing power as Moore law[25] has explained that ICT and ICT enabled labour force able to restore Thailand's growth back to be stable with average growth rate of 5.14 which is more than half of its boom period.

Within the neoclassical growth accounting framework, ICT investment contributes to labour productivity through capital deepening. It means the worker who has more computing and communication equipment is more efficient than the worker who doesn't. The contribution of ICT capital to labour productivity has found about 6 percent during 1991 to 2005. During the pre-crisis period, the ICT capital deepening accounted for 4 percent and it declined to 3 percent in the post crisis period. Apart from ICT capital, Non ICT capital contributes 41 percent, human capital contributes 7 percent and TFP accounts for 46 percent in Thailand through out the whole study period of 1991 to 2005. Although both non-ICT capital and human capital contributes positively in pre-crisis period, their contribution turned to negative: former with - 2 percent and latter with -7 percent respectively in the post crisis period (Table 5.3). Since TFP accounts for all the residual coming out from accounting process, certain part of factor productivity growth comes from growth in ICT investment. TFP of Thailand's contribution is 46 percent and it is comparable to TFP with ICT studies by Lee and Khatri (2003) and Oliner snd Sichel (2000). Both TFP of Singapore and Taiwan in former's study accounts for 44.2 percent in 1990-1999 and TFP of US in latter's study accounts for 45.1 percent.

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[24] Many denoted that latter decade of boom period

[25] Moore proved that the computing power becomes double in every 18 months.

Table 5.3 Contribution of Human Capital, ICT Capital and Non-ICT Capital to Average Labour Productivity (1991-2005) (Unit: percentage)

	Growth of					
	Average Labour productivity	ICT Capital Deepening	Non ICT Capital Deepening	Hourly HC* Contribution	TFP Contribution	Output per Hour (attributable to TFP)
1991-1996	7.76	0.33 (0.04)	3.33 (0.43)	0.54 (0.07)	3.56 (0.46)	0.46
1997-2000	-0.61	0.27 (-0.44)	0.95 (-1.56)	0.44 (-0.72)	-2.28 (3.74)	3.74
2001-2005	2.68	0.08 (0.03)	-0.05 (-0.02)	-0.20 (-0.07)	2.85 (1.06)	1.06
1991-2005	3.83	0.23 (0.06)	1.57 (0.41)	0.27 (0.07)	1.77 (0.46)	0.46

Figure in the parenthesis are percentage contribution
*HC = Human Capital

The study has found that slower rate of increase in human capital than that of increase in labour force. It seems to believe that rapid increase in general labour rather than skills labour in the economy after the crisis period. Since the general employment has increased tremendously, most of them are transferring from agriculture sector to industrial sector and less likely to have enough skills. It is resulting in slow rate of human capital while the number of workers has increased. Therefore, it is need to expand the skills of the labour. This phenomenon is also highlighting that ICT capital deepening alone is not enough to yield the adequate labour productivity which is able to restore Thailand's growth into stable rate after the crisis.

Since all the accounting process is based on the assumption of depreciation rate of 13 % of the ICT capital, the study also conducted sensitivity analysis by using ICT capital with different rates of deprecation as discussed in previous chapter. Depreciation rate is seeing as the part of return on ICT investment, the capital service of ICT capital will also be varied with different depreciation rates. The study yields the result with higher depreciation rates allows higher contribution to growth and productivity. The contribution of ICT capital to growth is the maximum of 13 percent and productivity is the maximum of 14 percent. The concept of higher depreciation rate contributes more to growth and productivity may be true with the ICT capital because the ICT enable machines and communication devices need to utilize intensively during the short time span before it becomes obsolete. The higher the deprecation rates the shorter the time span of usage, then more investment needs to come in. This is demonstrating that the higher growth rate of ICT capital as compare to non-ICT capital in Thailand since 1997. Table (5.4) and Table (5.5) exhibit the contribution of ICT capital with different deprecation rates to growth and productivity in Thailand.

The empirical results show in this chapter that Thailand's economic growth largely comes from factors accumulation, which also proves that the neo-classical approach of growth accounting is still relevant today. More than 50 percent of Thailand growth is driven by the expansion of capital formation both ICT and non ICT capital. Among then, ICT capital has grown at a faster rate than any other form of capital since 1997. The study has also found that the higher ICT capital growth rate also contributes to the rapid recovery of Thailand even though the actual depreciation rate of Thailand's ICT capital stock is still unknown.

Table 5.4 Sources of Growth with Different Depreciation Rates of ICT Capital (1991-2005) (Unit: Percentage)

	Growth of																
	Output	ICT Capital					Non ICT Capital*					HC	TFP*				
		13%	15%	20%	25%	30%	13%	15%	20%	25%	30%		13%	15%	20%	25%	30%
1991-1996	8.17	0.34	0.41	0.56	0.72	0.87	3.50	3.46	3.40	3.34	3.29	0.77	3.56	3.52	3.44	3.34	3.24
		(0.04)	(0.05)	(0.07)	(0.09)	(0.11)	(0.43)	(0.42)	(0.42)	(0.41)	(0.40)	(0.09)	(0.44)	(0.43)	(0.42)	(0.41)	(0.40)
1997-2000	-0.70	0.27	0.30	0.38	0.46	0.54	0.88	0.87	0.84	0.81	0.78	0.43	-2.28	-2.30	-2.35	-2.40	-2.46
		(-0.38)	(-0.43)	(-0.55)	(-0.66)	(-0.78)	(-1.26)	(-1.24)	(-1.20)	(-1.16)	(-1.13)	(-0.62)	(3.26)	(3.30)	(3.37)	(3.45)	(3.53)
2001-2005	5.14	0.21	0.23	0.29	0.34	0.39	0.47	0.47	0.44	0.42	0.40	1.60	2.85	2.84	2.80	2.77	2.74
		(0.04)	(0.05)	(0.06)	(0.07)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.31)	(0.56)	(0.55)	(0.55)	(0.54)	(0.53)
1991-2005	4.79	0.28	0.32	0.42	0.52	0.62	1.79	1.77	1.73	1.69	1.66	0.96	1.77	1.74	1.68	1.62	1.56
		(0.06)	(0.07)	(0.09)	(0.11)	(0.13)	(0.37)	(0.37)	(0.36)	(0.35)	(0.35)	(0.20)	(0.37)	(0.36)	(0.35)	(0.34)	(32.44)

Figure in the parenthesis are percentage contribution
*Non ICT Capital & TFP of respective ICT capitals with different depreciation rates

66

Table 5.5 Contribution of ICT Capital (with different depreciation rates) to productivity (1991-2005) (Unit: Percentage)

	Growth of																
	Hourly productivity	ICT Capital per hour					Non ICT Capital per hour*					Hourly HC Contribution	TFP*				
		13%	15%	20%	25%	30%	13%	15%	20%	25%	30%		13%	15%	20%	25%	30%
1991-1996	7.76	0.33 (0.04)	0.39 (0.05)	0.54 (0.07)	0.69 (0.09)	0.84 (0.11)	3.33 (0.43)	3.30 (0.43)	3.24 (0.42)	3.18 (0.41)	3.14 (0.40)	0.54 (0.07)	3.56 (0.46)	3.52 (0.45)	3.44 (0.44)	3.34 (0.43)	3.24 (0.42)
1997-2000	-0.61	0.27 (-0.44)	0.30 (-0.50)	0.39 -0.63)	0.47 (-0.77)	0.55 (-0.90)	0.95 (-1.56)	0.94 (-1.54)	0.91 (-1.50)	0.88 (-1.45)	0.86 (-1.41)	0.44 (-0.73)	-2.28 (3.73)	-2.30 (3.77)	-2.35 (3.86)	-2.40 (3.94)	-2.46 (4.03)
2001-2005	2.68	0.08 (0.03)	0.09 (0.03)	0.12 (0.05)	0.16 (0.06)	0.19 (0.07)	-0.05 -0.02)	-0.05 .02)	-0.05 (-0.02)	-0.05 (-0.02)	-0.05 (-0.02)	-0.20 (-0.07)	2.85 (1.06)	2.84 (1.06)	2.80 (1.05)	2.77 (1.03)	2.74 (1.02)
1991-2005	3.83	0.23 (0.06)	0.27 (0.07)	0.36 (0.09)	0.45 (0.12)	0.54 (0.14)	1.57 (0.41)	1.55 (0.41)	1.52 (0.40)	1.49 (0.39)	1.47 (0.38)	0.27 (0.07)	1.77 (0.46)	1.74 (0.45)	1.68 (0.44)	1.62 (0.42)	1.56 (0.41)

Figure in the parenthesis are percentage contribution
*Non ICT capital & TFP of respective ICT capitals with different depreciation rates

67

Chapter VI

Summary and Conclusion

6.1 Summary of the Study

The rapid growth in ICT investment, especially during the late 1980s in the US and other developed world has led to a call for new economics theories to be able to access the impact of ICT investment on growth and productivity. Researchers, in recent years, studying the impact of ICTs on productivity used different economic models of interpretation. ICT leads to productivity growth by increasing the efficiency of factor inputs (capital and labour) and fostering technological innovation as a source of total factor productivity growth. Labour productivity grows as a result of capital deepening by increasing ICT investment and utilized ICT technology in the production process. Many studies have found the positive impact of ICT on labour productivity and growth both in developed and developing world. This study has attempted to investigate the role of ICT in growth and labour productivity of Thailand.

Thailand has been focusing its economic development initiatives in the direction of building an information and knowledge economy since the days of 1990s. The new direction has been shaped by implementing several IT policies and master plans. With the successive encouragement of the government, per capita expenditure on ICT has been increasing almost two times during 2000 and 2006. With extensive use of ICT, both hardware and software market has grown with average rate of 21 percent and 17 percent respectively between 1997 and 2004. The mobile phone penetration has also increased from 5.6 percent in 2000 to 36.3 percent in 2004 by surpassing that of fixed-line of 10.1 percent in 2004. Overall broadband penetration rate is increased from 3 people per 1000 population in 2001 to 170 people per 1000 population in 2005, but the penetration is only concentrated in urban area and nation wide distribution is still not even yet. In general, Thailand is able to make the progress in infrastructure development. World Economic Forum ranked Thailand as 34th for network readiness in 2005 and ITU ranked it as 60th among 154 countries for the ICT development index in 2007.

The empirical results show that Thailand's economic growth largely comes from factors accumulation. The average growth rate of GDP is 4.79 percent from 1991 to 2005. More than 40 percent of Thailand growth is driven by the expansion of capital formation both ICT and non ICT capital. Among them, ICT capital has grown at a faster rate than any other form of physical capitals since 1997. The ICT capital contributes 6 percent to the GDP growth of average 5 percent per year during 1991 to 2005. Moreover, the study found that the contribution of ICT capital has been restored to its pre-crisis level in a short time owing to the factor of declining the prices of ICT goods. The same amount of investment in IT nowadays brings more computing power that ICT and ICT enabled labour force able to restore the Thailand's growth back to be stable with average growth rate of 5.14 which is more than half of its boom period. On the other hand, non-ICT contributes 37 percent in GDP growth of Thailand from 1991 to 2005. Non-ICT capital contributes 43 percent in pre-crisis period and its contribution falls dramatically to 9 percent after the crisis. The reason of lower contribution of non-ICT comes from slower growth rate of non-ICT capital which is fall down from 12 percent in pre crisis to 2.21 percent after the crisis.

Labour productivity is also mainly comes from the capital deepening. ICT capital deepening contributes 6 percent per year during 1991 to 2005 while non-ICT capital deepening contributes 41 percent per year. However, both the contribution of ICT capital and non-ICT capital to average labour productivity in pre-crisis period is higher than that of crisis and post-crisis period. The reason is slower rate of both ICT and non ICT investment growth during and after the crisis. Especially non ICT capital growth rate in post crisis falls down up to less than one fifth of its pre-crisis. Nevertheless, ICT capital contributes positively in the post-crisis period.

The study has also tried by using ICT capitals with depreciation rates that yield ICT capital contribution to growth and productivity in Thailand. The higher depreciation of ICT capital brings higher contribution to growth and labour productivity with the maximum of 13 percent to growth and 14 percent to labour productivity respectively. The concept of higher depreciation rate contributes more to growth and productivity because the ICT enable machines and communication devices must be utilized during the short life span before it becomes obsolete. The higher the depreciation rate, the shorter the life-span of usage, then the more investment needs to come in. This is demonstrating that the higher growth rate of ICT capital than that of non-ICT capital in Thailand since 1997. Although the actual depreciation rate of Thailand's ICT capital stock is still unknown, the study has found that the positive contribution of ICT capital to the rapid recovery of Thailand after crisis period.

Next to capitals, it is also needed to consider the contribution of quality of general work force to be able to utilize advanced technology like ICT. In general, contribution of human capital to growth has increased from average of 9 per cent in pre-crisis to 31 percent after the crisis with average of 20 percent during 1991 to 2005. The reason of higher contribution of human capital comes from the increased in education. The secondary education enrollment has increased more than 17 percent from 2001 to 2006 and tertiary education has increased about 40 percent from 1999 to 2006.

However, the expansion of education is not adequate for the expansion of general labour force. It can be clearly seen in declination of contribution of human capital to average labour productivity. Per hour human capital contributes 7 percent in pre-crisis and declines to -7 percent in post crisis period. This is due to the high employment growth rate of post-crisis period which is more than 5 times of its pre-crisis period. This also comes from shift of labour from rural or agriculture sector to urban or manufacturing sector. Therefore, there is possible to say that labour force has less likely to have adequate skills to utilize advance technology. Inadequate skills may hinder the effective utilization of technology like ICT because the shorter life span of ICT enabled machines and devices must need intensive utilization before it becomes obsolete. This phenomenon is also highlighting that ICT capital deepening alone is not enough to yield the adequate labour productivity and need of human capital development which is also another important factor to derive Thailand into stable growth.

6.2 Policy Recommendations

Thailand could be regarded as moderately efficient in the use of ICT for development that enhances competitiveness, productivity and stimulates the growth. As we have found that increase in contribution of ICT Capital to growth and productivity comes from increase investment rate of ICT, therefore, the government should provide the context and framework that encourage investing more in ICT technology. Shorter commitment period of capital input like ICT needs higher rate of gross investment to maintain the capital stock. Where the reinvestment cycle is shortening, firms need to adjust the changing conditions more quickly. For this reason, government should consider to provide loans with reasonable interest rate to firms especially small and medium enterprises with high market potential to be able to invest in new and faster ICT technologies.

There are still many constraints and challenges to be able to utilize ICT in full strength. Although Thailand has achieved rapid growth in ICT penetration, regional or urban-rural gaps still remain large. The disparity of PC and internet penetration among different regions becomes constraint for fully utilization of ICT technology for Thailand. Therefore, Thailand's ICT policies should pay more attention to the issue of digital divide among its regions as well as that between the urban and rural communities. In order to so, it is required to expand type of services and coverage of network and improve the efficiency of communication networks. Domestic and foreign investments should be encouraged by ensuring the fair competition among providers.

As study has pointed out that investing in ICT alone doesn't brings the benefits that need of skilled or ICT enabled workforce is also another concern. The level of education or skills of labour force means human capital which is more important to foster the innovation and creativity. There is inadequate numbers of ICT professionals in the labour market that it is required to increase the number of ICT professionals in order to fill the gap. In order to fill the gap, the role of vocational education becomes important because the formal education takes time to deliver required skill labour into the market while the vocational one is able to focus on only on specific skills. For that reason, academics need to work closely with business and industry counterparts in order to have better understanding of the needs of market. In addition, ICT professional working in the industry should be further developed for improving of knowledge and skills. Incentive need to be created for getting more training. Moreover, ICT skills of current labour forces should also be developed for improving efficiency and effectiveness. Incentives should be given to workplaces to invest in ICT knowledge and skills development. In order to ensure the dynamic nature of the qualification of labour consistent trainings and testing of the skills should be monitored in regular basis.

At the same time, it is also needed to reconsider the public policies to encourage and support the higher education level. Currently, Thailand's tertiary enrollment is about 50 percent. The government should pay attention to education policies to increase the higher education enrollment and completion rates to be able to boost local supply of skilled and semi-skilled workers. It is also necessary to improve the contents of school education such as English language proficiency and IT skills. Furthermore, the upgrade in ICT skills of teachers should be undertaken in conjunction with curriculum reform to improve skills in analytical thinking and problem solving by using ICT as a tool. Therefore, ICT budgets should be allocated to schools including service fees and funds for training staff.

There is also required to expand non-formal education. ICT education outside the formal education system should be developed in order to promote life-long learning. ICT centers should be set up in the community to provide basic knowledge of electronic media and trainings to users. It will allow people to access to information and would be beneficial of every day life of the rural communities. Since, English is the standard language for most of the commonly use software that localization of software is also essential factor for Thailand. Moreover, putting more Thai language content on the Web is also necessary.

As a conclusion, Thailand is at the very early stage of the pathway of development that it is calling for further accumulation of human capital. Without successive planning on human capital that Thailand will not be able to achieve its goal as becoming a knowledge economy. Therefore, it is an urgent task for the government to set the goals and plans for improvement of the human capital of the country while prompting the advance technology like ICT.

6.3 Limitations and Suggestions for Further Study

The study has tried to construct the ICT capital series by using the ICT spending series from WITSA. WITSA’s ICT spending does not describe the expenditure shares of enterprises, government and households. It neither does divide the spending between investment and services. Since spending by households and spending on services should not regarded as ICT investment, ICT spending series provided by WITSA could be able to bias upward to be regarded as ICT investment series. Moreover, the depreciation rate and capital services of ICT are based on numerous assumptions. There is one more limitation that the study is not able to decompose the ICT contribution to TFP growth since there is no availability of data on ICT investment in different industries of Thailand. Therefore, there would be a need for further empirical research on the sources of Thailand’s growth and productivity to investigate whether there has been a capital reallocation between ICT sector (ICT producing and using industries) and non-ICT sector by taking into consideration of disparity among different regions of Thailand.

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APPENDICES

Appendix A

ICT Capital Stock Series with Different Deprecation Rates

	ICT Capital Stock Series in 1988 Prices (Million Baht)				
	13%	15%	20%	25%	30%
1990	318934.94	288862.59	233759.65	196311.58	169205.09
1991	338744.56	312581.61	264642.05	232062.23	208479.59
1992	361514.79	338753.03	297045.61	268701.17	248184.27
1993	390087.16	370284.43	333998.98	309339.31	291489.61
1994	420704.66	403476.28	371907.94	350454.03	334924.78
1995	463251.42	448262.73	420798.27	402133.37	388622.93
1996	500267.10	487226.94	463332.86	447094.40	435340.31
1997	535093.65	523748.71	502960.86	488833.40	478607.34
1998	581023.42	571153.32	553067.89	540777.00	531880.33
1999	590767.38	582180.39	566446.07	555752.99	548012.89
2000	609099.81	601629.14	587940.28	578637.30	571903.41
2001	623544.50	617045.01	605135.70	597042.11	591183.63
2002	641776.01	636121.46	625760.36	618718.93	613622.06
2003	667102.87	662183.41	653169.25	647043.21	642608.93
2004	700709.64	696429.71	688587.39	683257.74	679399.91
2005	737685.01	733961.47	727138.66	722501.86	719145.55

Source: Author’s Calculation

Appendix B

Raw and Adjusted Labour Share of Thailand (1980-2005)

	Raw	Approach (1)	Approach(2)	Adjusted Labour share
1980	0.259	0.917	0.795	0.856
1981	0.261	0.888	0.742	0.815
1982	0.277	0.900	0.775	0.837
1983	0.284	0.901	0.784	0.843
1984	0.281	0.876	0.741	0.808
1985	0.279	0.870	0.730	0.800
1986	0.273	0.873	0.733	0.803
1987	0.265	0.884	0.744	0.814
1988	0.252	0.863	0.703	0.783
1989	0.246	0.855	0.689	0.772
1990	0.248	0.807	0.628	0.718
1991	0.250	0.769	0.586	0.678
1992	0.261	0.752	0.577	0.665
1993	0.279	0.752	0.597	0.674
1994	0.279	0.726	0.573	0.650
1995	0.291	0.710	0.569	0.640
1996	0.279	0.697	0.562	0.630
1997	0.291	0.719	0.590	0.655
1998	0.293	0.761	0.636	0.698
1999	0.303	0.817	0.699	0.758
2000	0.311	0.803	0.681	0.742
2001	0.314	0.799	0.676	0.738
2002	0.313	0.788	0.662	0.725
2003	0.312	0.794	0.666	0.730
2004	0.307	0.805	0.675	0.740
2005	0.302	0.777	0.640	0.709

Source: Author's Calculation

Appendix C

ICT Development Index (IDI) 2002 and 2007

Economy	Rank 2007	IDI 2007	Rank 2002	IDI 2002	Economy	Rank 2007	IDI 2007	Rank 2002	IDI 2002
Sweden	1	7.5	1	6.05	Iran (I.R.)	78	2.94	92	1.93
Korea (Rep.)	2	7.26	3	5.83	Palestine	79	2.92	67	2.2
Denmark	3	7.22	4	5.78	Georgia	80	2.91	75	2.13
Netherlands	4	7.14	6	5.43	Libya	81	2.84	78	2.08
Iceland	5	7.14	2	5.88	Ecuador	82	2.75	85	1.97
Norway	6	7.09	5	5.64	Tunisia	83	2.73	94	1.86
Luxembourg	7	7.03	21	4.62	Fiji	84	2.73	83	2
Switzerland	8	6.94	7	5.42	Albania	85	2.73	93	1.92
Finland	9	6.79	8	5.38	Azerbaijan	86	2.71	100	1.71
United Kingdom	10	6.78	10	5.27	South Africa	87	2.7	77	2.11
Hong Kong, China	11	6.7	12	5.1	Mongolia	88	2.67	84	1.97
Japan	12	6.64	18	4.82	Syria	89	2.66	102	1.69
Germany	13	6.61	14	5.02	Dominican Rep.	90	2.65	87	1.97
Australia	14	6.58	13	5.02	Philippines	91	2.63	79	2.07
Singapore	15	6.57	16	4.83	Viet Nam	92	2.61	107	1.59
New Zealand	16	6.44	19	4.79	Kyrgyzstan	93	2.61	86	1.97
United States	17	6.44	11	5.25	Egypt	94	2.54	95	1.81
Ireland	18	6.37	26	4.36	Cuba	95	2.53	91	1.94
Canada	19	6.34	9	5.33	Paraguay	96	2.52	82	2.02
Austria	20	6.32	20	4.64	Algeria	97	2.51	105	1.61
Macao, China	21	6.25	23	4.41	Bolivia	98	2.45	80	2.03
Italy	22	6.18	24	4.38	El Salvador	99	2.43	99	1.74
France	23	6.16	25	4.37	Sri Lanka	100	2.38	97	1.75
Belgium	24	6.14	15	4.91	Morocco	101	2.34	111	1.37
Taiwan, China	25	6.04	17	4.82	Honduras	102	2.28	114	1.31
Estonia	26	5.97	31	3.93	Guatemala	103	2.28	106	1.6
Spain	27	5.91	28	4.1	Turkmenistan	104	2.23	89	1.96
Slovenia	28	5.88	22	4.47	Cape Verde	105	2.18	103	1.67
Israel	29	5.6	27	4.24	Tajikistan	106	2.14	96	1.76
Malta	30	5.54	29	4.04	Gabon	107	2.14	110	1.48
Portugal	31	5.47	32	3.87	Indonesia	108	2.13	109	1.54
United Arab Emirates	32	5.29	40	3.27	Botswana	109	2.1	101	1.7
Lithuania	33	5.29	43	3.17	Uzbekistan	110	2.05	98	1.75
Greece	34	5.25	30	3.94	Nicaragua	111	2.03	112	1.37
Hungary	35	5.19	36	3.49	Namibia	112	1.92	108	1.58
Latvia	36	5.01	39	3.3	Swaziland	113	1.73	113	1.32
Cyprus	37	4.97	33	3.78	Ghana	114	1.63	122	1.1
Slovak Republic	38	4.95	35	3.51	Bhutan	115	1.63	118	1.17

Poland	39	4.95	37	3.34	Kenya	116	1.62	116	1.21
Czech Republic	40	4.88	34	3.74	Lao P.D.R.	117	1.6	125	1.08
Brunei Darussalam	41	4.8	41	3.27	India	118	1.59	117	1.19
Bahrain	42	4.69	38	3.3	Myanmar	119	1.57	104	1.64
Croatia	43	4.68	42	3.19	Sudan	120	1.56	131	1.03
Qatar	44	4.44	47	2.84	Cambodia	121	1.53	126	1.07
Bulgaria	45	4.37	51	2.74	Gambia	122	1.49	139	0.96
Romania	46	4.16	60	2.48	Lesotho	123	1.48	119	1.15
Argentina	47	4.12	44	3.06	Yemen	124	1.47	129	1.04
Chile	48	4	45	2.97	Cameroon	125	1.46	120	1.12
Uruguay	49	3.88	46	2.9	Zimbabwe	126	1.46	115	1.29
Russia	50	3.83	52	2.71	Pakistan	127	1.46	146	0.89
Ukraine	51	3.8	59	2.5	Côte d'Ivoire	128	1.41	134	1.01
Malaysia	52	3.79	50	2.74	Zambia	129	1.39	124	1.08
Jamaica	53	3.78	48	2.79	Nigeria	130	1.39	123	1.09
Belarus	54	3.76	57	2.53	Senegal	131	1.38	142	0.95
Saudi Arabia	55	3.62	73	2.13	Congo	132	1.37	121	1.1
Trinidad & Tobago	56	3.61	58	2.5	Madagascar	133	1.36	140	0.96
Kuwait	57	3.57	49	2.77	Mauritania	134	1.36	135	1
Bosnia	58	3.54	66	2.33	Benin	135	1.28	149	0.76
Turkey	59	3.49	63	2.41	Haiti	136	1.27	127	1.05
Brazil	60	3.48	54	2.55	Togo	137	1.26	130	1.03
Panama	61	3.46	62	2.42	Bangladesh	138	1.26	132	1.02
Mauritius	62	3.45	61	2.45	Nepal	139	1.23	133	1.01
Thailand	63	3.44	70	2.17	Uganda	140	1.21	143	0.92
Lebanon	64	3.43	56	2.53	Malawi	141	1.17	141	0.95
TFYR Macedonia	65	3.42	53	2.65	Comoros	142	1.17	145	0.91
Costa Rica	66	3.41	55	2.54	Rwanda	143	1.17	136	0.99
Venezuela	67	3.34	69	2.18	Papua New Guinea	144	1.14	128	1.05
Moldova	68	3.31	74	2.13	Tanzania	145	1.13	138	0.96
Kazakhstan	69	3.25	68	2.18	Mali	146	1.12	150	0.75
Colombia	70	3.25	72	2.13	Ethiopia	147	1.03	147	0.78
Maldives	71	3.16	88	1.96	Mozambique	148	1.02	148	0.77
Armenia	72	3.12	81	2.03	Eritrea	149	1	137	0.96
China	73	3.11	90	1.95	Burkina Faso	150	0.97	151	0.68
Peru	74	3.11	71	2.15	D.R. Congo	151	0.95	144	0.92
Mexico	75	3.09	64	2.38	Guinea-Bissau	152	0.9	153	0.56
Jordan	76	3.06	65	2.36	Chad	153	0.83	152	0.65
Oman	77	3	76	2.12	Niger	154	0.82	154	0.51

source: ITU

Appendix D

Data Employed in the Study

	GDP* (million Baht	Capital Stock Index* (million Baht)	Employment (in thousands)	Total Hours Worked (million hours)	ICT Capital Stock * (million Baht)	Non ICT* Capital Stock (million Baht)	Human Capital	Labour Share (LS)	ICT Capital Services (ICTS)	Non-ICT Capital Services
sources	NESDB	0.75*Gross + 0.25*Net	NSO (LFS)	NSO (LFS)	Initial Method (13%)	Capital Stock Index – ICT Capital Stock	Ruttiya Bhula-or	Adjusted	Rc=Rf+Rp +d**	1- LS-ICTS
1990	1,945,372.00	5242117.75	29956	78,602.68	318934.94	4923182.81	208	0.718	0.046	0.237
1991	2,111,862.00	5907081.00	28168	73,771.82	338744.56	5568336.44	210	0.678	0.045	0.278
1992	2,282,572.00	6616503.00	29262	76,576.08	361514.79	6254988.21	212	0.665	0.044	0.291
1993	2,470,908.00	7393242.50	30200	78,434.19	390087.16	7003155.34	200	0.674	0.044	0.282
1994	2,692,973.00	8267824.50	29420	76,615.54	420704.66	7847119.84	188	0.650	0.044	0.307
1995	2,941,736.00	9187667.75	30541	79,327.13	463251.42	8724416.33	205	0.640	0.044	0.317
1996	3,115,338.00	10214849.00	30692	80,261.02	500267.10	9714581.90	222	0.630	0.045	0.326
1997	3,072,615.00	10941117.75	31522	81,195.83	535093.65	10406024.10	226	0.655	0.049	0.297
1998	2,749,684.00	11188645.75	30104	77,152.30	581023.42	10607622.33	229	0.698	0.059	0.243
1999	2,871,980.00	11397824.50	30663	77,643.76	590767.38	10807057.12	228	0.758	0.057	0.185
2000	3,005,394.00	11626455.25	31293	79,839.32	609099.81	11017355.44	228	0.742	0.057	0.202
2001	3,073,601.00	11813471.00	32104	81,649.98	623544.50	11189926.50	230	0.738	0.057	0.206
2002	3,237,042.00	12019385.75	33060	83,816.49	641776.01	11377609.74	237	0.725	0.055	0.220
2003	3,468,166.00	12283475.75	33841	86,455.00	667102.87	11616372.88	240	0.730	0.054	0.217
2004	3,688,189.00	12624346.25	34729	89,057.87	700709.64	11923636.61	247	0.740	0.053	0.207
2005	3,858,019.00	13024848.75	35245	90,116.61	737685.01	12287163.74	254	0.709	0.053	0.238

*Data are in 1988 constant prices ** Rc= ICT capital services, Rf = Risk free rate, Rp= Risk premium rate, d=assumed depreciation rate

82

BIOGRAPHY

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Education

- Bachelor of Computer Technology, University of Computer Technology, Yangon (2003)
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Fields of Interest

- Productivity and Growth
- Macroeconomics
- Technology Change
- Human Development, Management, and Training