ERIA Research Project Report 2010, No. 11

THE EFFECT AND IMPLICATION OF THE IT REVOLUTION ON THE POTENTIAL GROWTH OF EAST ASIAN COUNTRIES

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March 2011

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DR. YUZO KUMASAKA (PROJECT LEADER): President and CEO of ITeconomy Advisors, LLC, U.S.A.

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ACKNOWLEDGEMENTS

Since the Information Technology (IT) revolution started in the late 1980s and began to permeate economic activities, we have been intensely working on the effect of IT on the economy, paying particular attention to the quantitative analysis aspects. Although many economists applied the Growth Accounting method to measure the effects of IT on the economy, Prof. Lawrence R. Klein at the University of Pennsylvania recognized the drawbacks of this method. For example, it ignored the possibility of increasing returns to scale, one of the most important characteristics brought about by the IT revolution. Instead, Prof. Klein introduced a generalized Cobb-Douglas production function to correctly analyze the effects of IT on the economy and tried to explicitly explain Total Factor Productivity (TFP) using IT variables. Since our approach is based on his ideas, we want to acknowledge and thank Prof. Klein for his original work and advice.

We also appreciate the support for our project from two Japanese statesmen, Mr. Masajuro Shiokawa, a former Minister of Finance and Mr. Hidenao Nakagawa, former Secretary-General of the Liberal Democratic Party. Both have maintained for some time that Japan can achieve economic growth that is much higher than many economists and politicians assume. Mr. Nakagawa proposed the “Rising Tide Policies” for the Japanese economy and indicated that Japan’s potential growth should be much more than 3.0%, thanks to the IT revolution.

It was Dr. Filemon A. Uriarte, Jr., former Executive Director of the ASEAN Foundation, who first endorsed our project proposal. Dr. Uriarte immediately understood the importance of our project for the development of ASEAN countries. We could not have commenced without his remarkable knowledge of IT and ASEAN economies, as well as his great support.

Finally, we thank Mr. Hidetoshi Nishimura, Executive Director at ERIA and Mr. Daiki Kasugahara, General Manager at ERIA, for giving this challenging project to us. We hope our project will assist ASEAN countries in further developing through the IT revolution.

We regret to report that Prof. F. Gerard Adams, one of our project members, passed away suddenly on January 15, 2011. We are very grateful for his contributions to our project up until the last minute. We would like to dedicate this report to the late Prof. F. Gerard Adams.

FOREWORD[1]

East Asia comprises basically of the ten Member States of the Association of Southeast Asian Nations (ASEAN), namely, Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam, and three of its Dialogue Partners, namely, China, Japan and Korea. This wider regional grouping is also commonly referred to as ASEAN + 3, reflecting the regular dialogues and the institutionalized cooperation that exist among these thirteen countries.

The Leaders of ASEAN have agreed to establish the ASEAN Community by 2013, which will create a single market and production base comprising five core elements: (i) free flow of goods; (ii) free flow of services; (iii) free flow of investment; (iv) freer flow of capital; and (v) free flow of skilled labor. To attain this goal, a Roadmap for an ASEAN Community has been adopted comprising the ASEAN Political-Security Community Blueprint, the ASEAN Economic Community Blueprint, and the ASEAN Socio-Cultural Community Blueprint. An important component of this Roadmap is the promotion of sustainable economic growth and development through, among others, the effective use and wide application of information and communication technology, including the promotion of ICT innovation and improvement of ICT infrastructure.

The Economic Community Blueprint gives highest priority to establishing a harmonized legal infrastructure for e-commerce in ASEAN by 2015. This requires Member States to enact, update, and/or amend their e-commerce laws, implement harmonized guidelines and principles for electronic contracting and online dispute resolution services, adopt regional framework and strategy for the mutual recognition of digital signatures, and advance cross-border electronic transactions. The Socio-Cultural Community Blueprint, on the other hand, calls for the implementation of human resources development programs to promote and increase ICT literacy and use, and to develop a workforce and manpower with high levels of ICT proficiency and expertise.

ASEAN cooperation in ICT formally started in 2000 when the ASEAN Leaders signed the e-ASEAN Framework Agreement that called for harnessing ICT to foster closer regional economic integration, enhance overall competitiveness, and develop an

[1] Written by Dr. Filemon A. Uriarte, Jr., Chairman, LAUDS Technologies, Inc., and former Executive Director, ASEAN Foundation, and Science and Technology Secretary (Minister), Republic of the Philippines.

ASEAN information society. This was followed by the development and implementation of the e-ASEAN Integration Roadmap (2004-2010). In 2003, the ASEAN Member States adopted an action agenda, the Singapore Declaration, to harness technological advances in information and communications technology to create digital opportunities for ASEAN and enhance ASEAN's overall competitiveness. Through these agreement, roadmap and action agenda, ASEAN aimed, among others, to enhance intra-ASEAN trade and investment in the ICT sector by identifying and eliminating impediments, fostering pro-business policies on ICT trade and investment and establishing transparent, predictable and non-discriminatory policy environments, and reducing tariffs on ICT products.

Recognizing the important role of ICT in economic growth and development, there have also been extensive efforts to enhance collaboration with other East Asian Countries, in the context of the ASEAN + 3 cooperation framework. An ASEAN-China Memorandum of Understanding on Cooperation in Information and Communications Technology was signed in October 2003 to cover joint activities in ICT skills training and certification, and construction and development of information infrastructure such as fixed/mobile networks, multimedia applications and the Internet. In January 2007 this cooperation was further strengthened with the signing of the Plan of Action to Implement the Beijing Declaration on ASEAN-China ICT Cooperative Partnership for Common Development which covers ICT infrastructure development, universal service, human capacity building, network and information security, trade and investment facilitation, and inter-governmental dialogue and exchange. ICT cooperation was further enhanced with the recent adoption of the ASEAN-China ICT Work Plan (2010-2011). In the case of Japan, cooperation in ICT is implemented through the ASEAN-Japan ICT Work Plan (2009-2011) and the ASEAN-Japan Collaboration Framework on Information Security. On the other hand, ASEAN-Korea ICT cooperation is carried out under the ICT Cooperation towards Co-prosperity in East Asia (2007-2011).

The future of ICT cooperation and development in ASEAN will be guided by the Kuala Lumpur Statement 2011 on ICT: Positioning ASEAN for the Future, which officially announced the adoption of the ASEAN ICT Master Plan 2015 (AIM2015) with the vision "Towards an Empowering and Transformational ICT: Creating an Inclusive, Vibrant and Integrated ASEAN." AIM2015 is expected to deliver four key outcomes: (i) ICT as an engine of growth for ASEAN Member States; (ii) recognition for ASEAN as a global ICT hub; (iii) enhanced quality of life for the peoples of ASEAN; and (iv) contribution towards ASEAN integration. AIM2015 also calls for stronger and closer cooperation with other East Asian countries, particularly China, Japan and Korea. With China new areas of cooperation will be initiated in ICT applications for small- and medium-sized enterprises and in e-education while continuing the existing work related to telecommunications development, ICT policies, network security and capacity building. With Japan new areas of joint activities will be developed including the use of ICT in disaster response and management and the preservation of the environment. Finally, with Korea future cooperation will cover areas such as joint use of ICT infrastructure, support for expansion of ICT infrastructure, capacity building and expansion of digital opportunities.

This small study and brief report is expected to contribute to and complement the various studies and projects being implemented under the aforementioned work plans and collaboration frameworks in ASEAN as well as those carried out in cooperation with other East Asian countries.

Executive Summary

Although people admit that IT plays an increasingly important role in economic growth and development, they do not grasp quantitatively the effect of IT on the economy. Indeed, the Growth Accounting method has been popular among economists, but this approach is not appropriate to correctly analyze the effect of IT on the economy. By using the Growth Accounting method, many economists erroneously concluded at the beginning of the IT revolution that the effect of IT on the economy was not significant because the IT capital share of total capital stock was very small. This is the same mistake many economists made in the beginning of the first oil crises in 1973-74. They concluded that the effect of the oil embargo would not be significant because the energy input share in production was very small. These economists miss the point that both the energy input and IT play very important roles in production. Specifically, we cannot correctly measure the effect of IT on the economy without estimating a new production function that includes IT factors.

IT innovation is quite different from traditional innovations such as the invention of the steam engine because the effectiveness of IT innovation is related to not only the IT infrastructure but also management style, culture, languages and so on. We cannot use a traditional production function where disembodied technical progress can be explained by a proxy of time. We have to introduce a new production function where endogenous technical progress can be explained using IT variables. Namely, if we use a traditional production function, we miss the effect of IT on the economy through TFP. As a result, we overlook the fact that the IT revolution can raise potential growth as a sustainable long-term economic growth rate without accelerating inflation.

Since IT related time series data, such as real net IT capital stock, have not been prepared yet in most ASEAN countries, we used the data of 108 Japanese industrial sectors that are classified based on the Stages of Development Ladder in East Asia.

The main conclusions from this project are as follows:

- IT did not play an important role in both primary industries and some resource-related industries, implying that these countries are in the early stage of the Development Ladder.
- The higher the stage of the Development Ladder they reached, the more significantly IT affected output in industries.
- IT variables such as quality of capital (IT capital stock / total capital stock) or IT capital intensity (IT capital stock / Labor input) affected output in industries through TFP.
- Output elasticity w.r.t. IT capital stock increased as IT capital stock increased. As the IT revolution advanced, its effect on the economy increased.
- It is useful to know that output elasticity w.r.t. IT capital stock was 0.1 ~ 0.15 for the Japanese manufacturing sector in the mid 2000s, about 0.25 for high-tech manufacturing and about 0.5 for wholesale and retail trade industries.
- As industries moved up in the Stages of Development Ladder, the marginal product of IT capital stock in General Manufacturing in Stage 2, High-Tech Manufacturing in Stage 3 and Finance, Insurance and Real Estate (FIRE) industries in Stage 4, showed an increasing trend. This implies the possibility of improving the economy of scale in these industries as IT capital stock increases.
- If we use time as a proxy of disembodied technical progress in a traditional production function, we miss the opportunity of raising potential growth due to the IT revolution because we ignore the contribution of IT to the output through TFP.
- We can clearly show that Japan's potential output is much higher than the Bank of Japan and the Japanese economists think.
- The effect of IT on the economy may be more significant in Thailand than in Japan.
- We can assume what the different S-Shape production functions are for ASEAN countries by considering our empirical results for the effects of IT on 108 Japanese industries. These 108 industries were classified into several groups representing characteristics of ASEAN countries based on the Stages of

Development Ladder. This method allows us to better understand the different effects of IT on ASEAN economies and show how ASEAN ITC and human development policies increase potential growth by shifting the S-Shape production functions upward through TFP.

We have some following recommendations from this study:

- ASEAN countries should have common IT database and Input-Output tables in order o analyze the economic development of ASEAN through the globalization due to the IT revolution.
- Since “Openness” and “Globalization” are key concepts of the IT revolution, “free flow of information and knowledge” should be added as one more core element to the following five core elements for an ASEAN single market and production base: (i) free flow of goods; (ii) free flow of services; (iii) free flow of investment; (iv) freer flow of capital; and (v) free flow of skilled labor.

CHAPTER 1

Introduction:
The IT Revolution, Globalization, and Economic Progress

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Recent East Asian economic development has been astonishing, thanks mainly to the Information technology (IT) revolution, a process that, in the course of only a few of generations, has benefited many countries in the region in terms of primary production for domestic use and participation in advanced aspects of the global economy. Following Japan, Taiwan, South Korea, Singapore, and Hong Kong have moved rapidly to the most advanced industries and financial services. Other East Asian countries, particularly, China, Malaysia, Thailand, the Philippines, and Indonesia are following in their footsteps.

The pace of development in parts of East Asia reflects fundamental changes in the structure and geography of world production. These changes have been made possible by accumulation of capital, by technical change introducing new technology and by reallocation of resources to industrial activities (World Bank, 1993). In each case, the contribution of information technology has been substantial not only in the form of IT capital, but also as IT technology. Since, as a result of the IT revolution, knowledge, information and technology can radiate instantly among countries, globalization has been a significant contributing factor to economic development. Potentially the most promising mechanism for globalization is the international transfer of ideas and knowledge that are an essential ingredient of economic progress.

In this study, we are concerned with the role of IT in East Asian development. In particular, we discuss the role of IT in economic growth through quantitative analysis. If we do not have any empirical work about the effect of IT on the economy, we may overlook the chance of raising potential growth in East Asian countries.

As Jorgenson (2008) points out

"….a wealth of microeconomic evidence emphasizes the complexity of the link from technology to productivity. To leverage information technology, firms must typically make large complementary investments and innovations for areas such as business organization, workplace practices, human capital and intangible capital." (p. 10)

Jorgenson is particularly concerned here with investment in IT equipment. It is important, moreover, to recognize that complementary activities and organizational changes are especially important if the application of IT is in the infrastructure that connects industries to international markets. Modern low cost high speed communication and transportation services are basic to the transfer of production activities to East Asia and to the management of these operations at all stages of development. The fragmentation of the production process makes possible high tech production in the most advanced countries; production of chips, for example, and low tech operations, like assembly, in low wage countries. International transfers of programming services are possible on an efficient basis as a result of high speed electronic communication but require highly trained programming operators found only in some locations.

The role of the IT operations is very different in different East Asian countries as well as in different industries. The effectiveness of IT depends on not only IT infrastructure but also on other factors such as management style, human capital, culture, language and so on.

In this research, first we consider the conceptual issues that determine the role of IT in East Asian development. We then do empirical studies about the role of IT in the production function. This is the first stage of more extensive work covering various countries and industries.

Since the time series data of IT variables such as IT capital stock and IT service flow have not been prepared in most ASEAN countries, we use the time series data of IT variables for 108 Japanese industries by classifying the 108 industries into several groups that represent the characteristics of East Asian countries based on the Stages of Development Ladder. By doing the empirical work about the effect of IT on these

Japanese industrial groups, we can extrapolate the effect of IT on the economies of East Asian countries.

It would be very helpful if each East Asian country would construct IT time series data based on common definitions. This would enable each country to estimate a new production function of its own and, as shown in this study, find the possibility of potential growth that is higher than what is derived using a traditional production function.

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CHAPTER 2

The IT Revolution and East Asian Economic Growth

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1. IT and East Asian Development

IT has clearly made a substantial contribution to economic growth, globally, and in East Asia. The challenge faced by the researcher is to disentangle the various mechanisms that relate the use of IT capital to technology and economic development.

Over the past decade, East Asian countries have made considerable progress in advancing their information and communication technology (ICT) capabilities. Yet, they differ considerably among themselves and some still have a long way before they can make full use of the new technologies.

Table 1: Computer/ Internet Statistics

	Computers per 1000 people				**Internet Subscribers per 1000 people**	
	2001	2006			2003	2009
China	19	56			8	77
Hong Kong	186	698			186	295
Indoesia	11	20	(2007)		0.3	7
Malaysia	126	231			5	61
Philippines	22	72			0.7	19
Singapore	506	743	(2007)		100	237
South Korea	256	575	(2007)		24	338
Taiwan	n.a	694			134	216
Thailand	28	67			0.7	15
Vietnam	12	96			0.1	30
Japan	349	407	(2003)		117	249

Source: World Telecommunication/ICT Indicators Database, 14th edition 2010

As the statistics in Table 1 indicate, some of the East and Southeast Asian countries are at the forefront in the use of computer equipment. All have made progress from 2001 to 2006 but some still lag far behind on the negative side of the "digital divide". In terms of computers per capita, the smaller countries, Hong Kong, Singapore, Taiwan, and South Korea have reached levels comparable (and in many cases ahead of) advanced countries like Japan. On the other hand, Indonesia, Thailand, Vietnam, and the Philippines, still lag far behind in computer ownership, as does China. Similar differences, that reflect differences in real per capita income and urbanization, are also apparent in the statistics for Internet subscribers. This suggests that availability of computation facilities and interconnections at the consumer level is significantly different among East Asian countries, high in some but very low in others. The availability of computers for manufacturing and commercial use may not be as different as these figures suggest, as these are often determined by international enterprises. Spending on ICT equipment (Table 2) follows somewhat similar patterns, reflecting differences in economic wellbeing. In terms of shares of GDP, expenditures on ICT products increased from 2001 to 2008 in most of the countries except Vietnam and Japan, and have reached the range from 5 to 9 percent of the GNP in 2008 (Table 2). In terms of dollar per capita, however, the differentials remain very large reflecting the large differentials in per capita income that remain in East and Southeast Asia.

Table 2: ICT Spending Statistics

	ICT Spending as Percent of GDP			**ICT Spending $ per capita**	
	2001	2008		2001	2008
China	5.7	9		53	195
Hong Kong	8.7	9.2		2110	2839
Indonesia	2.2	3.3		17	74
Malaysia	6.6	9.7		262	797
Philippines	4.2	6.1		41	113
Singapore	9.9	7.1		2110	2663
South Korea	7.4	9.1		676	1734
Taiwan	n.a.	n.a..		n.a.	n.a.
Thailand	3.7	6.2		76	251
Vietnam	6.7	4.9		26	51
Japan	9.6	6.7		2250	2571

Source: World Telecommunication/ICT Indicators Database, 14^{th} edition 2010

Another approach to evaluating the roles, actual and potential, of ICT in East Asian economies is by way of the WEF (World Economic Forum) Network Readiness Indexes. These computations involve some hard data based measures, like the ones shown above, as well as some judgmental survey estimates by business people knowledgeable about the different countries. The data are shown as values and rankings for overall network readiness, and for subsidiary categories: Environment, Readiness, and Usage. (We show only the rankings here). From the perspective of the total index, a few of the East and Southeast Asian countries rank high—Singapore, 2: Hong Kong, 8, Taiwan, 11 in October 2009. But most of them remain in the middle range. It is interesting that total rankings in 2009 for the countries except Indonesia are better than their own rankings in network environment. This implies that East Asian countries can utilize IT infrastructure better than other countries. The relative positions of most of the countries have improved during the past six or seven years.

Table 3: WEC Network Readiness Estimates

	Rankings of 104 countries	**Rankings of 130 countries**		**Environment**	**Readiness**	**Usage**
	2003	October-09		October-09		
China	41	37		57	19	36
Hong Kong	18	8		15	9	6
Indonesia	73	67		66	43	89
Malaysia	25	27		37	11	28
Philippines	60	85		95	79	72
Singapore	2	2		9	1	4
South Kore	20	15		27	21	1
Taiwan	17	11		21	10	5
Thailand	38	47		50	46	50
Vietnam	68	54		69	37	67
Japan	12	21		22	36	14

Source: World economic Forum Network Readiness Indexes

2. Economy-Specific and Sector-Specific Views of IT

Another perspective, that is important in explaining East Asian growth, is the role of IT in the variety of East Asian economies and to recognize the likely differences in the impact of IT in the different sectors.

The requirements for IT vary considerably in the different East Asian economies and in their various sectors. Thus, in the most advanced countries like South Korea and Taiwan, producers of sophisticated products like chips and computers require a high level of mechanization and IT capital equipment. Countries that are at much earlier stages of development like the Philippines and Indonesia, where wages are relatively low and where IT products are assembled or packaged, may operate with much less advanced equipment and methods. Other countries, like Malaysia and China may have some industries at the technological frontier while other sectors are still at a pre-IT stage of development. Consequently, we anticipate that our empirical work on East Asia will show important differences in the role of IT among the East Asian countries, differences related to their relative stage of development, industrial structure, and labor costs.

IT activities to be considered include not only the information technology and communications industries but also IT's effect on productivity in the evolving East Asian development process. These activities have played decisive roles in the development processes, which, moreover, vary greatly depending on the country considered and its stage of development.

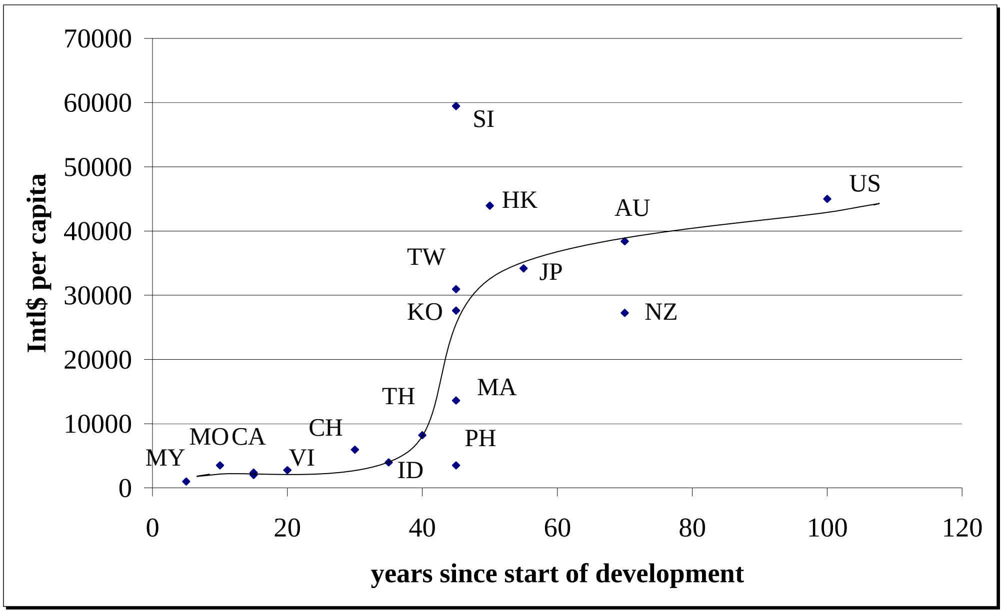
3. The Product Cycle and the East Asian Development Ladder

The product cycle (Vernon, 1966) helps to explain the gradual movement of production facilities from advanced countries to less developed areas and provides a framework for visualizing the development of the East Asian region. Vernon considered the production and exports of a product beginning in an advanced country, the United States. At first, a new industry builds up in an advanced country and uses its home production facilities as a base for supplying the domestic market and for exporting. Over time, as the product becomes standardized and as producers become aware that it can be produced more cheaply elsewhere, typically because of lower labor cost, manufacturing is shifted to less developed countries, and the advanced country becomes an importer. Foreign direct investors and managers sent abroad play an important role in this pattern of trade.

East Asian development is an interesting illustration of how the product cycle process has helped the East Asian countries integrate into the modern world economy. One after another, the East Asian countries have gone from being poor producers of agricultural products to world scale suppliers of advanced manufacturers. Some of the smaller East Asian countries, like South Korea, have gone all the way from subsistence agriculture to modern industry. China has leap-frogged its way into the world economy by hinging much of its development on world export markets, as other East Asian countries have done before. (One should not, however, ignore the high rates of investment and total factor productivity of industries directed at the Chinese internal market).

Figure 1 illustrates the S-curve of East Asian development. The growth path of most of these economies has followed an S-shaped curve, with initial slow growth, then rapid development, and finally a slower growth path as they have achieved a degree of economic maturity. In the chart, the horizontal axis shows for each country the number of years since the start of rapid economic growth. For Japan, that means some 60 plus years since the end of World War II. Other East Asian countries began a growth spurt somewhat later, for example, South Korea after its war, Singapore after separation from Malaysia in the early 1960s and China at the end of the 1970s when it turned toward a market economy. On the vertical axis, we show for each country the per capita GDP on a purchasing power equivalent basis. The points lie broadly along an S-curve. Initially, growth seems to be slow, then accelerates rapidly as countries develop foreign markets and the internal market grows, with the countries acquiring the more advanced technologies of their neighbors already ahead on the development path. Finally, when countries mature, growth comes more slowly as costs are high and advanced techniques must be developed at home.

Figure 1 :The S-Curve of east Asian Growth



China (CH)	HongKong (HK)	Korea (KO)	Mongolia (MO)	Taipei (TW)	Cambodia (CA)
Indonesia (ID)	Laos (LA)	Malaysia (MA)	Myanmar (MY)	Philippines (PH)	Singapore (SI)
Thailand (TH)	Vietnam (VI)	Japan (JP)	Australia (AU)	New Zealand (NZ)	United States (US)

The growth ladder process lies behind this development path on which China is now by far the leading participant. The explanation for the sequential pattern of East Asian development lies in the changing patterns of comparative advantage and technological competence as countries advance. At the beginning, the East Asian countries were very poor, with low wages, and little capital and technology. They had little finished product to export, only simple consumer goods with a reputation for shoddiness. As these countries developed and gained the benefits of direct foreign investment, they began to send low cost but quality product to market. Eventually, wages and costs rose, and labor-intensive production like assembly work became less competitive. The production of labor-intensive products was shifted abroad to neighboring countries, on the next step down on the development ladder, where costs were lower. The advancing country turned to more sophisticated products, to more capital- and technologically-intensive goods. This sequence of events, as described in table 2.4, represent the Stages of Development Ladder. The beginning stage (Stage 1) represents primary production taking advantage of cheap abundant land and labor. The next stage (Stage 2) represents labor-intensive manufacturing. This ranges from labor-intensive assembly production of simple products like clothing and toys to more mechanical products like consumer electronics. Stage 3 focuses on more advanced products, including high-tech manufacturing like computers, digital cameras, and machine tools that require capital-intensive technically sophisticated inputs. And, finally, there is the sophisticated service stage (Stage 4) calling for financial, programming, and management services that require a highly educated labor force.

This sequential development process described here represents an international application of Vernon's product cycle (Vernon 1966). Rising production costs and maturity of the production process made it more economical to produce goods in less advanced lower wage countries. As countries advance economically, they "hand off" industries to less advanced neighbors. Fujita *et al*. (2001) describe the process as follows:

> "…the process of industrialization is not uniform across countries. Instead, it proceeds in a series of waves with countries successively undergoing rapid industrialization as each establishes a critical mass of industry. Successful industrialization, however, raises wages—given our continuing growth of demand for manufacturers—and thus eventually prepares the way for the spread of industry to yet another country". (p. 273)

Note the role of wage differentials and of increasing returns to scale—critical mass—in this discussion that reflects the thinking of the "new economic geography."

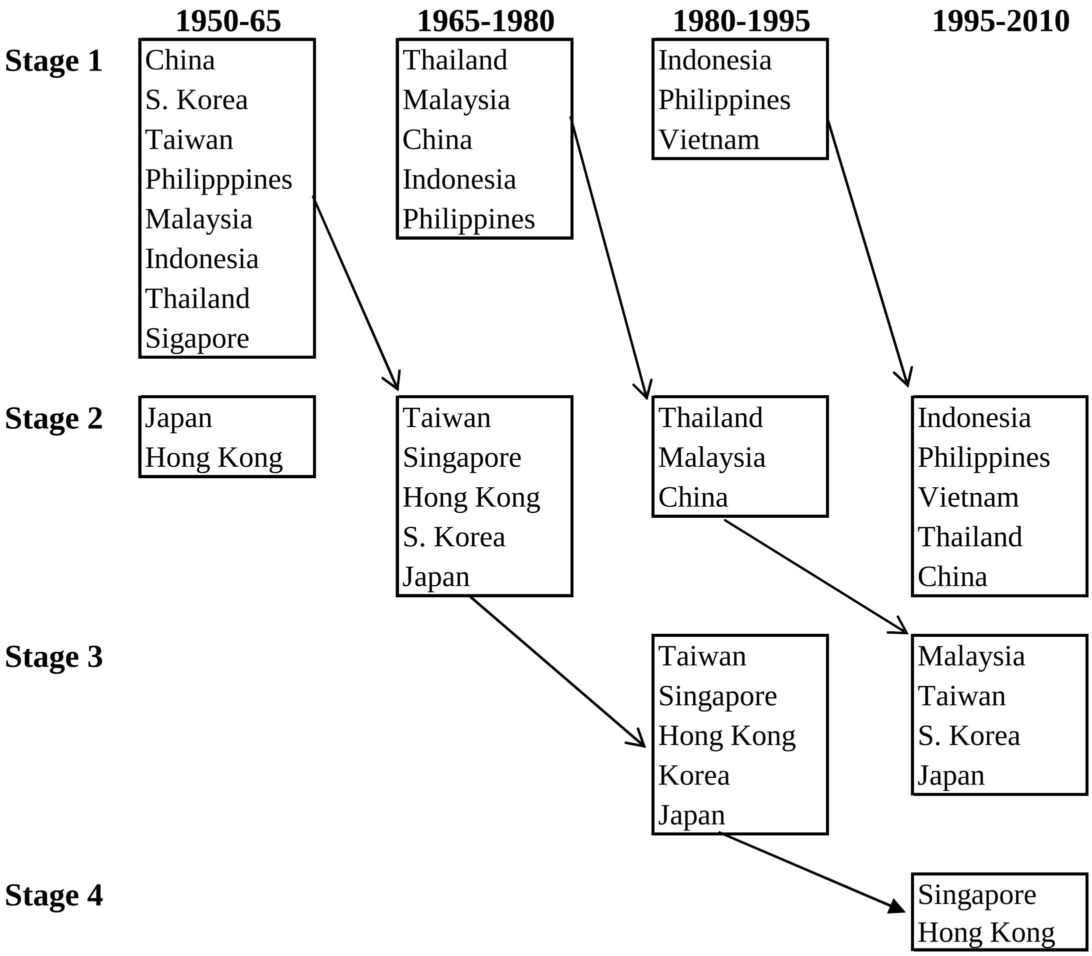
Often managers and technicians from one country will help develop the industry in neighboring countries; skilled technicians from South Korea setting up manufacturing operations in Malaysia and Indonesia, for example. FDI plays an important role in this process.

Table 4: The Stages of the Development Ladder

		Product Category		Resource Requirements
Stage 1	**Primary Products**			
		Raw foodstuffs		Abundant cheap land and labor
		Processed foodstuffs		Mineral and energy resources
		Minerals + fuels		
Stage 2	**Labor-intensive manufactures**			
		Basic textiles		Low cost labor
		Garments		Transport
		Athletic shoes		
		Leather goods		
		Toys		
		Electronic assembly		
Stage 3	**High-tech manufactures**			
		Motor vehicles		Technically skilled labor
		Televisions		Capital management
		Cell phones		
		Computers		
		Pharmaceuticals		
		Machinery		
Stage 4	**High-level services**			
		Programming		Educated labor force, language
		Movies and entertainment		Communications network
		Finance		
		Management		

The progress of the product cycle and development ladder in East Asia is described in figure 2.2. The period from 1950 to 1965 was a period in which Asia was largely a producer of primary products, only Japan and Hong Kong were major producers for the world market and their exports were largely simple manufactured products like textiles. The time from 1965 to 1980 saw some upgrading as Singapore and South Korea joined Hong Kong and Japan into the Stage 2 category producing manufactured goods for the world market. More recently, from 1980 to 1995, we show a number of East Asian countries becoming leaders in the market for more sophisticated products: cameras, televisions, automobiles, and other advanced consumer goods. These call for a high level of manufacturing skill, capital intensity, and advanced technology. Taiwan, Singapore, South Korea and Japan were the leaders in these products. In the period 1995 to 2010, still further shifts have occurred; Singapore and Hong Kong joined the advanced service economy, too costly and too small in size now to be competitive in manufacturing, they have become financial and managerial centers. Japan, however, remains a manufacturing economy specializing in high-level electronics and machinery and cars.

Figure 2: The Stages of the Product Cycle Process



4. The Role of IT in the East Asian Development Ladder

The IT revolution has played a substantial role in the product cycle process related to East Asian development. But this role varies greatly depending on the stage of development that each country has attained.

In Stage 1, there is little function for IT except as a mechanism for ordering, accounting, market clearance and finance. Primary industry production does not involve information technology or computers. Subsistence agriculture is not capital or IT intensive. Mining requires large scale capital but little involving modern IT.

Stage 2, mass production of simple products, similarly does not call for much direct use of information technology, though as countries advance the use of machinery to automate the assembly process increases. In this case, however, industry may rely heavily on an IT infrastructure for communications and financial management. Note, moreover, that assembly of electronic products falls into this category. Many of the sophisticated IT devices now available to consumers, like cellular telephones, are assembled, albeit by often by hand, in factories located in Stage 2 areas.

Stage 3 involves all the dimensions of IT. The production of sophisticated products, like computer chips, and the design and manufacturing of advanced mechanical products, such as cars, relies increasingly on electronic controls, information technology and communication. Industries in this group compete directly with the products of advanced countries in Europe, Japan, and North America, where industrial processes are largely controlled electronically. These industrial operations require a high level of technological competence that is available in some, but not all, countries of East and Southeast Asia.

Stage 4, the sophisticated service industries are greatly dependent on highly developed IT networks linked to a global network. IT activities relevant to high level services run the gamut from large computer and communications systems necessary for the development and transmission of computer code, to banking systems, computerized management tools, and equipment for movies and TV.

It is apparent that IT has played an increasingly important role as East Asian countries have gone from primary production to more sophisticated stages of the production process.

5. Implications for Industrial Structure and IT

As we have noted, the nature of the East Asian growth process has important implications for industrial structure and for the role of IT. At an early stage in the process, industrialization depends on the use of hand labor in industry, for assembly or manufacture of simple products. Industrialization proceeds as unskilled low wage workers are drawn into industrial centers. At this stage of development, the role of IT is limited, largely to control the channels of supply and delivery, since little, if any, sophisticated machinery is used in production.

At more advanced stages of development, the role of IT in industries increases, both in manufacturing industries for export markets and as IT utilization in the production process. The sophistication of products increases, so that countries like South Korea have become primary producers of sophisticated chips and of products like advanced TVs that include sophisticated IT equipment. At still more advanced stages, like the level of development we observe in Hong Kong and Singapore, the role of industry diminishes to be replaced by management, finance, and communication, all of which require high levels of communication and computer connections.

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CHAPTER 3

The IT Revolution and New Production Functions for the IT Economy

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1. IT Revolution Raised U.S. Potential Growth

Economists in the United States were pessimistic about potential U.S. growth in the early 1990's. In those days the consensus about the U.S. potential growth rate among economists was 2.0% - 2.5%. The thinking behind this was they believed that the U.S. economy had matured and that most great innovations had already taken place. However, a few economists noticed that the ongoing economic recovery was different from the usual patterns of the past, such as when the U.S. economy started to recover from the recession of 1990Q4-1991Q1[1]. Namely, in the traditional pattern of economic recovery, capacity utilization of capital stock rose first, followed by employment increases. This time, however, the traditional economic recovery pattern was not there. In short, economic recovery was brought about by an increase in productivity. In particular, output rose due to factors other than capital and labor input. It was an economic recovery by increase in total factor productivity (TFP).

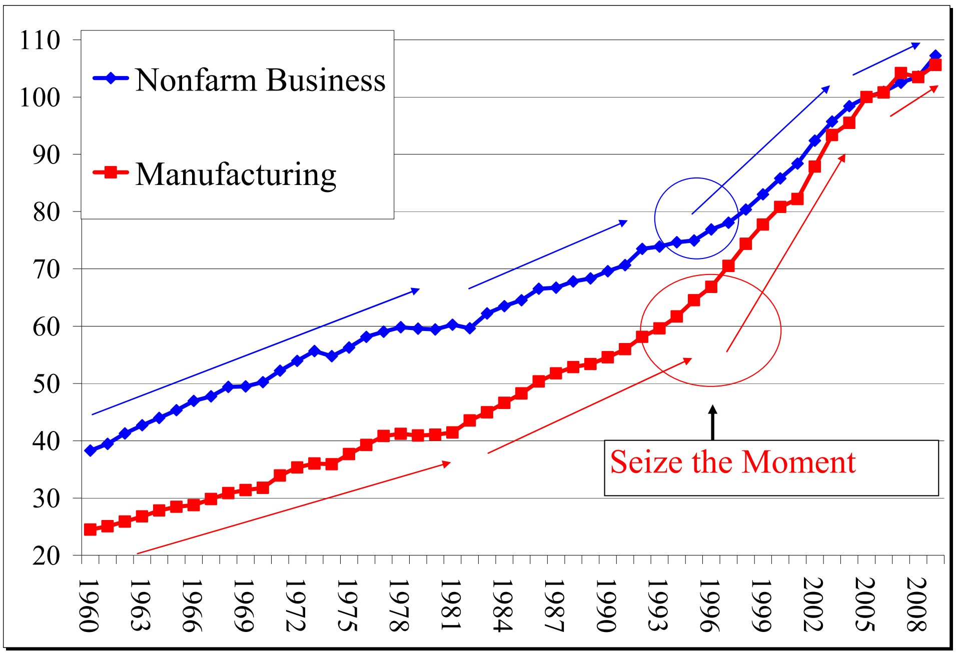
Since 1994, as seen in graph 3.1, there has been a sharp increase in the productivity trend in the U.S. manufacturing sector. It usually takes at least 3-5 years for a productivity trend change to clearly appear in economic statistics. It is important, therefore, whether economic policymakers can make economic policies that will respond to the increase in productivity trend. They would need to be aware of this productivity trend increase sooner rather than later, in 1995 for example, in the 1990s period. It was propitious for the U.S. economy that there were some economists who insisted that the productivity trend had been improving in the middle of the economic recovery. In the book "The Rising Tide" edited by Jerry Jasinowski, economists insisted that there was the possibility that the U.S. economy could grow faster than the conventional wisdom, which held that U.S. potential economic growth was 2%-2.5%, without accelerating inflation[2]. In addition, then-Federal Reserve Chairman Alan Greenspan admitted there was the possibility of an increase in the U.S. potential growth rate due to a rise in the productivity trend brought about by the IT revolution. Alan Greenspan said in March 1997: "The nation's productivity is greater than the statistics

[1]For example, Lawrence R. Klein &YuzoKumasaka"The Re-Opening of the U.S. Productivity-Led Growth Era" NLI Research report, 1995, No.76

[2]see "The Rising Tide" edited by Jerry J. Jasinovwski (John Wiley & Sons, Inc. 1998) for detail.

acknowledge" and told Congress that Fed policymakers would have to decide whether the expansion "will continue to be met by solid productivity growth."[3] Greenspan hardly raised interest rates even though the economy was growing at an annual rate of more than the conventional potential growth rate of 2.0%-2.5% (graphs 3.2 and 3.3). For example, the average growth rate of real GDP during the period of 1995Q3 ~ 1999Q4 was 4.5%, much higher than the conventional potential growth rate. Nonetheless, the Federal funds target rate was cut from 5.75% in 1995Q3 to 5.00% in 1999Q4. As a result, in the 1990s, the economy achieved economic growth rates that were much higher than the traditional idea of 2%-2.5% without accelerating the inflation rate, resulting in the longest economic expansion since the end of World War II. The Federal budget had a surplus during the period of 1998-2001. Economists finally admitted among themselves that the U.S. potential economic growth had risen from 2% - 2.5% to about 3.5% - 4.5%.

Graph 3.1：Productivity Trends for U.S. Business and Manufacturing Sectors 1992=100

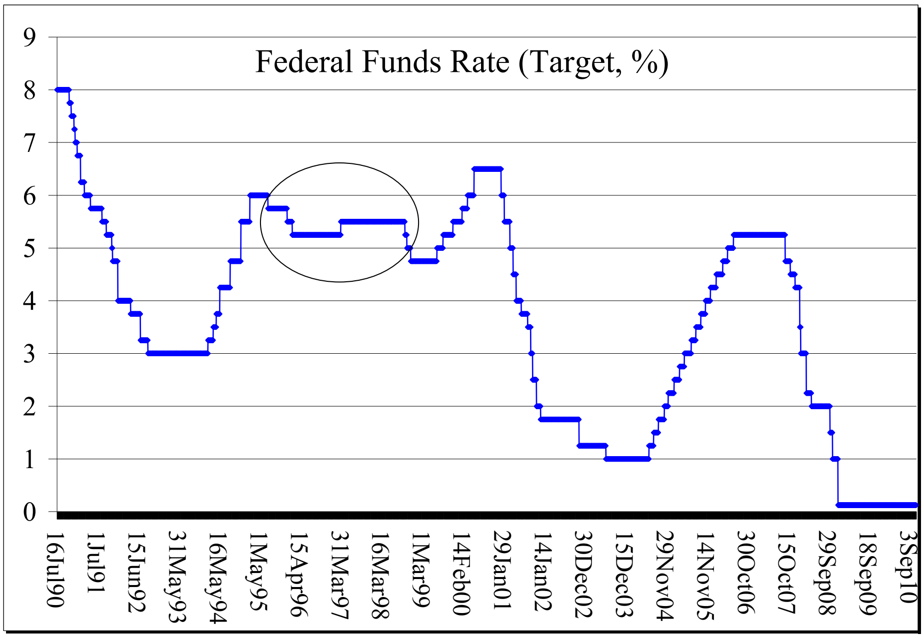


[3]New York Times, "Greenspan's Limited Faith in the Nation's Productivity"March 26, 1997.

It is an obvious fact that this increase in the potential output growth was brought about by the IT revolution. According to Dale W. Jorgenson's study, the average labor productivity growth rate during the period of 1995-2002 was 2.43%, 1% higher than both the 1.36% during the period of 1973-89 and the 1.40% during the period of 1989-95 (table 3.1). IT contributed more than half of this 2.43%. The IT contribution to labor productivity during the 1995-2002 period was 1.35% with 0.88% from IT capital deepening and 0.47% from the rise of TFP due to IT.

What is more fortunate for the U.S. economy is that the effect of the IT revolution has been very visible in the U.S. manufacturing sector. Indeed, it was Jerry J. Jasinowski, then president of the National Association of Manufacturers, who proposed the "The Rising Tide" Project. As seen in graph 3.1, productivity trends in the nonfarm sector and especially in the manufacturing sector have improved since 1995 and show signs of a "New Economy." The average growth rate of labor productivity in the U.S. manufacturing sector rose by 1.5% from 3.0% during the 1981-1994 period to 4.5% during the 1995-2005 period and that in the nonfarm sector also increased by 1.0 from 1.7% during the period of 1981-1994 to 2.7% during the period of 1995-2005.

Graph 3.2：U.S. Monetary Policy： Federal Funds Rate (Target, %)



Graph 3.3: Real GDP vs. Conventional Potential Growth Rate (%,saar)

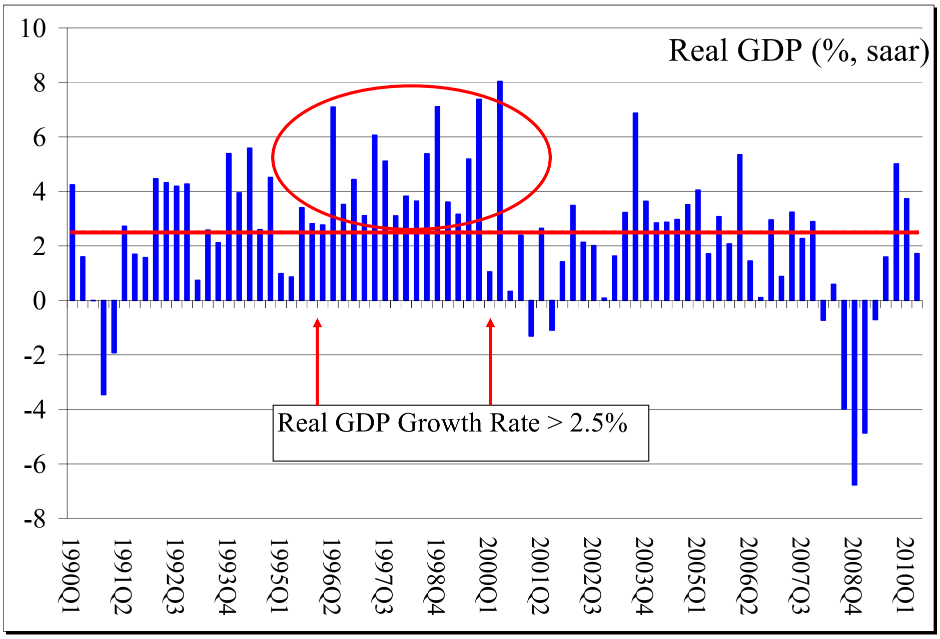


Table 3.1 : Sources of Average U.S. Labor Productivity Growth

	1973-89	1989-95	1995-2002
Average Labor Productivity	1.36	1.40	2.43
Capital Deepening	0.85	0.78	1.52
IT	0.34	0.44	0.88
NonIT	0.51	0.34	0.64
Quality of Labor	0.23	0.36	0.2
Total Factor Productivity	0.29	0.26	0.71
IT	0.2	0.23	0.47
NonIT	0.09	0.03	0.24

Source: summarized from Table 2.7 "Sources of Average Labor Productivity Growth" "Productivity" Volume 3, Dale W. Jorgenson, Mun S. Ho, and Kevin J. Sitroh, 2005

2. Why was Japan's Potential Growth Rate Considered to be So Low?

Japan overlooked the effect of the IT revolution on its economy in the latter half of the 1990s because, unlike in the United States, the effects of the IT revolution were not all that obvious. As seen in the official report "Japan's 21st Century Vision"[4] published by the Japanese Cabinet Office in April 2005, Japanese policymakers considered 1.5% to be the Japanese potential growth rate and they tried to formulate economic policies under that assumption, thus underestimating Japan's economic potential, even though the IT revolution was been progressing. What is worse is that Bank of Japan reported in the December 2009 *Outlook for Economic Activities and Prices* that the potential growth rate during the current projection period declined to "around 0.5%" from "around 1 percent" estimated in the April 2009 *Outlook for Economic Activities and Prices*."[5]

So, why did Japanese economists and policymakers fail to appreciate Japan's potential growth rate? The reason is that they measured Japan's potential growth rate without considering the effect of the IT revolution on the economy. They came to their conclusions using the traditional methods explained below.

2.1. Peak-to-Peak Approach

This is the simplest method and is often used to understand the potential growth rate. Draw a graph of the real GDP and connect the peaks. The average growth rate between the peaks is considered the potential growth rate (graph 3.4). According to graph 3.4, the potential growth rate during the 1973-91 period was about 6% and declined to 1.4% during the 1991-1997 period and to 1.2% after 1997. Or it can also be concluded that Japan's potential economic growth has been about 1% ~ 1.5% since 1991. If there were no structural changes in the Japanese economy in the 2000s, this would be correct. Indeed, there were no explicit statistics for improving Japanese labor productivity due to the IT revolution in the latter half of 1990s, but the IT revolution has been steadily affecting the Japanese economy. We need to analyze how the IT revolution has been influencing the Japanese economy in order to correctly measure Japan's potential growth.

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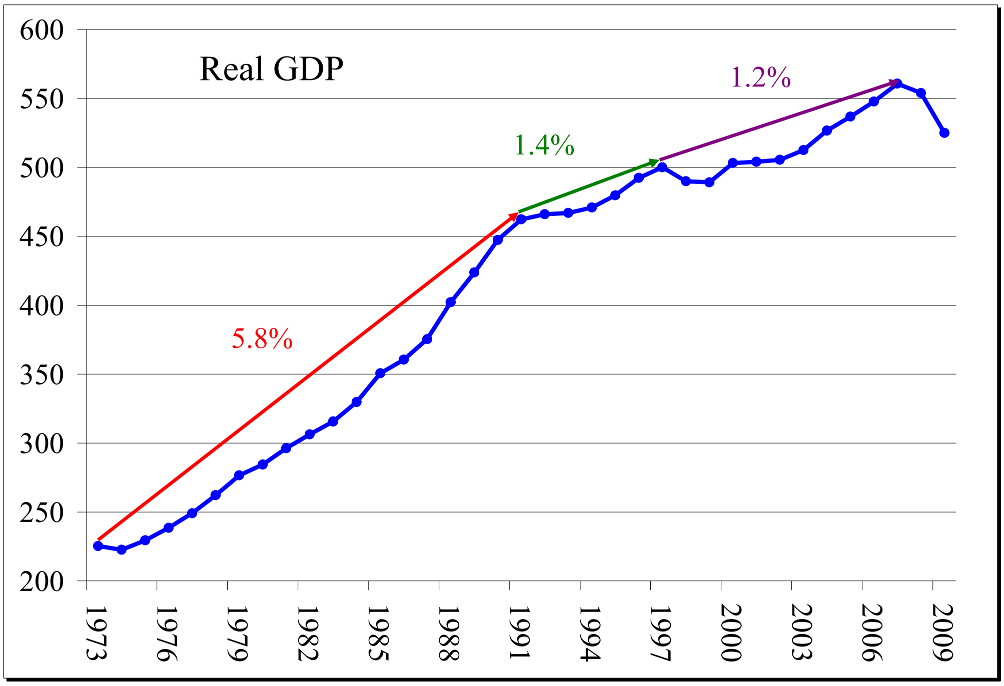
[4] http://www5.cao.go.jp/keizai-shimon/english/publication/pdf/050419visionsummary_fulltext.pdf
[5] http://www.boj.or.jp/en/type/release/teiki/tenbo/gor0910a.pdf

Graph 3.4 : Measuring Japan's Potential Growth Rate using the Peak-to-Peak Approach



2.2. Labor Productivity Approach:

Economic Growth Rate = Labor Productivity Growth Rate + Labor Input Growth Rate

The real GDP is separated into labor productivity (GDP/L) * labor input (L). Thus, the potential growth rate as a sustainable economic growth rate without accelerating inflation is calculated as follows:

Potential Growth Rate ≡ Growth Rate of Labor Productivity Trend + Maximum Growth Rate of Labor Input

Table 3.2 shows that the average growth rate of labor productivity during the period of 1991-2006 was 1.4%. It may be acceptable for economists to conclude that the growth rate of labor productivity will continue to be about 1.5% in the future because the effects of the IT revolution on the economy have not been obvious in statistics during the first half of 2000s. As for labor input, the average growth rate of the employed for the same period was almost zero but there were negative growth rates during the period of 1998 – 2003 where the average growth rate was -0.97%. Even if economic policies are adopted that gear toward increasing the participation rate for older people, women, and immigrant workers in the labor market, it is realistic that the growth rate of labor input will be in a range of zero ~ -0.5% in the future. In short, it might have been reasonable for economists to conclude in the early 2000s that Japan's potential growth rate would be 1.0% ~ 1.5%.

Table 3.2 : Japan's Labor Productivity Growth Rate and the Growth Rate of Labor Input (%)

	Employed	Labor Productivity
1991	2.04	1.69
1992	1.12	−0.51
1993	0.38	−0.32
1994	0.10	0.55
1995	0.12	1.59
1996	0.41	3.04
1997	0.70	0.67
1998	−1.18	−0.55
1999	−1.37	1.46
2000	−0.63	2.97
2001	−0.75	0.31
2002	−1.56	2.23
2003	−0.33	2.31
2004	0.22	2.49
2005	0.37	2.74
2006	0.44	1.28
Average	0.01	1.37

2.3. Production Function Approach

Most economists often measure the potential growth rate using a production function. They estimate a production function of the real GDP using capital stock (K), labor input (L) and time trend (t), which is a proxy to obtain technical progress rate per year (λ) (eq. 3.1a and eq. 3.1b). Once they have estimated this production function, they can calculate the potential output by using the maximum input of both capital stock and labor inputs.

$$Y_t = A_t * K_t^{\alpha} L_t^{\beta}$$ ………………………... eq. 3.1a

Where

A_t = exp(λ*time) …………………………………………………..eq. 3.1b

In order to estimate eq. 3.1a, economists usually assume constant returns to scale and decreasing marginal product of both capital and labor. This production function has the following characteristics:

- Constant returns to scale （α＋β=1） where α and β are constant.
- Marginal products w.r.t. K and L are decreasing.
- Disembodied technical progress, which applies equally and alike to all resources of men and machines in current use, is assumed. The technical progress rate is constant (λ).

Table 3.3 shows the estimation result for the eq. 3.1a. We find the following:

- Disembodied technical progress occurs at an annual rate of 1.04% (λ) every year.
- α＝0.18：Real GDP increases by 0.18% when capital stock (K) increases by 1%.
- β=0.82：Real GDP rises by 0.82% when labor input increases by 1%.

The average growth rates of K and LH (Man-hours) during the sample period of 1991-2006 were 2.62% and -0.76% respectively. By assuming these growth rates in the future, the growth rate of the real GDP is calculated to be 0.89% (table 3.4). We can understand why the Bank of Japan reported in the December 2009 *Outlook for Economic Activities and Prices* that the potential growth rate during the current projection period declined to “around 0.5%” from “around 1 percent” estimated in the

April 2009 *Outlook for Economic Activities and Prices.* If the growth rate of man-hour (LH) is assumed to be zero, the potential growth rate is calculated to be about 1.5% (=0.47%+1.04%), which is similar to the conclusions derived using the previous two approaches.

Table 3.3 Estimation Results of Eq. 3.1a

Dependent Variable: LOG(V_112)

Method: Least Squares

Date: 10/12/10 Time: 10:46

Sample: 1991 2006

Included observations: 16

LOG(V_112) = C(1)+C(2)*LOG(CU*K)+(1-C(2))*LOG(LH*L_Q) +C(3)*T

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-19.86072	2.955956	-6.718883	0.0000
C(2)	0.181104	0.059353	3.051335	0.0093
C(3)	0.010421	0.001547	6.734078	0.0000

R-squared	0.985768	Mean dependent var	20.01503
Adjusted R-squared	0.983578	S.D. dependent var	0.054457
S.E. of regression	0.006979	Akaike info criterion	-6.924601
Sum squared resid	0.000633	Schwarz criterion	-6.779740
Log likelihood	58.39680	Durbin-Watson stat	2.139349

Note：V_112: Real GDP, CU: capacity Utilization, K: Net Capital Stock

LH: Man-Hour labor input, L_Q: Quality of Labor (2000=1.0) and T: Time trend

Table 3.4: Calculation of Potential Growth Rate from the Estimation Results

	Contribution to Growth	
K	0.47%	(=0.18*2.62%)
LH	-0.62%	(=0.82*(-0.76))
Technical Progress	1.04%	
Total	0.89%	

KEY QUESTION: "Is Japan's potential growth rate only 1.5%", which would mean that it takes about 50 years for income to double? If the Bank of Japan were right, it takes about 140 years for Japan to make income double.

What we should focus on in these three methods is that any method does not fully incorporate the effect of the IT revolution on the economy.

3. S-Shape Production Function

3.1. Characteristics of the IT Revolution[6]

A key to the IT revolution is the improvement of the productivity trend, which leads to an increase in the potential growth rate. The IT revolution has brought about extremely rapid technical progress. It not only has constructed the global information highway but also has enabled shared software and resources through cloud computing. The IT revolution formed an IT capital stock that is different from the traditional capital stock such as machinery and equipment. IT capital stock consists of the following:

- Computer hardware and information equipment.
- Software as a type of human capital.

[6] See in detail "Infrastucture and Productivity: An Extension to Private Infrastructure and IT Productivity" by Vijaya G. Duggal, Cynthia Salzman and Lawrence R. Klein.

- Infrastructure of the information highway such as wireless telecommunications, broadband and the Internet, which create a global network connecting hardware and software.
- Cloud computing, which is Internet-based computing, whereby shared resources, software, information are provided to computers and other devices on demand.

In order to analyze the IT revolution, a new production function is essential to take into account at least the following two topics:

- While the prices of IT assets have been rapidly falling, compared to those of other capital assets, we must explain the relationship between IT capital stock and non IT capital stock. When total capital stock increases, IT capital stock increases more rapidly than the other capital stock. As a result, the quality of total capital stock improves and shifts the production function upward like technical progress.
- The above former effect of IT capital stock on the economy can be treated just like an increase in the input factor of IT capital stock. The effect on the economy of the information highway infrastructure created by IT capital stock is more important. The improvement of the information highway infrastructure contributes to raising economic efficiency for people, firms and government. For example, transaction and search costs are dramatically reduced and network systems combining computers and software bring about the possibility of a scale economy. Specifically, IT capital stock or IT capital intensity can raise Total Factor Productivity (TFP) through the network effect.

In order to analyze the above effects of IT capital stock we have to consider the following factors in a new production function:

- There is the possibility that marginal product w.r.t. IT capital stock is increasing during some period.
- Constant returns to scale should not be assumed.

- Since IT capital stock is considered to be one of the factors in TFP components, we have to introduce endogenous technical progress explained by IT variables.
- Technical progress due to IT capital stock affects the marginal products of labor and non-IT capital stock differently. (We are assuming that IT capital stock influences the marginal product of labor much more than that of non-IT capital stock through the learning effect of IT).
- The effect of IT capital stock on the economy is not the same every year. For example, the output elasticity w.r.t. IT capital stock will be different in 1995 and in 2005. It will increase as the IT revolution penetrates into the economy.

When we grasp the IT revolution above, it is easy to understand that the traditional production function is inadequate in an IT Economy, which suggests that the growth accounting method is not adequate to analyze the effect of the IT revolution on the economy. This is because this method assumes "constant returns to scale" and "perfect competition in input factor markets" where the input factor share is equal to the output elasticity of the input factor. This approach must lead to the conclusion that the effect of the IT revolution on the economy is minor in the beginning of the IT revolution. This is because IT capital stock is very small, compared to non-IT capital stock in the beginning of the IT revolution. Many economists made the same mistake when the first oil crises occurred. They concluded that the effect of the oil crisis was minimal because the energy share in the output was very small. But, the effect of the oil crisis turned out to be huge as the subsequent stagflation showed. Namely, these economists had not analyzed the effect of the energy input factor on the economy using the empirical work of estimating a production function that explicitly includes the energy input factor. Although energy input was small, it was an inevitable input factor for the production. Based on this oil crisis lesson, we need a new production function that clearly includes the IT input factor. In addition, the empirical work for the IT revolution is much more difficult than that for an oil crisis because the IT revolution also affects the economy through the effect of network systems on TFP. For example, if we attach an additional $150 display screen to our PC or laptop and work with two screens, our productivity will dramatically increase. This suggests the importance of analyzing the effect of IT on TFP.

Since the IT revolution influences not only countries very differently but also industries in a country differently, we have to estimate various specifications in a new production function that will fit with each country and each industry in order to propose economic policies in an IT Economy. We can summarize the shift from a traditional production function to a new production function as follows:

Assumptions with a traditional production function:

- Constant returns to scale
- Decreasing marginal product of input factors
- Constant exogenous technological progress

Considerations using a new production function:

- Possibility of scale economy
- Possibility of increasing marginal product of input factor over a certain range.
- Possibility of increasing output elasticity w.r.t. IT capital stock.
- Role of IT input factor as one of the components in endogenous technological progress.
- Non-neutral effect of endogenous technological progress on the marginal products of non-IT capital stock and labor input.

3.2. The S-Shape Production Function[7]

Before we show some examples of a new production function, we will introduce a graph of the S-Shape production function that represents the characteristics of the IT revolution. Graph 3.5 shows the output of Y axis and IT capital stock by X axis. This illustrates the relationship between IT capital stock and output, given that other input factors are fixed at a certain level. Since the production function looks like an S, it is called the S-Shape production function. This production function is more realistic than

[7]See http://cepa.newschool.edu/het/essays/product/prodfunc.htm

a traditional production function, which always shows a decreasing marginal product of any input factor. In particular, since the new input factor of IT capital stock was introduced, the S-Shape production function has played an important role. In the beginning of the IT revolution, the effect of IT capital stock may be very small. But once the revolution reaches a certain level, the effect on the economy will be substantial until it reaches another level. This is illustrated by the range of I1-I2 on X axis on the S-shape production function of S1. And once IT capital stock exceeds the IT capital stock level of I2, the effect will become small again, which is shown by the relationship between output and IT capital stock in a traditional production function where marginal product of IT capital stock is decreasing.

A traditional production function shows the relationship between output and input in the phase of G0-F-I0 where the marginal product of the input is always decreasing. For example, when assuming output to be coal and input to be labor, the labor input has to be more in order to produce an additional one ton of coal than to produce the previous one ton of coal. This is because more labor is needed to dig deeper to produce the additional one ton of coal. The law of decreasing marginal product holds. However, IT capital stock is different. When computers are first introduced, the effect on productivity is small, such as being used primarily as a substitute for typewriters. However, when the speed and capacity of computers develop so quickly and many computers are connected to each other through the improvement of IT infrastructure, the effect of additional computers on the economy becomes much larger than that of the previous generation of computers. Specifically the marginal product of IT capital stock increases in some range. "Metcalfe's Law" is a good example of this. Robert Metcalfe, the founder of 3M corporation, said "The more people there are on a network, the greater the value of the network to each other." This idea is a key to thinking a rise in potential growth rate in an IT Economy.

It is important to find out when the effect of the IT revolution on the economy will start to accelerate in each country and in each industry. If it takes less time for IT capital stock to reach the I1 level in the S-shape production function of S1 and the slope of the S-Shape production function is sharp and large, the IT revolution will significantly affect the economy in a short time.

Now we can develop a hypothesis to solve this problem: "The U.S. economy raised its potential output in the latter half of 1990's due to the IT revolution, while Japan could not." We can assume an S-shape production function of S1 for the U.S. economy and S2 for the Japanese economy. As S1 shows, IT capital stock reached the I1 level in the latter half of the 1990s, indicating that the U.S. economy was significantly affected by the IT revolution in that period. During the I1-I2 range, the marginal product of IT capital stock shows an increase, bringing about the possibility of increasing returns to scale. As a result, the U.S. economy was able to raise its potential output growth from 2%-2.5% to i.e. 3.5%-4.5%.

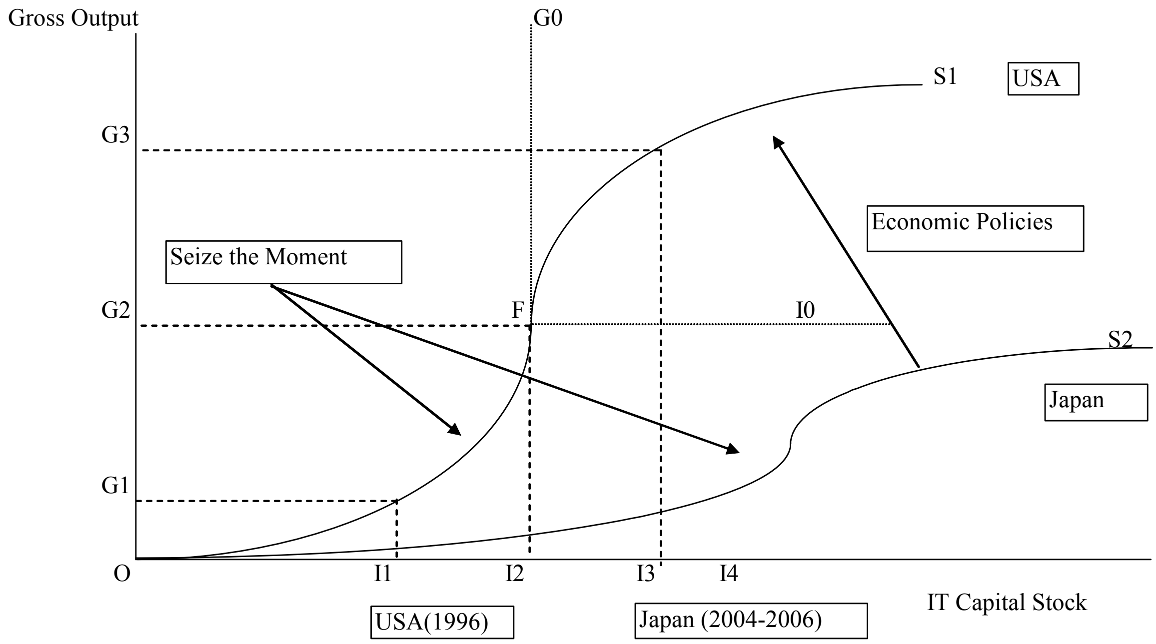
In the case of the Japanese economy, IT will start to significantly affect the economy when IT capital stock reaches I3 on S2. We may interpret that it takes more time for Japan to realize a significant effect caused by the IT revolution than it does for the United States. S1 and S2 show that Japan is behind the United States by 10 years or more. In addition, it is assumed that the effect of the IT revolution is much smaller in Japan than in the United States because the S-shape of S2 is much flatter than that of S1.

Now we have another quandary. The IT revolution has been progressing globally. Japan and the United States have been using the same computers, broadband system and so on. The broadband spread is much wider in Japan than in the United States, so why is Japan behind the United States by 10 years or more, with the effect of the IT revolution on the economy smaller? The answer will also explain why the productivity trend improved in the United States in the second half of 1990s while in Japan it did not.

The IT revolution is different from the traditional technological revolution such as the invention of the steam engine, light bulb and so on. People need education and organizations such as firms and governments must be flexible in order to utilize IT efficiently. To be precise, human capital and culture in countries or firms are very important to the efficacy of the IT revolution. For example, whether there are expert venture capitalists who can find and develop promising start-ups in a country is one important factor. Since the IT revolution has been progressing globally, English-speakers have much more of an advantage than non-English speakers. U.S. companies can outsource some jobs such as call-center and data input work to other English-speaking countries like the Philippines and India. Can firms realize a scale economy through mergers & acquisitions, which take advantage of the IT revolution? Although firms become one company through M&A, the resultant large company may not have improved efficiency because the employees in each company often adhere to their own company's culture. This often happens in the M&As of Japanese companies. Another factor is that people in the United States have their own social security number, which is very convenient in the IT economy. And attitude is important as well. The Japanese have the habit of too readily apologizing, hiding, acquiescing, and being jealous of others' success as shown in the proverb "Go farther and fare worse." These habits do not work with a global economy brought about by the IT revolution. The "hiding" habit is not adequate in the openness of an IT society where people benefit from sharing information. The culture of "Go farther and fare worse" is not going to foster entrepreneurship for innovative and successful young people in the IT Economy. Namely, in a country where the culture and organizations do not fit with the IT revolution and the quality of human capital is low, the S-shape production function becomes flatter. If S1 and S2 represent the United States and Japan respectively, the S-Shape production function for India, Singapore, Taiwan and Korea may be between S1 and S2.

Therefore, in order to improve the productivity trend as well as raise potential economic growth, we should propose economic policies that shift S2 to S1. Nowadays, English capability and computer usage are basic skills in the IT Economy. People, firms and government must be very flexible in order to use IT efficiently.

Graph 3.5：The S-Shape Production Function



3.3. Specifications for the S-Shape Production Function - Example of the Japanese Manufacturing Sector

Theoretically, we set up a transcendental production function that is one of the generalized Cobb-Douglas production function forms[8]. With this function it is possible for marginal products to rise before eventually falling. A key to estimating the S-Shape production function is how we specify Total Factor Productivity (TFP) using input factors including IT variables. Since endogenous technological progress is different for each industry and for each country, we must always find the unique TFP specification that fits each industry and each country[9]. We show, therefore, as one example, the S-Shape production function of the Japanese manufacturing sector, which will give

[8]See "Econometric Models, Techniques, and Application" edited by M.D. Intriligator, R.D. Bodkin and C. Hsiao for Generalized Cobb-Douglas Production Function., p297.

[9]See the following papers for concrete specifications of the S-Shape production function;
"Information technology and productivity: the case of the financial sector",Survey of Current Business, August, 2003 by Lawrence R. Klein, Cynthia Saltzman, Vijaya G. Duggal and their paper in footnote 9
"The Effect of Information Technology on the Japanese Macro-Economy" by YuzoKumasaka and Toshiko Tange, presented at the conference of the Japanese Economic Association on June 10 and 11, 2004.

standard numerical value for the output elasticity w.r.t. IT capital stock when we will estimate the S-Shape production functions for other industrial groups.

In order to analyze the effect of the IT revolution on the economy more correctly, Prof. Klein replaced a Cobb-Douglas production function (eq. 3.1a) with a generalized KLEM production function[10] (eq. 3.2).

$$G = K^{c(2)}L^{c(3)}M^{c(4)}\exp[t^{c(5)}] \exp[c(6)*K/(KIT*L)] \exp[c(7)*(KIT)(I) - c(8)*L/(KIT*I)] \exp[c(1)]$$
…………………………………………………………eq. 3.2

where G: Real Gross Output

K: Real NetTotal Capital Stock

L: Labor Input

M: Real All Intermediate Inputs, excluding Information Service Input (I)

KIT: Real Net Capital Stock of IT (IT capital stock)

I: Real Information Technology Service Input (B to B)

t: Time trend to proxy Disembodied Technology Change

We considered the following characteristics of the IT revolution in the generalized Cobb-Douglas production function:

1: Constant returns to scale (sum of coefficients for primary inputs = 1) is not assumed. We can therefore measure the economies of scale.

[10] Prof. Klein first introduced a generalized Cobb-Douglas production function to analyze the effect of IT on the auto and parts sector in his and his colleagues' paper "Contributions of input-output analysis to the understanding of technological change: the information sector in the United States", p.p. 311-336 in "*Biographical Memoir of Wassily Leontief*", *Proceedings of the American Philosophical Society*, 194 4 (December 2000)

2: Variable elasticities of production w.r.t. input factors and variable elasticity of substitution over the certain range of inputs are permitted.

3: Real gross output is used for the real GDP. Information service flow as an intermediate input may play an important role in the production function.

4: Not only disembodied technical progress but also embodied technical progress is clearly defined. Embodied technical progress is endogenously determined.

Prof. Klein applied this production function to the U.S. automobile and parts sector and financial sector respectively (see footnotes 11 and 12). We modified eq. 3.2 and applied eq. 3.3 to the Japanese manufacturing sector. The estimation result of the aggregated manufacturing industries will be a standard case to compare those of other industries.

$$G = K^{c(2)}L^{c(3)}M^{c(4)}\exp\left[(t*KIT/K)^{c(5)} + c(6)*K/(KIT*L) + c(7)*(KIT)(I) - c(8)*L/(KIT*I) + c(1)\right] \quad \text{eq. 3.3}$$

In this form, one might consider technological change as having both disembodied and embodied elements. The possibility of interaction between embodied and disembodied technological change is considered as $\exp[(t*KIT/K)^{c(5)}]$ in the equation (eq.3.3). KIT/K means quality of capital. The functional form $\exp[(t*KIT/K)^{c(5)}]$ for the time trend is used instead of the more common exp. [c(5)*t] because it allows for a non-constant growth rate over time and is more likely to yield trend stationary dependent variables.

The functional form, exp [c(6)*K / (KIT * L) + c(7)*(KIT)(I) – c(8)*L /(KIT * I)], reveals embodied technological change. [c(6)*K/(KIT*L)] shows that embodied technological change depends on the capital/labor ratio (capital intensity) with labor weighted by IT capital stock. [c(7)*(KIT)(I)] means the interaction of KIT and I. [-c(8)*L/(KIT*I)] indicates that the increase in KIT or I enhances the marginal productivity of labor. Embodied technological change will increase or decrease, depending on the interaction of the values of c(6), c(7), c(8), K, KIT, I and L. The functional form of the information service input and information capital stock, depending on the coefficient values, c(6), c(7) and c(8), specifically allows for an increasing marginal product of I and KIT over some range of I and KIT values.

By forming the natural logarithm of eq. 3.3 we have the structural equation to be estimated:

$$\ln G = c(1) + c(2)*\ln K + c(3)*\ln L + c(4)*\ln M + (t*KIT/K)^{c(5)} + c(6)* K / (KIT * L) + c(7)*KIT * I - c(8) * L / (KIT * I) \quad \text{eq. 3.4}$$

This functional form was developed to analyze the effect of IT on the economy. This is one of several functional forms used to generalize the Cobb-Douglas production function (see footnotes 11 and 12). The implication of this generalization allows for the possibility of a variable returns to scale coefficient, as well as a variable elasticity of substitution.

We used Cu: capacity utilization and Q: quality of labor in the actual estimation for the Japanese manufacturing sector as seen in eq. 3.5.

$$\ln G = -1.359020 + 0.213476*\ln(cu* K) + 0.252301*\ln (L*Q) + 0.607110*\ln M$$

(t=-9.2) (t=5.0) (t=3.7) (t=8.9)

$$+ (t*KIT(-1)/K)^{0.036945} + 0.017612* K / (KIT * L) + 0.019347*KIT * I$$

(t=2.6) (t=2.6) (t=1.9)

$$- 0.292552/1000 * L / (KIT * I) \quad \text{eq. 3.5}$$

(t=5.0)

Sample: 1975-2006, D-W: 1.72, R_2: 0.99

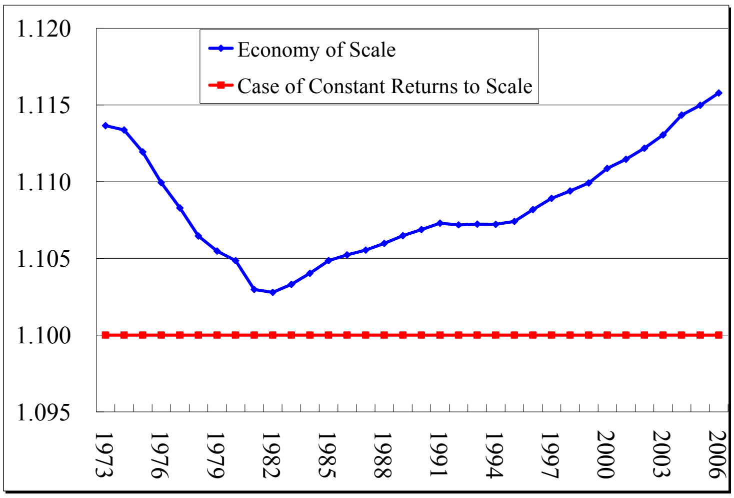
We summarize the most relevant findings as follows:

(i) Variable Returns to Scale

We can calculate the variable economy of scale from eq. 3.5, where we assume that all input grows at 10% every year. In the case of constant returns to scale, output increases by 10% (see the red line in graph 3.6). Returns to scale declined from 1.113 in 1973 to 1.103 in 1981 and then started to increase to 1.116 in 2006. There are very small increasing returns to scale. Although the IT revolution has been steadily advancing, the Japanese manufacturing sector has not benefitted significantly yet from it.

Graph 3.6: Economies of Scale for the Japanese Manufacturing Sector

Assumption: All inputs grow at an annual rate of 10%



(ii) Interaction between Embodied and Disembodied Technical Progress

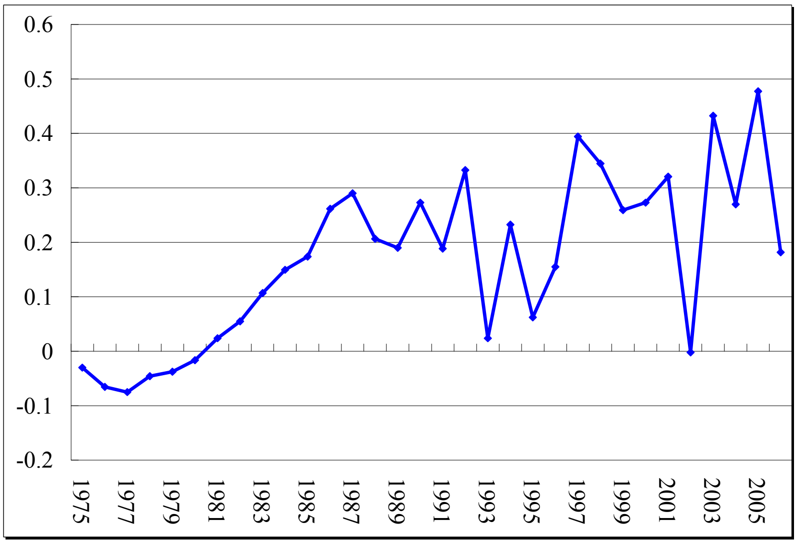
We assume a stationary trend for disembodied technical progress multiplied by the quality of capital. We examine how $\{t*KIT(-1)/K\}^{c(5)}$ affects the growth rate of G in the following calculation:

$$G\_Time \equiv \frac{\partial \ln G}{\partial t} = \{t * \frac{KIT(-1)}{K}\}^{c(5)} * c(5) * \frac{KIT(-1)}{K} \quad \text{..... eq. 3.6a}$$

c(5) = 0.036945 in eq. 3.5.

$$DG\_Time \equiv G\_Time - G\_Time(-1) \quad \text{.................................. eq.3.6b}$$

Graph 3.7: Contribution to the growth rate of G by Interaction between Embodied and Disembodied Technical Change (%, DG_Time *100)



The average contribution to economic growth by the interaction between embodied and disembodied technical progress increases by about 0.2% every year (graph 3.7).

Although this specification works for the aggregated manufacturing sector, it is too complicated to apply to several industrial groups. Also, the economy of scale in the manufacturing sector did not fluctuate significantly at all, as shown in graph 3.6. Therefore, we will apply a less complicated specification to explain TFP by capital intensity (IT capital stock / Labor input) or the quality of capital (IT capital stock / total capital stock). Although we can not measure variable returns to scale in this specification, we do not assume constant returns to scale. We still can measure variable output elasticity w.r.t. IT capital stock and check whether the marginal product of IT capital stock is increasing or decreasing.

We estimate a traditional production function with TFP (time) and a new production function with TFP(IT variables) as follows:

A traditional production function for the Japanese manufacturing:

ln G = -15.83384 + 0.137122*ln(cu* K) + 0.334864*ln (L*Q) + 0.624251*ln M

(t=-6.3) (t=4.6) (t=5.8) (t=10.7)

+ 0.007558*Time ………………………………………………. eq. 3.7a

(t=5.8)

Sample: 1973-2006, D-W: 1.85, R_2: 0.99, ma(1)

Sum of coefficients: 1.096

where

Q: Quality of labor

A new production function for the Japanese manufacturing:

ln G = -13.73593 + 0.078802*ln(cu* K) + 0.349677*ln (L*Q) + 0.733352*ln M

(t=-6.9) (t=2.8) (t=7.9) (t=13.8)

+ 0.005888*Time + 2.481674*{(KIT/L)*(KIT/K)} ………………………. eq. 3.7b

(t=5.5) (t=3.9)

Sample: 1973-2006, D-W: 1.85, R_2: 0.99, ma(1)

Sum of coefficients: 1.162

KIT/L: IT capital intensity (IT capital stock / labor input)

KIT/K: Quality of capital (IT capital stock / Total capital stock)

Since Time was statistically significant in eq.3.7b, we left it in the equation. This was expected because the interaction between embodied and disembodied technological change was statistically significant in eq. 3.5. We can calculate output elasticity w.r.t. IT capital stock as well as the marginal product of IT capital stock from eq. 3.7b.

(iii) **Output Elasticity w.r.t. IT Capital Stock (=ela_MF**G)

We can calculate output elasticity w.r.t. IT capital stock from eq. 3.7a as follows:

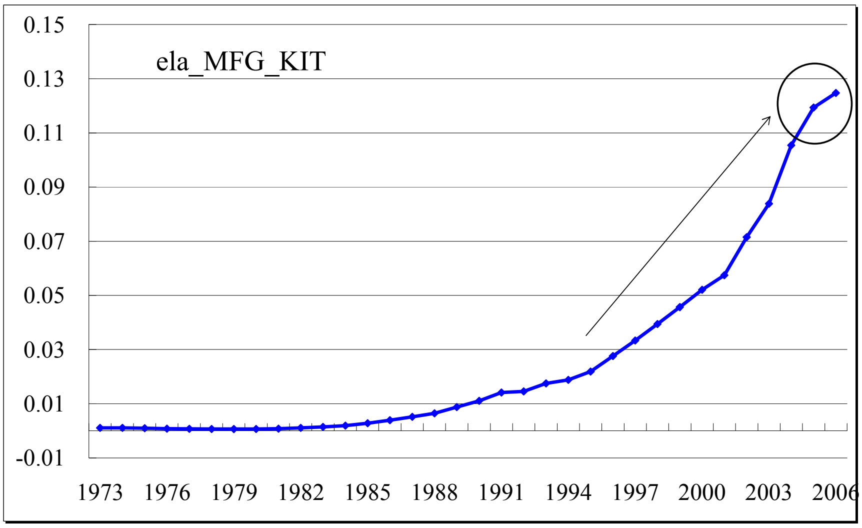
$$ela\_MFG = KIT * \{\frac{c(2)}{K} + \frac{c(6)}{L} * KIT(\frac{2K - KIT}{K^2})\}$$ ……………. eq. 3.8

where

c(2)=0.078802 and c(6)=2.481674 in eq. 3.7b.

Output elasticity w.r.t. IT capital stock started to increase sharply in the mid-1990s when the Internet began to permeate the economy (graph 3.8). Its value is 0.12 in 2006. We can consider this value as a kind of standard when we calculate the output elasticity w.r.t. IT capital stock in other industrial sectors.

Graph 3.8: Output Elasticity w.r.t. IT capital Stock (ela_MFG)



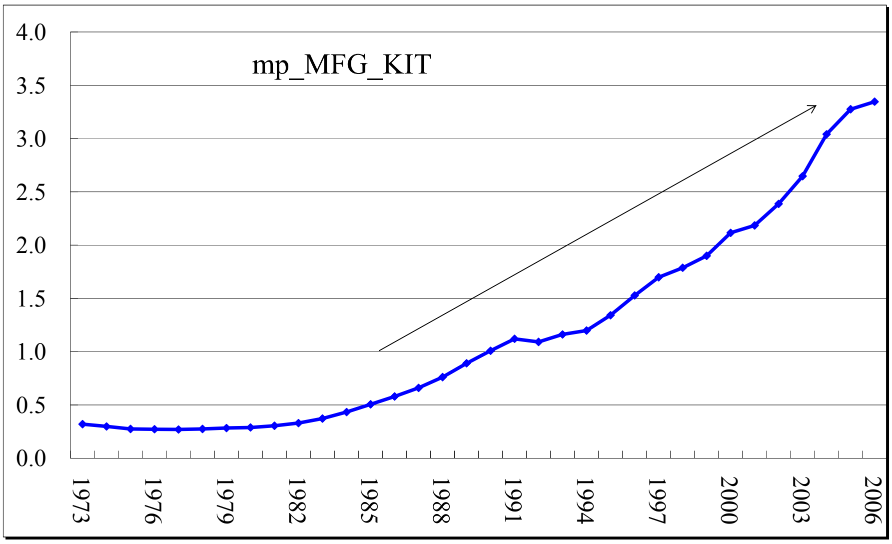
(iv) The Marginal Product of IT Capital Stock (= mp_MFG)

Eq. 3.9 shows the marginal product of IT capital stock calculated from eq. 3.7b.

$$mp\_MFG = G * \{\frac{c(2)}{K} + \frac{c(6)}{L} * KIT(\frac{2K - KIT}{K^2})\} \quad \text{.................... eq. 3.9}$$

The marginal product of IT capital stock has an increasing trend since the mid-1980s (graph 3.9). As long as both output elasticity w.r.t. IT capital stock and the marginal product of IT capital stock are increasing, the Japanese manufacturing sector will have the possibility of having benefited from increasing IT capital intensity or improving quality of capital.

Graph 3.9: Marginal Product of IT Capital Stock (mp_MFG) for the Japanese Manufacturing Sector



(v) Output Growth Rates calculated from traditional and new production functions for the Japanese Manufacturing Sector: A Comparison

We made simulations for how much the output in the Japanese manufacturing sector will grow, using the same assumptions about the growth rates of input factors for both traditional and new production functions (eq. 3.7a and eq. 3.7b). We calculated the average growth rates of output and input for three periods, 1975-2006 (total period: from the end of the first oil crisis to the last sample period), 1975-1992 (pre-bubble period) and 1993-2006 (post-bubble period) in order to make reasonable assumptions for the growth rates of inputs in the $2^{nd} \sim 4^{th}$ rows in each simulation study table (table 3.5a and 3.5b). We show that a traditional production function will produce much lower growth rates of output than a new production function, as IT investment increases. The output growth rate calculated by a traditional production function is lower by 0.35% in the Pessimistic case, by 0.86% in the Standard case, by 1.16% in the Optimistic case and by 1.06% in the Intensive IT investment case (tables 3.5a and 3.5b). Namely, we may underestimate potential output by using a traditional production function. If we assume that IT capital stock increases by 12.0% instead of 9.0% in the Standard case (table 3.5b), output will increase 3.52%, only 0.35% below the average growth rate of the pre-bubble output growth rate.

Since the effect of the IT revolution is quite different among industries as well as countries, we will analyze several Japanese industry groups classified by their stages on the development ladder, implying some similarities with ASEAN countries.

We simplify the new production function of eq. 3.4 introduced by Prof. Klein without losing our primary purpose that a new production function will show higher potential output than does a traditional one.

Table 3.5a: Simulation Studies of the Japanese Manufacturing Sector from a Traditional Production Function. eq. 3.7a

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	K_IT/K(KQ)
Average Growth Rate	1975-2006	2.28	3.29	10.49	-1.01	0.52	1.93	11.62	6.78
	1975-1992	3.87	4.08	12.68	0.19	0.46	3.68	12.45	8.05
	1993-2006	0.49	2.40	8.01	-2.38	0.59	-0.05	10.69	5.33
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	-2.5	0.5	0.0	7.7	2.8
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		0.36	0.29		-0.68		0.0	0.76	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	9.0	-1.0	0.5	2.0	10.1	5.5
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.26	0.44		-0.17		1.23	0.76	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	12.0	0.0	0.6	3.0	12.0	7.3
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		3.39	0.59		0.20		1.85	0.76	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-2.5	0.5	0.0	17.9	12.1
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		0.43	0.35		-0.68		0.00	0.76	

Table 3.5b: Simulation Studies of the Japanese Manufacturing Sector from a New Production Function. eq. 3.7b

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	2.28	3.29	10.49	-1.01	0.52	1.93	11.62	6.78
	1975-1992	3.87	4.08	12.68	0.19	0.46	3.68	12.45	8.05
	1993-2006	0.49	2.40	8.01	-2.38	0.59	-0.05	10.69	5.33
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	-2.5	0.5	0.0	7.7	2.8
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	TFP (KI*KQ)
		0.71	0.17		-0.71		0.0	0.59	0.66
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	9.0	-1.0	0.5	2.0	10.1	5.5
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	TFP (KI*KQ)
		3.12	0.25		-0.18		1.45	0.59	1.00
Assumed Growth Rate (%) **Optimistic Case**		G							
			4.0	12.0	0.0	0.6	3.0	12.0	7.3
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	TFP (KI*KQ)
		4.55	0.34		0.21		2.17	0.59	1.25
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-2.5	0.5	0.0	17.9	12.1
Contribution to Growth Rate of Manufacturing			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	TFP (KI*KQ)
		1.49	0.21		-0.71		0.00	0.59	2.00

4. Estimation of Traditional and New Production Functions for 7 Japanese Industrial Groups Classified by the Stages of Development Ladder and Public Activities Group: A Comparison

4.1. Classification of Industries

We used the Japan Industrial Productivity (JIP) database constructed by the Research Institute of Economy, Trade and Industry (RIETI)[11] because time series data of IT variables such as IT capital stock have not been prepared yet in most ASEAN countries. The JIP database has 108 industrial sectors (table 3.6). According to the "Stages of Development Ladder" in figure 2.2, we classify 108 industries into 4 stages and public activities so that these classified groups are considered to have similarities with ASEAN countries in the Stages of Development Ladder (table 3.6).

Stage 1 has three categories, including "Primary Products (1a)", "Resource Related (1b)" and "Local Services (1c)". Stage 2 includes "Labor Intensive Manufacturing (2a)" and "General Manufacturing (2b)". Stage 3 is "High-Tech manufacturing". Stage 4 is "High-Level Services". We aggregate public related industries as "Public activities (9)".

We will estimate a traditional production function with TFP (Time) and a new production function with TFP (KI: IT capital intensity or KQ: Quality of capital), if IT variables are statistically significant in order to explain TFP. We can compare the possible output growth rates calculated from the two production functions using the same assumptions about the growth rates of input factors. As a result, we will prove that the IT revolution can raise the potential growth rate for Japan and ASEAN countries higher than is thought by many economists who use the traditional production function.

[11] see http://www.rieti.go.jp/en/database/d05.html

Table 3.6: Classification of Industries based on the Stages of Development Ladder

		Stages of Development Ladder							
		1			2		3	4	
JIP Code	Industries	Primary Products	Resouce Related	Lcal Services	Labor Intensive Mfg.	General Mfg.	High-Tech. Mfg.	High-Level Services	Public Activities
1	Rice, wheat production	1a							
2	Miscellaneous crop farming	1a							
3	Livestock and sericulture farming	1a							
4	Agricultural services	1a							
5	Forestry	1a							
6	Fisheries	1a							
7	Mining	1a							
8	Livestock products		1b						
9	Seafood products		1b						
10	Flour and grain mill products		1b						
11	Miscellaneous foods and related products		1b						
12	Prepared animal foods and organic fertilizers		1b						
13	Beverages		1b						
14	Tobacco		1b						
15	Textile products				2a				
16	Lumber and wood products				2a				
17	Furniture and fixtures				2a				
18	Pulp, paper, and coated and glazed paper					2b			
19	Paper products				2a				
20	Printing, plate making for printing and bookbinding						3		
21	Leather and leather products				2a				
22	Rubber products				2a				
23	Chemical fertilizers					2b			
24	Basic inorganic chemicals					2b			
25	Basic organic chemicals					2b			
26	Organic chemicals						3		
27	Chemical fibers						3		
28	Miscellaneous chemical products						3		
29	Pharmaceutical products						3		
30	Petroleum products		1b						
31	Coal products		1b						
32	Glass and its products				2a				
33	Cement and its products				2a				
34	Pottery				2a				
35	Miscellaneous ceramic, stone and clay products				2a				
36	Pig iron and crude steel				2a				
37	Miscellaneous iron and steel				2a				
38	Smelting and refining of non-ferrous metals				2a				
39	Non-ferrous metal products				2a				
40	Fabricated constructional and architectural metal products						3		
41	Miscellaneous fabricated metal products						3		
42	General industry machinery						3		
43	Special industry machinery						3		
44	Miscellaneous machinery						3		
45	Office and service industry machines						3		

(continued)

46	Electrical generating, transmission, distribution and industrial apparatus						3		
47	Household electric appliances				2a				
48	Electronic data processing machines, computer equipment and accessories						3		
49	Communication equipment						3		
50	Electronic equipment and electric measuring instruments						3		
51	Semiconductor devices and integrated circuits						3		
52	Electronic parts						3		
53	Miscellaneous electrical machinery equipment						3		
54	Motor vehicles						3		
55	Motor vehicle parts and accessories						3		
56	Other transportation equipment						3		
57	Precision machinery & equipment						3		
58	Plastic products						3		
59	Miscellaneous manufacturing industries						3		
60	Construction							4	
61	Civil engineering							4	
62	Electricity		1b						
63	Gas, heat supply		1b						
64	Waterworks		1b						
65	Water supply for industrial use		1b						
66	Waste disposal		1b						
67	Wholesale			1c					
68	Retail			1c					
69	Finance							4	
70	Insurance							4	
71	Real estate							4	
72	Housing (imputed rent)								
73	Railway			1c					
74	Road transportation			1c					
75	Water transportation			1c					
76	Air transportation							4	
77	Other transportation and packing			1c					
78	Telegraph and telephone							4	
79	Mail								9
80	Education (private and non-profit)							4	
81	Research (private)							4	
82	Medical (private)							4	
83	Hygiene (private and non-profit)			1c					
84	Other public services								9
85	Advertising							4	
86	Rental of office equipment and goods							4	
87	Automobile maintenance services							4	
88	Other services for businesses							4	
89	Entertainment							4	
90	Broadcasting							4	
91	Information services and internet-based services							4	
92	Publishing							4	
93	Video picture, sound information, character information production and distribution							4	
94	Eating and drinking places			1c					

(continued)

95	Accommodation			1c					
96	Laundry, beauty and bath services			1c					
97	Other services for individuals			1c					
98	Education (public)								9
99	Research (public)								9
100	Medical (public)								9
101	Hygiene (public)								9
102	Social insurance and social welfare (public)								9
103	Public administration								9
104	Medical (non-profit)								9
105	Social insurance and social welfare (non-profit)								9
106	Research (non-profit)								9
107	Other (non-profit)								9
108	Activities not elsewhere classified								

4.2. Estimation of Production Functions for Classified Groups

(1) Group-1a: Primary Products industries (1a) in Stage 1

Group-1a includes the first seven industries, including rice, wheat products (JIP:1) ~ mining (7), which are classified as "Primary Products in Stage 1" in table 3.6.

All industries in Group-1a, except agricultural services, have very low IT capital intensity and a low quality of capital (Appendix A). When the TFP calculated using the average factor shares during the sample period has a declining trend, we usually cannot explain the TFP by either Time or IT variables with any statistical significance.

Estimation Result for Group-1a:

Log(G) = 1.712384 + 0.219403*log(cu*K) + 0.296591*log(LH*L_Q) + 0.392921*log(M)

(t=0.9) (t=2.2) (t=4.7) (t=4.9)

…………………………………………………………………………………… eq. 3.10

Sample: 1973-2006, D-W:1.84, R_2:0.96, ma(1)

Sum of Coefficients: 0.909

where

G: Real gross output

K: Real net capital stock (IT capital stock (KIT) + Non-IT capital stock (KO))

LH: Labor input (Man-hours)

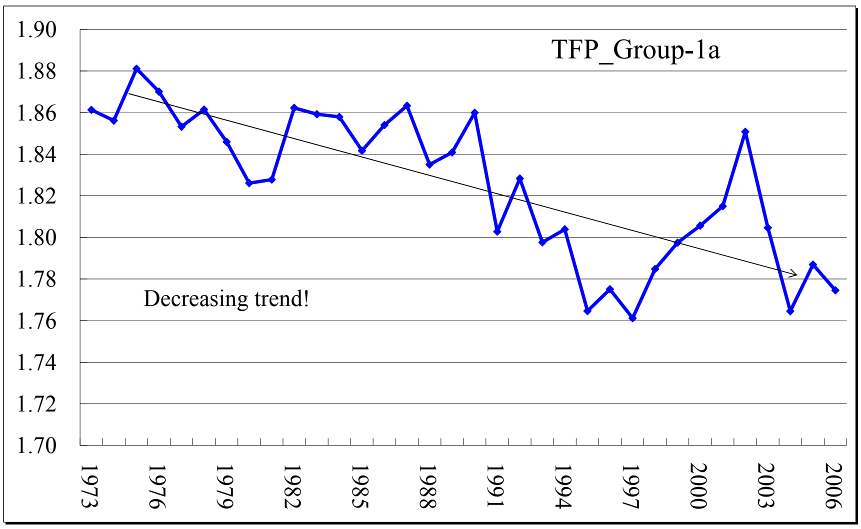
L_Q: Quality of Labor (2000=1.0)

M: Intermediate input.

Findings:

- TFP could not be explained with statistical significance by either Time or IT variables such as IT capital intensity and quality of capital. This is seen in the graph of TFP, which shows a decreasing trend (graph 3.10). We can find neither exogenous nor endogenous technical progress in Group-1a.
- There is decreasing returns to scale (sum of coefficients =0.909).

Graph 3.10: TFP calculated for Group-1a of "Primary Products Industries"



Simulation Studies for Real Output Growth for Group-1a

We can simulate how much output (G) in Group-1a will grow by assuming the growth rates for input factors. First, we calculated the historical average growth rates for output and input for 1975-2006 (total period: from the end of the first oil crisis to 2006), 1975-1992 (pre-bubble period) and 1993-2006 (post-bubble period) respectively in Rows 2, 3 and 4 in table 3.7. Based on the actual average growth rates of input factors for the three periods, we assumed their growth rates for four simulation cases: the "Pessimistic case", "Standard case", "Optimistic case" and "Intensive IT investment case" and calculated the output growth rates for the four cases.

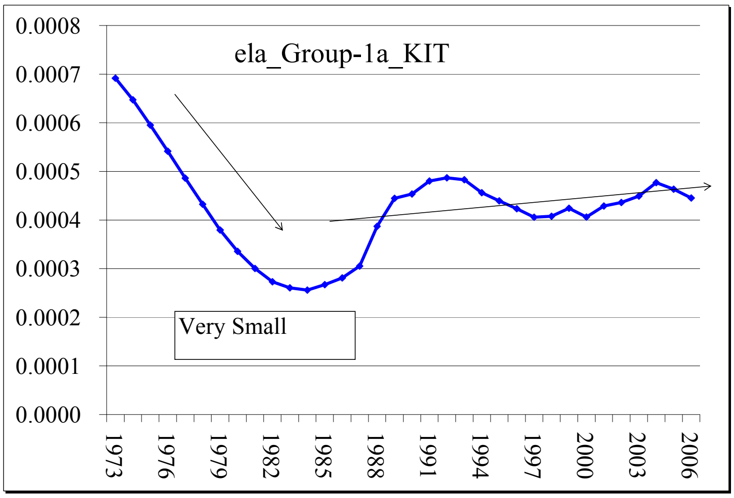
We usually compare the simulation cases with the results from a traditional production function with TFP (Time) and those from a new production function with TFP (IT variables). But, we show only the results from a traditional production function without TFP (Time) for Group-1a.

We can conclude the following from eq. 3.10 and table 3.7:

- Low output growth in Group-1a is caused by a sharp reduction in labor input.
- Neither Time nor IT variables can explain TFP statistically.
- Since IT variables do not affect TFP, output elasticity w.r.t. IT capital stock (KIT) included in total capital stock (K) is very small, 0.003 ~ 0.007 (graph 3.11). This is calculated from eq. 3.10 by

$$ela\_Group-1a\_KIT = KIT * \frac{\partial \log(G)}{\partial K} * \frac{\partial K}{\partial KIT} .$$

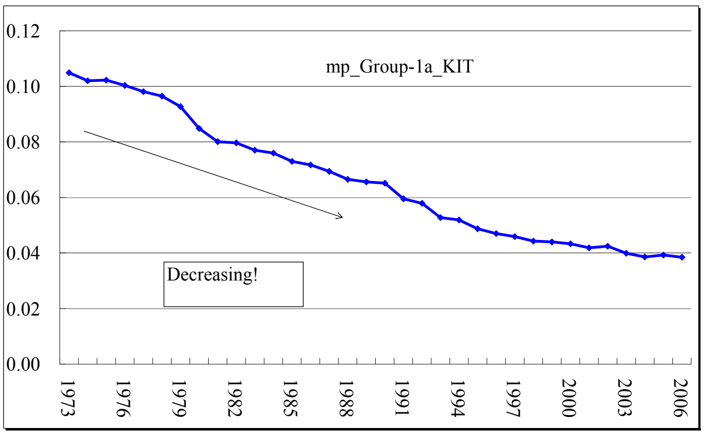
Graph 3.11: Output Elasticity w.r.t. IT capital stock in Group-1a (ela_Group-1a_KIT)



- Marginal product of IT capital stock is decreasing (graph 3.12). This is calculated from eq. 3.10 as follows:

$$mp\_Group-1a\_KIT = G * \frac{\partial \log(G)}{\partial K} * \frac{\partial K}{\partial KIT}.$$

Graph 3.12: Marginal Product of IT capital stock in Group-1a (mp_Group-1a_KIT)



- Quality of capital (KIT/K≡KQ) was decreasing (see the last column in table 3.7), suggesting that IT capital stock did not increase faster than non-IT capital stock.
- It will be difficult for Group-1a to achieve the growth rate in the pre-bubble period without increasing labor input.
- It will be very hard for Group-1a to achieve 3% as the macroeconomic target growth rate proposed by the "Rising Tide Policy" in Japan.
- Group-1a has not yet benefitted from the IT revolution. This group should consider utilizing IT effectively in order to increase output instead of depending intensively on labor input

Table 3.7: Simulation Studies for Group-1a

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K (KQ)
Average Growth Rate	1975-2006	-0.62	2.44	1.55	-3.74	0.14	0.01	5.53	-0.84
	1975-1992	0.20	3.40	2.13	-3.58	-0.10	1.61	5.96	-1.20
	1993-2006	-1.54	1.34	0.90	-3.92	0.43	-1.80	5.03	-0.43
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			1.0	1.0	-4.0	0.0	-1.0		
Contribution to Growth Rate of Group-1a			K(=KO+KIT)		L(LH+L_Q)		M		
		-1.39	0.22		-1.21		-0.39		
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			2.0	1.5	-3.0	0.0	0.5		
Contribution to Growth Rate of Group-1a			K(=KO+KIT)		L(LH+L_Q)		M		
		-0.27	0.43		-0.9		0.2		
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			3.0	2.0	-2.0	0.5	1.5		
Contribution to Growth Rate of Group-1a			K(=KO+KIT)		L(LH+L_Q)		M		
		0.78	0.65		-0.45		0.59		
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			1.0	5.0	-4.0	0.0	-1.0		
Contribution to Growth Rate of Group-1a			K(=KO+KIT)		L(LH+L_Q)		M		
		-1.38	0.22		-1.21		-0.39		

(2) Group-1b: Resource Related industries (1b) in Stage 1

Group-1b consists of Livestock products (JIP:8) ~ Tobacco (14), Petroleum products (30), Coal products (31) in the manufacturing sector and Electricity (62) ~ Waste disposal (66) in the service sector. Neither Time nor IT variables explain TFP in Group-1b. We focus on the industries in the service sector (≡Group-1bs), which are Electricity (62), Gas, heat supply (63), Waterworks (64), Water supply for industrial use (65) and waste disposal (66) because they are a form of infrastructure. We estimate both traditional and new production functions for Group-1bs below:

Estimation Results for Group-1bs:

We used factor share as a coefficient for labor input because of the multicollinearity among explanatory variables.

Log(G) = -13.62756 + 0.208748*log(cu*K) + 0.155232*log(LH*L_Q) + 0.381525*log(M)

(t=-3.5) (t=2.8) (Factor Share) (t=7.0)

+ 0.009220*Time ……………………………………………… eq. 3.11a

(t=3,7)

Sample: 1974-2006, D-W:1.95, R_2:0.99, ar(1)

Sum of Coefficients: 0.746

Log(G) = 2.368825 + 0.304795*log(cu*K) + 0.155232*log(LH*L_Q) + 0.414463*log(M)

(t=3.7) (t=6.4) (Factor Share) (t=8.0)

+ 10.31675*(KIT/K) …………………………………………… eq. 3.11b

(t=3.5)

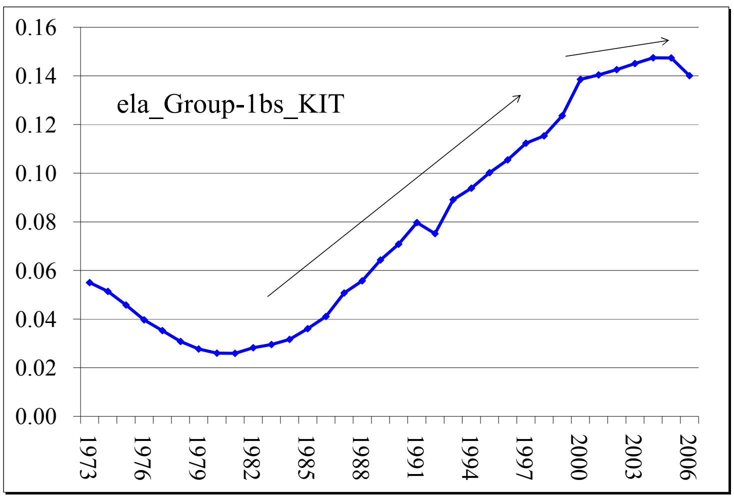
Sample: 1974-2006, D-W:2.05, R_2:0.99, ar(1))

Sum of Coefficients: 0.874

Findings:

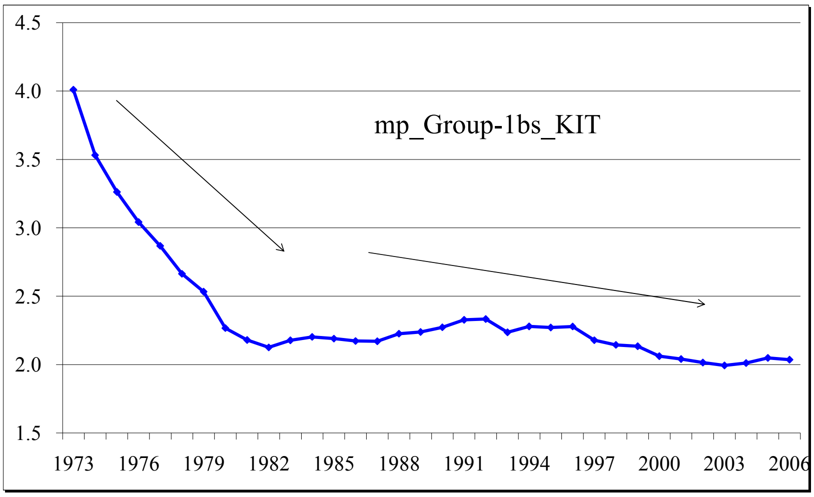
- Both equations of eq. 3.11a and eq. 3.11b show significant decreasing returns to scale (see sum of coefficients).
- If we use a traditional production function, the exogenous technological progress rate is estimated to be 0.922% per year (eq. 3.11a).
- TFP is also explained by quality of capital (eq. 3.11b). Group-1bs can increase output through TFP by improving quality of capital (KIT/K ≡KQ).
- Output elasticity w.r.t. IT capital stock calculated from eq. 3.11b is increasing after 1985. Its value is 0.14 in 2006 (graph 3.13), almost equal to the 0.12 calculated from the manufacturing sector (graph 3.8).

Graph 3.13: Output elasticity w.r.t. IT capital stock for Group-1bs(ela_Group-1bs_KIT)



- Although output elasticity w.r.t. IT capital stock has seen an increasing trend after 1985, marginal product of IT capital stock has seen a decreasing trend, suggesting that it will be difficult for this group to improve the economy of scale (graph 3.14).

Graph 3.14: Marginal product of IT capital stock for Group-1bs (mp_Group-1bs_KIT)



Simulation Studies for Real Output Growth for Group-1bs

- TFP(Time) in a traditional production function always contributes to output growth rate by 0.92% (table 3.8a) while the contribution to output growth of TFP (KQ: Quality of capital) in a new production function increases from 0.40% in the pessimistic case to 1.73% in the Intensive IT investment case (table 3.8b).
- In the standard case, TFP contributes 0.92% to output growth in a traditional production function and 0.79% in a new production function (tables 3.8a and 3.8b). However, a new production function proves that output will grow by more than 3%, because the output elasticity w.r.t. total capital stock is larger in a new production function than in a traditional production function.
- But it may not be easy for this group to achieve the average growth rate of the pre-bubble period, 4%, unless IT capital stock increase more than 12% (table 3.8b).

Table 3.8a: Simulation Studies for Group-1bs: In case of TFP(Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K (KQ)
Average Growth Rate	1975-2006	2.83	4.59	8.23	0.67	0.33	2.81	7.52	3.64
	1975-1992	3.98	6.57	9.68	0.99	0.20	4.05	8.62	3.28
	1993-2006	1.53	2.35	6.59	0.30	0.48	1.40	6.27	4.04
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	0.3	0.2	1.5		2.9
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.99	0.42		0.08		0.57	0.92	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	9.0	0.6	0.3	2.5		5.7
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.82	0.63		0.14		1.13	0.92	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	12.0	1.0	0.5	4.0		8.1
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		3.49	0.84		0.23		1.50	0.92	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	0.3	0.2	1.5		12.6
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.02	0.45		0.08		0.57	0.92	

Table 3.8b: Simulation Studies for Group-1bs: Case of TFP (KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	2.83	4.59	8.23	0.67	0.33	2.81	7.52	3.64
	1975-1992	3.98	6.57	9.68	0.99	0.20	4.05	8.62	3.28
	1993-2006	1.53	2.35	6.59	0.30	0.48	1.40	6.27	4.04
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	0.3	0.2	1.5		2.9
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		1.71	0.62		0.08		0.62		0.40
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	9.0	0.6	0.3	2.5		5.7
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		3.08	0.92		0.14		1.23		0.79
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	12.0	1.0	0.5	4.0		7.6
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		4.12	1.23		0.23		1.63		1.04
Assumed Growth Rate (%) **Intensive IT Investment Improvement Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	0.3	0.2	1.5		12.6
Contribution to Growth Rate of Group-1bs			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		3.08	0.66		0.78		0.62		1.73

(3) Group-1c: Local Services industries (1c) in Stage 1

Group-1c includes wholesale trade (67) and retail trade sale (68) industries. Other industries are local transportation such as railway (73), road transportation (74) and water transportation (75), hygiene (private and non-profit) (83), eating and drinking establishments (94), accommodation businesses (95), laundry, beauty and bath services (96) and other services for individuals (97).

<u>Estimation Results for Group-1c:</u>

We used factor share as a coefficient for intermediate input (M) because of multicollenearity among explanatory variables.

Log(G) = -15.12046 + 0.143502*log(cu*K) + 0.402584*log(LH*L_Q) + 0.395592*log(M)

(t=-2.9) (t=3.6) (t=3.7) (Factor share)

+ 0.008575*Time ………………………………………………… eq. 3.12a

(t=3.1)

Sample: 1975-2006, D-W:2.05, R_2:0.99, ar(2), ma(1,2,3,4)

Sum of Coefficients: 0.942

Log(G) = -4.364040 + 0.226604*log(cu*K) + 0.672553*log(LH*L_Q) + 0.395592*log(M)

(t=-1.5) (t=4.1) (t=3.8) (Factor share)

+ 20.36989*(KIT/L)*(KIT/K)………………………………………… eq. 3.12b

(t=2.4)

Sample: 1973-2006, D-W:1.99, R_2:0.99, ma(1,2,3,4,5)

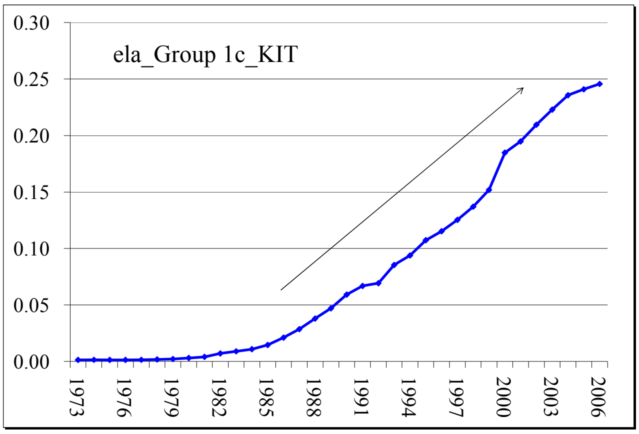
Sum of Coefficients: 1.295

Findings:

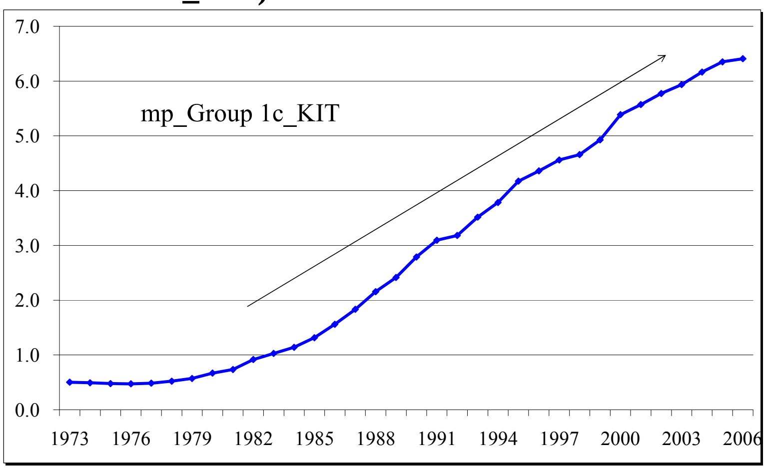
- A traditional production function shows decreasing returns to scale while a new production function illustrates increasing returns to scale. This group, especially wholesale and retail sale industries, has the potential of realizing economy of scale through the IT revolution.
- The multiplier of IT capital intensity and quality of capital explains TFP (eq. 3.12b).
- Output elasticity w.r.t. IT capital stock (KIT) has increased sharply since 1985. Its value is 0.25 in 2006 (graph 3.15), much higher than that of the manufacturing sector, 0.12.

- Similarly, marginal product of IT capital stock has kept increasing since the early 1980s (graph 3.16).
- As graphs 3.15 and 3.16 illustrate, Group-1c can benefit significantly from the increase in IT capital stock.
- When we aggregated wholesale trade (67) and retail trade (68) industries only, the output elasticity w.r.t. to IT capital stock became much higher, 0.6 at 2006 (graph 3.17). This is because these two industries have been utilizing IT effectively.

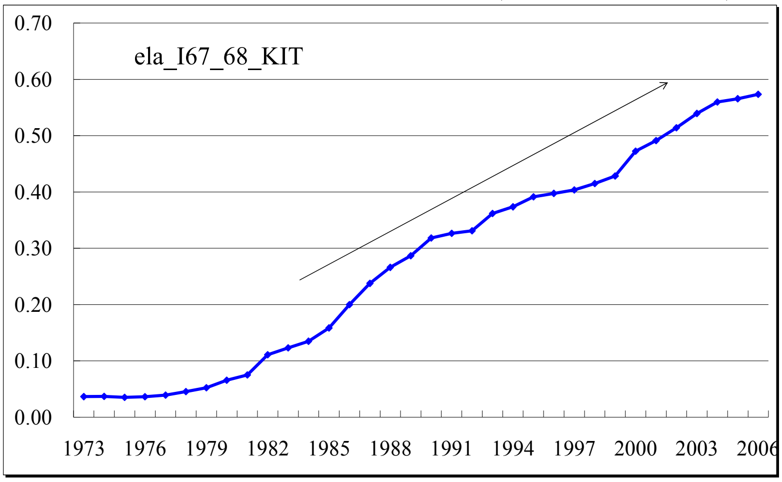
Graph 3.15: Output elasticity w.r.t. IT capital stock for Group-1c (ela_Group 1c_KIT)



Graph 3.16: Marginal product of IT capital stock for Group-1c (mp_Group 1c_KIT)



Graph 3.17: Output elasticity w.r.t. IT capital stock for Wholesale Trade and Retail Trade Industries (ela_I67_68_KIT)



Simulation Studies for Real Output Growth for Group-1c

- Tables 3.9a and 3.9b illustrate quite different simulation results for the output growth rates of a traditional production function and a new production function, with the exception of the pessimistic case.
- Contribution to output growth rates of TFP(KI*KQ) in a new production function increases from 0.98% in the Pessimistic case to 3.84% in the Intensive IT investment case (table 3.9b). (KI: Capital intensity = KIT / LH and KQ: Quality of capital = KIT / K.) This group is able to utilize the IT revolution significantly to raise TFP.
- TFP(Time) in a traditional production function always contributes to output growth by 0.86% (table 3.9a).
- A new production function proves that this group can achieve more than 3% growth in the standard case and an average growth rate during the pre-bubble period in the optimistic case where the assumed growth rates of input are realistic (table 3.9b).
- Even if we assume that IT capital stock increases 15% instead of 8% in the Standard case in table 3.9b, output will increase 5.19%. Group-1c can recover the pre-bubble output growth by increasing IT capital stock.

- Group-1c is one of the best examples of how we underestimate potential output when we use a traditional production function.

Table 3.9a: Simulation Studies for Group-1c: Case of TFP (Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	2.75	3.25	11.65	0.17	0.60	2.79	11.42	7.97
	1975-1992	4.44	5.18	17.69	1.01	0.61	4.19	16.52	11.82
	1993-2006	0.85	1.06	4.81	-0.78	0.58	1.21	5.64	3.62
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			1.0	4.0	-1.0	0.5	1.0	5.1	2.9
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.41	0.16		0.00		0.39	0.86	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			2.0	8.0	0.0	0.6	2.0	8.0	5.7
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.19	0.31		0.24		0.78	0.86	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			3.0	12.0	1.0	0.6	3.0	10.9	8.4
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		3.13	0.46		0.64		1.17	0.86	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			1.0	15.0	-1.0	0.5	1.0	16.2	13.3
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.25	0.21		-0.20		0.39	0.86	

Table 3.9b: Simulation Studies for Group-1c: Case of TFP (KI*KQ)

History		G	KO	KIT	LH	L_Q	M	K_IT/LH (KI)	K_IT/K (KQ)
Average Growth Rate	1975-2006	2.75	3.25	11.65	0.17	0.60	2.79	11.42	7.97
	1975-1992	4.44	5.18	17.69	1.01	0.61	4.19	16.52	11.82
	1993-2006	0.85	1.06	4.81	-0.78	0.58	1.21	5.64	3.62
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			1.0	4.0	-1.0	0.5	1.0	5.1	2.9
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		1.28	0.25		-0.34		0.39	0.98	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			2.0	8.0	0.0	0.6	2.0	8.0	5.7
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		3.32	0.49		0.34		0.78	1.71	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			3.0	12.0	1.0	0.6	3.0	10.9	8.4
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		5.36	0.73		1.00		1.17	2.45	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			1.0	15.0	-1.0	0.5	1.0	16.2	13.3
Contribution to Growth Rate of Group-1c			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.22	0.33		-0.34		0.39	3.84	

(4) Group 2a: Labor Intensive Manufacturers (2a) in Stage 2

Group-2a of Labor intensive manufacturers in stage 2 consists of mainly two groups. The first group includes industries from textile products (JIP: 15) to lumber products (22) excluding pulp, paper, and coated and glazed paper (18) and printing, plate making for printing and bookbinding (20). The second group consists of industries from glass and its products (32) to non-ferrous metal products (39) (table 3.6). The household electric appliance industry (47) is also added to Group-2a.

Estimation Results for Group-2a:

TFP can be explained by Time or quality of capital. But, IT capital intensity was not statistically significant in explaining TFP.

Log(G) = -15.72735 + 0.140979*log(cu*K) + 0.268604*log(LH*L_Q) + 0.692020*log(M)

(t=-4.3) (t=3.1) (t=3.3) (t=7.3)

+ 0.007414*Time ………………………………………………… eq. 3.13a

(t=3.9)

Sample: 1973-2006, D-W:2.09, R_2:0.99, ar(1), ar(2)

Sum of Coefficients: 1.102

Log(G) = -0.959980 + 0.139156*log(cu*K) + 0.258628*log(LH*L_Q) + 0.701379*log(M)

(t=-1.1) (t=2.5) (t=2.7) (t=8.2)

+ 3.506392*(KIT/K))………………………………………………... eq. 3.13b

(t=1.9)

Sample: 1973-2006, D-W:1.81, R_2:0.99, ar(1)

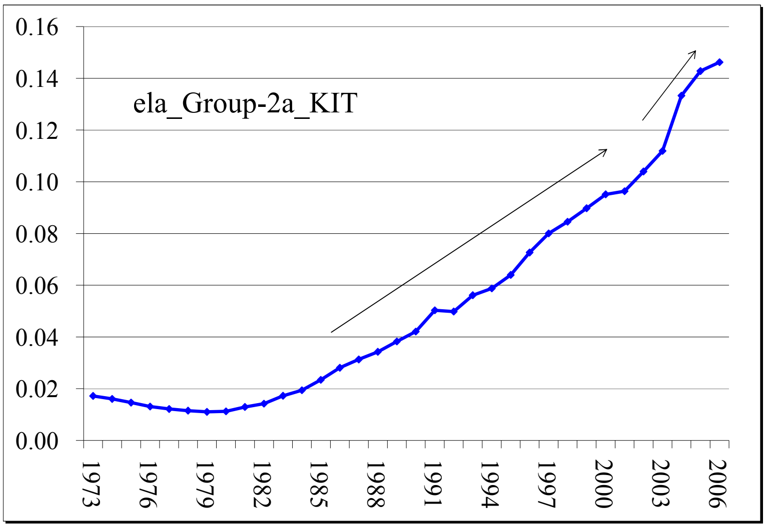
Sum of Coefficients: 1.099

Findings:

- Both equations of eq. 13a and eq.13b show the same increasing returns to scale (sum of coefficients is 1.1).
- Technological progress in a traditional production function is estimated to be 0.741% per year (eq. 3.13a).

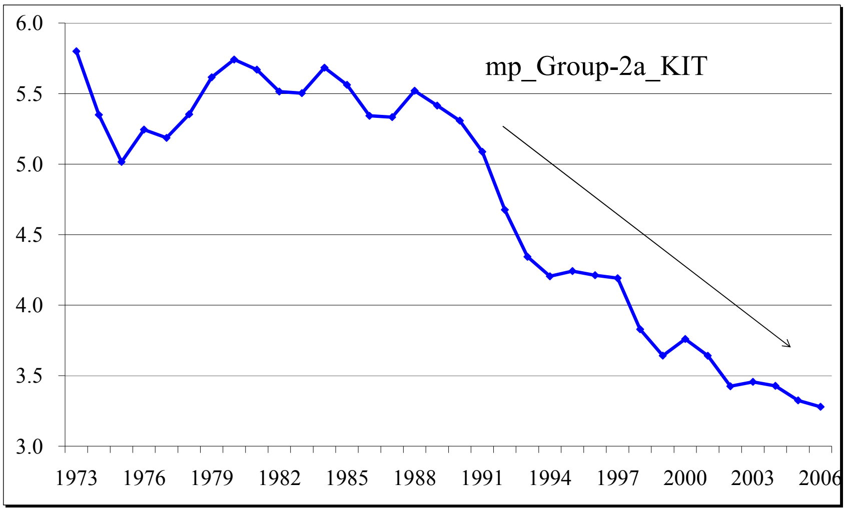
- Only quality of capital explains TFP (eq. 3.13b). IT capital intensity may not be a critical factor yet in labor intensive manufacturing group.

Graph 3.18: Output elasticity w.r.t. IT capital stock for Group-2a (ela_Group-2a_KIT)



- Output elasticity w.r.t. IT capital stock (KIT) has been increasing since 1985. Its value is about 0.15 in 2006 (graph 3.18), slightly higher than that of the manufacturing sector, 0.12.
- Marginal product of IT capital stock has been on a decreasing trend since after 1988 (graph 3.19).

Graph 3.19: Marginal product of IT capital stock for Group-2a (mp_Group-2a_KIT)



<u>Simulation Studies for Real Output Growth for Group-2a</u>

- Contribution to output growth by TFP (KQ) increases from 0.63% in the Pessimistic case to 2.01% in the Intensive IT investment case while that of TFP (Time) is constant, 0.74%.
- As output elasticity w.r.t. to IT capital stock has been increasing but the marginal product of IT capital stock has been decreasing since 1988, the effect of IT on this group may be moderate.
- Group-2a can achieve the average growth rate (2.19%) of output during the pre-bubble period in the optimistic cases simulated from both a traditional and new production functions while it cannot do so in the standard case.
- However, it seems to be difficult for this group to achieve a 3% growth rate because of the moderate effect of IT on the output.

Table 3.10a: Simulation Studies for Group-2a: Case of TFP (Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K (KQ)
Average Growth Rate	1975-2006	0.40	1.66	9.59	-2.80	0.52	0.05	12.83	7.62
	1975-1992	2.19	2.36	10.26	-1.05	0.44	1.90	11.48	7.56
	1993-2006	-1.62	0.87	8.84	-4.78	0.61	-2.04	14.36	7.68
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			0.5	5.0	-5.0	0.4	-2.0		
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		-1.83	0.10		-1.27		-1.4	0.74	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			1.5	8.0	-2.0	0.5	1.0		
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.27	0.25		-0.41		0.69	0.74	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	10.0	-1.0	0.6	2.0		
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.33	0.33		-0.11		1.37	0.74	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			0.5	12.0	-5.0	0.4	-2.0		
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		-1.79	0.14		-1.27		0.69	0.74	

Table 3.10b: Simulation Studies for Group-2a: Case of TFP (KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	0.40	1.66	9.59	-2.80	0.52	0.05	12.83	7.62
	1975-1992	2.19	2.36	10.26	-1.05	0.44	1.90	11.48	7.56
	1993-2006	-1.62	0.87	8.84	-4.78	0.61	-2.04	14.36	7.68
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			0.5	5.0	-5.0	0.4	-2.0		4.3
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		-1.92	0.1		-1.22		-1.42		0.63
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			1.5	8.0	-2.0	0.5	1.0		6.1
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		1.44	0.24		-0.39		0.7		0.90
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	10.0	-1.0	0.6	2.0		7.5
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		2.70	0.32		-0.11		1.39		1.10
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			0.5	12.0	-5.0	0.4	-2.0		13.7
Contribution to Growth Rate of Group-2a			K(=KO+KIT)		L(LH+L_Q)		M		TFP (KQ)
		-0.7	0.15		-1.22		-1.42		2.01

(5) Group-2b: General Manufacturers (2b) in Stage 2

Group-2b includes four industries. They are pulp, paper and coated and glazed paper (18), chemical industries such as chemical fertilizer (23), basic inorganic chemicals (24), basic organic chemicals (25). Estimation results produced a very large coefficient for M while two coefficients for K and L were often negative because of typical multicollinearity. So, we had to use factor shares respectively as coefficients for K, L and M (eq. 3.14a and eq. 3.14b).

Estimation Results for Group-2b:

Log(G) = -10.37867 + 0.092647*log(cu*K) + 0.122120*log(LH*L_Q) + 0.715126*log(M)

(t=-5.8) (Factor share) (Factor share) (Factor share)

+ 0.006075*Time ………………………………………………… eq. 3.14a

(t=6.8)

Sample: 1973-2006, D-W:1.70, R_2:0.93, ma(1,2)

Sum of Coefficients: 0.930

Log(G) = 1.693586 + 0.092647*log(cu*K) + 0.122120*log(LH*L_Q) + 0.715126*log(M)

(t=3.0) (Factor share) (Factor share) (Factor share)

+ 0.552384*(KIT/LH)*(KIT/K)……………………………………eq. 3.14b

(t=3.3)

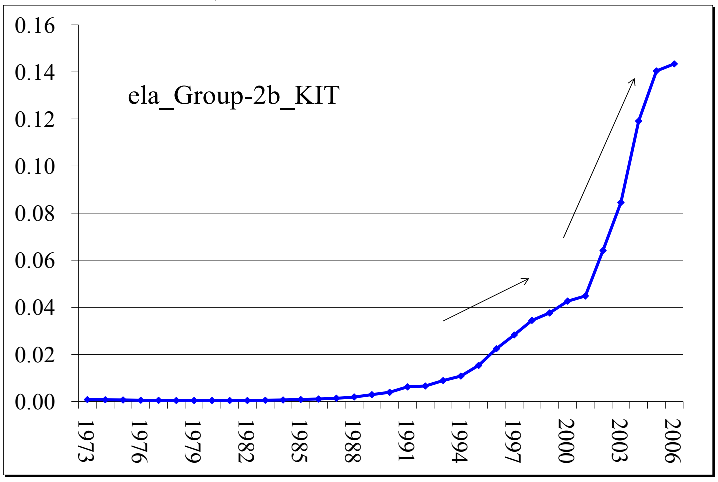
Sample: 1973-2006, D-W:1.92, R_2:0.89, ma(1,2,3)

Sum of Coefficients: 0.930

Findings:

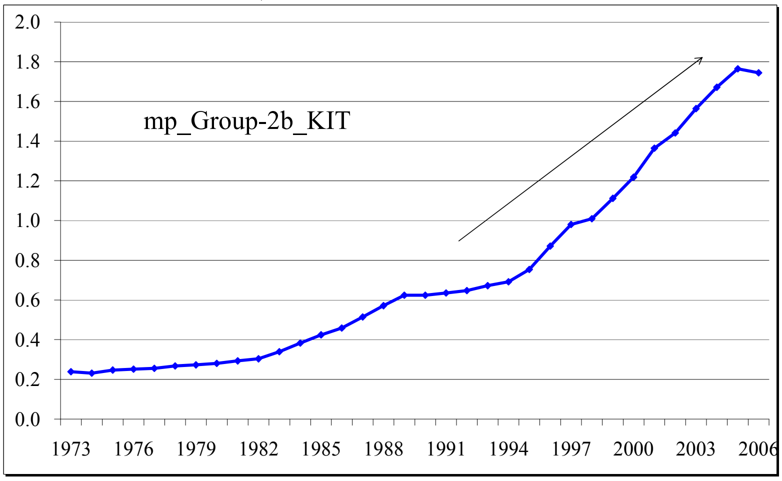
- This group shows decreasing returns to scale, the sum of coefficients =0.930.
- Output elasticity w.r.t. IT capital stock started to increase in the early 1990s and has accelerated since 2002 (graph 3.20). Its value is about 0.14 in2006, a bit higher than that of the manufacturing sector, 0.12.

Graph 3.20: Output elasticity w.r.t. IT capital stock for Group-2b (ela_Group-2b _KIT)



- Marginal product of IT capital stock was increasing (graph 3.21).

Graph 3.21: Marginal product of IT capital stock for Group-2b (mp_Group-2b_KIT)



- Since both output elasticity w.r.t. IT capital stock and the marginal product of IT capital stock have been increasing, especially in the 2000s, Group-2b can benefit from increasing IT capital stock from now on.

Simulation Studies for Real Output Growth

- The contribution to output growth of TFP (KI*KQ) increases from 1.16% in the Pessimistic case to 2.22% in the Intensive IT investment case (table 3.11b) while TFP (Time) constantly contributes to that by 0.61% (table 3.11a).
- This is another good case that shows that a traditional production function will conclude lower potential output than does the new production function (tables 3.11a and 3.11b).
- The Standard case in a new production function indicates the possibility that this group can achieve the average growth rate (1.84%) of output during the pre-bubble period while that using the traditional production function does not.
- Even if this group makes intense IT investment, it may be difficult to achieve a 3% growth rate.

Table 3.11a: Simulation Studies for Group-2b: Case of TFP (Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K (KQ)
Average Growth Rate	1975-2006	0.75	2.72	11.70	-1.76	0.50	0.23	13.76	8.47
	1975-1992	1.84	3.15	11.20	-1.30	0.60	1.04	12.67	7.55
	1993-2006	-0.48	2.23	12.27	-2.27	0.39	-0.70	14.99	9.50
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	8.0	-2.0	0.4	-0.5	10.2	5.5
Contribution to Growth Rate of Group-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		0.27	0.22		-0.20		-0.36	0.61	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			2.5	10.0	-1.0	0.5	0.5	11.1	6.9
Contribution to Growth Rate of Stage-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.17	0.27		-0.06		0.36	0.61	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			3.0	12.0	-0.5	0.6	1.0	12.6	8.2
Contribution to Growth Rate of Stage-2bb			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.65	0.32		0.01		0.71	0.61	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-2.0	0.4	-0.5	17.3	11.9
Contribution to Growth Rate of Stage-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		0.30	0.25		-0.20		-0.36	0.61	

Table 3-11b: Simulation Studies for Group-2b: Case of TFP (KI* KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	K_IT/K(KQ)
Average Growth Rate	1975-2006	0.75	2.72	11.70	-1.76	0.50	0.23	13.76	8.47
	1975-1992	1.84	3.15	11.20	-1.30	0.60	1.04	12.67	7.55
	1993-2006	-0.48	2.23	12.27	-2.27	0.39	-0.70	14.99	9.50
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	8.0	-2.0	0.4	-0.5	10.2	5.5
Contribution to Growth Rate of Group-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		0.82	0.22		-0.20		-0.36	1.16	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			2.5	10.0	-1.0	0.5	0.5	11.1	6.9
Contribution to Growth Rate of Group-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		1.89	0.27		-0.06		0.36	1.33	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			3.0	12.0	-0.5	0.6	1.0	12.6	8.2
Contribution to Growth Rate of Group-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		2.59	0.32		0.01		0.71	1.55	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-2.0	0.4	-0.5	17.3	11.9
Contribution to Growth Rate of Group-2b			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		1.91	0.25		-0.20		-0.36	2.22	

(6) Group-3: High-Tech Manufacturers in Stage 3

Stage 3 of High-tech manufacturers consists of 25 industries. They are printing, plate making for printing and bookbinding (20), industries from organic chemicals (26) to pharmaceutical products (29) and those from fabricated constructional and architectural metal products (40) to miscellaneous manufacturing industries (59) (see table 3.6). In order to avoid multicollinearity among explanatory variables we used factor share for a coefficient for M.

Estimation Results for Group-3:

Log(G) = -16.15706 + 0.137314*log(cu*K) + 0.320681*log(LH*L_Q) + 0.655194*log(M)

(t=0.1) (t=2.7) (t=5.6) (Factor Share)

+ 0.007586*Time ……………………………………………………….eq. 3.15a

(t=3.8)

Sample: 1973-2006, D-W:2.07, R_2:0.99, ma(1,2)

Sum of Coefficients: 1.121

Log(G) = -2.151557 + 0.191488*log(cu*K) + 0.325336*log(LH*L_Q) + 0.655194*log(M)

(t=0.1) (t=2.7) (t=5.6) (Factor Share)

+ 4.216209*(KIT/K)*(KIT/K) ………………………………………….eq. 3.15b

(t=2.3)

Sample: 1975-2006, D-W:2.22, R_2:0.99, ar(2), ma(1)

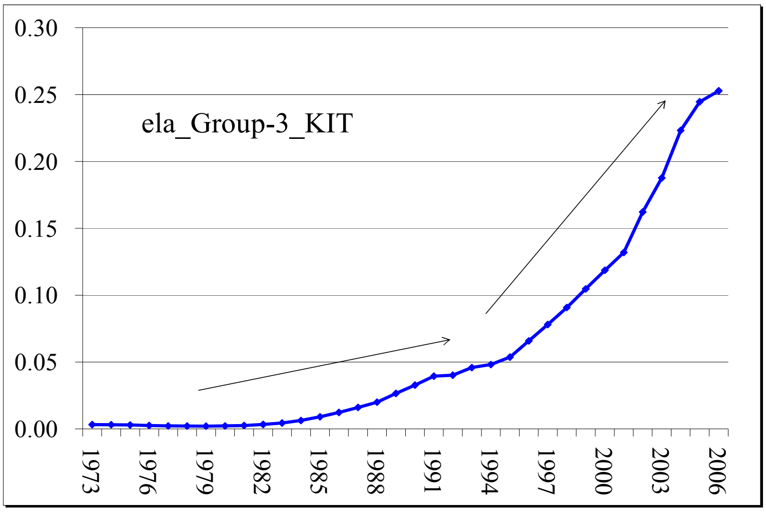
Sum of Coefficients: 1.171

Findings:

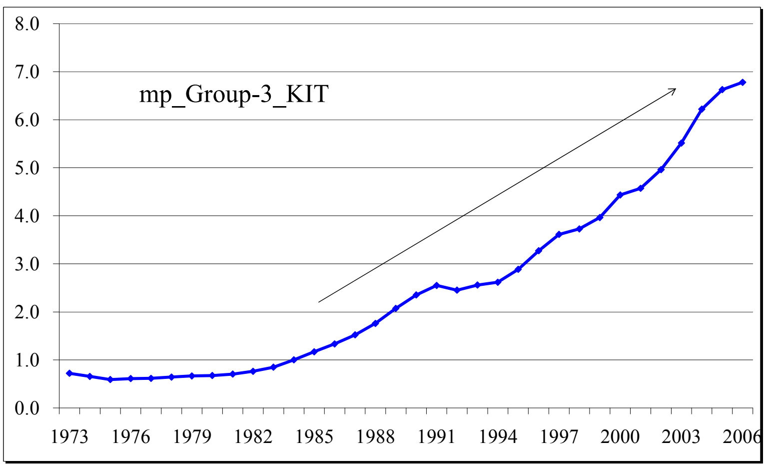
- Both equations of eq. 3.15a and eq. 3.15b show almost the same increasing returns to scale (see sum of coefficients),
- The disembodied technological progress rate is 0.7586% per year (eq. 3.15a).
- TFP in eq. 3.15b can be explained by the multiplier of IT capital stock and quality of capital.

- Output elasticity w.r.t. IT capital stock has increased sharply since 1995. Its value is about 0.25 in 2006 (graph 3.22), much higher than that of the manufacturing sector, 0.12.
- The marginal product of IT capital stock has been on an increasing trend since 1985 (graph 3.23).
- Since both output elasticity w.r.t IT capital stock and marginal product of IT capital stock are increasing, Group-3 can benefit significantly by increasing IT capital intensity and improving the quality of capital.

Graph 3.22: Output Elasticity w.r.t. IT Capital Stock for Group-3(=ela_group-3_KIT)



Graph 3.23: Marginal product of IT Capital Stock for Group-3(=mp_Group-3_KIT)



Simulation Studies for Real Output Growth

- Tables 3.12a and 3.12b illustrate the significant differences in the contribution to output by TFPs in traditional and the new production functions, suggesting that a traditional production function finds much lower potential output than does the new production function.
- The contribution to output growth by TFP in a new production function increases from 1.20% in the Pessimistic case to 3.85% in the Intensive IT Investment case, while that in a traditional production function is always 0.76%.
- A new production function proves that this group will easily achieve more than a 3% growth rate in the standard case as well as an average growth rate (5.49%) of output during the pre-bubble period in the optimistic case (table 3.12b).
- The assumed growth rates of KO and KIT in the optimistic case are both lower than their respective average actual growth rates during the pre-bubble period. Therefore, this group will be able to achieve the average growth rate of output during the pre-bubble period by increasing IT capital stock, which in turn will increase TFP's contribution to output.

Table 3.12a: Simulation Studies for Group-3 with TFP (Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	3.61	4.19	10.75	-0.22	0.55	3.10	10.95	6.08
	1975-1992	5.49	5.26	13.56	1.02	0.52	5.08	12.33	7.62
	1993-2006	1.48	2.98	7.58	-1.62	0.58	0.87	9.39	4.33
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	-1.5	0.5	1.0		
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.38	0.29		-0.32		0.65	0.76	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	10.0	0.0	0.6	2.0		
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		2.70	0.45		0.19		1.3	0.76	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	12.0	1.0	0.6	3.0		
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		3.80	0.59		0.51		1.94	0.76	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-1.5	0.5	1.0		
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.44	0..36		-0.32		0.65	0.76	

Table 3.12b: Simulation Studies for Group-3 with TFP (KI*KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH (KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	3.61	4.19	10.75	-0.22	0.55	3.10	10.95	6.08
	1975-1992	5.49	5.26	13.56	1.02	0.52	5.08	12.33	7.62
	1993-2006	1.48	2.98	7.58	-1.62	0.58	0.87	9.39	4.33
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			2.0	5.0	-1.5	0.5	1.0	6.6	2.8
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		1.92	0.41		-0.33		0.65	1.20	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			3.0	10.0	0.0	0.6	2.0	7.4	10.0
Contribution to Growth Rate of Groupp-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.21	0.45		0.19		1.3	2.27	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	12.0	1.0	0.6	3.0	10.9	7.0
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		5.66	0.87		0.52		1.94	2.33	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			2.0	15.0	-1.5	0.5	1.0	16.8	12.1
Contribution to Growth Rate of Group-3			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.67	0.5		-0.33		0.65	3.85	

(7) Group-4: High-Level Services industries in Stage 4

Group-4 has 19 industries classified into high-level services in Stage 4 (see table 3.6). There are various kinds of industries in Group-4 from construction (60) to video, sound, character information production and distribution (93). The aggregation of these 19 industries did not produce statistically significant results for the estimation of production functions. So, we focus on the so-called FIRE industries of Finance (69), Insurance (70) and Real Estate (71) as Group-4FIRE.

Estimation Results for Group-4FIRE:

Log(G) = -8.694937 + 0.304729*log(cu*K) + 0.352573*log(LH*L_Q) + 0.283617*log(M)

(t=-1.8) (t=5.1) (t=3.2) (Factor share)

+ 0.005340*Time ……………………………………………… eq. 3.16a

(t=2.2)

Sample: 1974-2006, D-W:1.82, R_2:0.99, ma(1)

Sum of Coefficients: 0.941

Log(G) = 0.447681 + 0.332785*log(cu*K) + 0.418178*log(LH*L_Q) + 0.280673*log(M)

(t=0.3) (t=6.9) (t=3.1) (t=12.6)

+ 2.324427*{(KIT/L)*(KIT/K)}…………………………………… eq. 3.16b

(t=1.9)

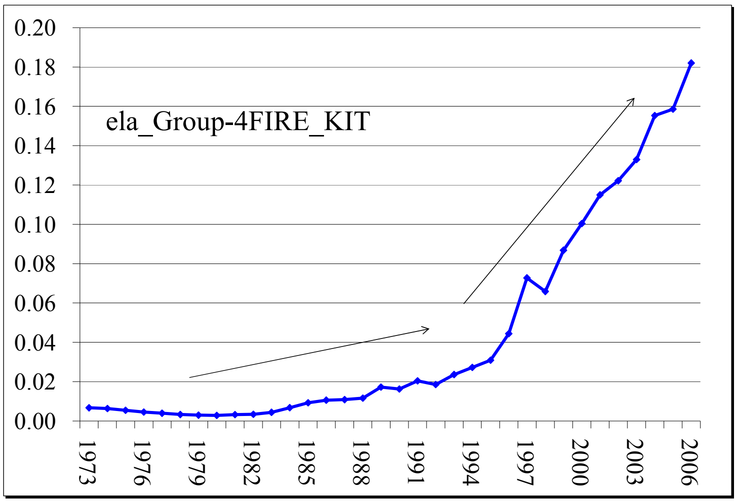
Sample: 1973-2006, D-W:1.72, R_2:0.99, ma(1,2)

Sum of Coefficients: 1.032

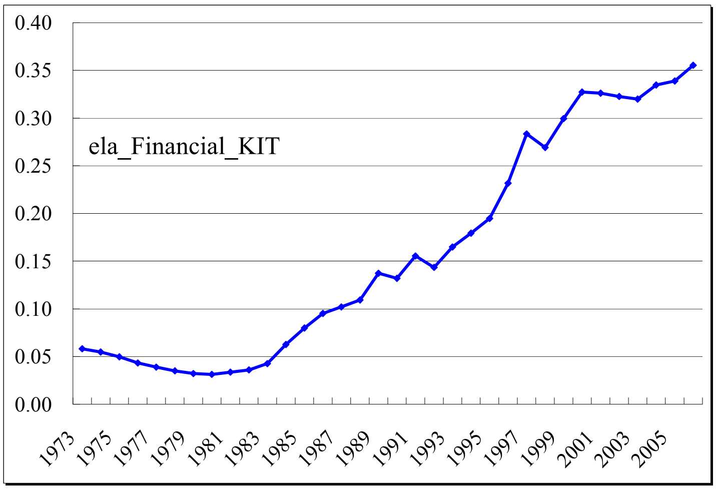
Findings:

- The disembodied technical progress rate is 0.534% per year. (eq. 3.16a).
- The multiplier of IT capital intensity and Quality of capital explains TFP (eq. 3.16b).
- Output elasticity w.r.t. IT capital stock (KIT) started to increase sharply after 1995 (graph 3.24a). Its value is 0.18 in 2006, higher than that of the manufacturing sector, 0.12. If we measure output elasticity w.r.t. finance industry only, output elasticity w.r.t. IT capital stock is much higher, 0.35 in 2006 (Graph 3.24b)

Graph 3.24a: Output elasticity w.r.t. IT capital stock for Group-4FIRE (ela_Group-4FIRE_KIT)

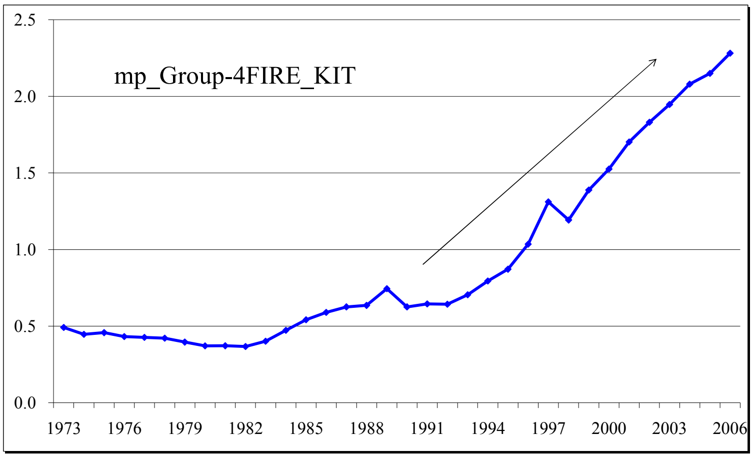


Graph 3.24b: Output elasticity w.r.t. IT capital stock for Group-4Financial (ela_Financial_IT)



- The marginal product of IT capital stock has been on an increasing trend since 1991 (graph 3.25).
- Since both output elasticity w.r.t. IT capital stock and the marginal product of IT capital stock are increasing, Group-4FIRE can increase output significantly by increasing IT capital intensity as well as improving the quality of capital.

Graph 3.25: Marginal product of IT capital stock for Group-4FIRE (mp_Group-4FIRE_KIT)



<u>Simulation Studies for Real Output Growth for Group-4FIRE</u>

- Contribution to output growth rates by TFP(KI*KQ) increases from 0.87% in the Pessimistic case to 2.72% in the Intensive IT investment case while that by TFP (Time) is constant, 0.53% (tables 3.16a).
- Comparing simulation studies, in particular the Intensive IT Investment Case, in tables 3.13a and 3.13b, it is obvious that FIRE industries can reap significant benefits by increasing IT capital intensity as well as improving quality of capital
- Although Group-4FIRE can achieve the average growth rate (5.80%) of the pre-bubble period in the Optimistic Case in table 3.13b, it cannot do so in the Standard Case. But it will be quite possible for Group-4FIRE to achieve a 3% growth rate.

Table 3.13a: Simulation Studies for Group-4FIRE: Case of TFP (Time)

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	4.03	5.09	10.43	0.93	0.63	4.66	9.54	4.98
	1975-1992	5.80	8.53	11.83	2.62	0.53	4.58	9.14	2.86
	1993-2006	2.02	1.18	8.83	-0.99	0.75	4.76	9.99	7.37
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			1.0	5.0	-1.0	0.5	4.0		
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.82	0.35		-0.18		1.12	0.53	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			4.0	8.0	1.0	0.6	4.5		
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		3.59	1.24		0.56		1.25	0.53	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			8.0	12.0	2.5	0.7	5.0		
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		5.42	2.39		1.12		1.38	0.53	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			1.0	15.0	-1.0	0.5	4.0		
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (Time)	
		1.94	0.47		-0.18		1.11	0.53	

Table 3.13b: Simulation Studies for Group-4FIRE : Case of TFP (KI*KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	4.03	5.09	10.43	0.93	0.63	4.66	9.54	4.98
	1975-1992	5.80	8.53	11.83	2.62	0.53	4.58	9.14	2.86
	1993-2006	2.02	1.18	8.83	-0.99	0.75	4.76	9.99	7.37
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			1.0	5.0	-1.0	0.5	4.0	6.0	3.8
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		2.14	0.38		-0.21		1.1	0.87	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			4.0	8.0	1.0	0.6	4.5	6.9	3.7
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.19	1.36		0.67		1.23	0.94	
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			8.0	12.0	2.5	0.7	5.0	9.3	3.6
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		6.44	2.61		1.32		1.37	1.13	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			1.0	15.0	-1.0	0.5	4.0	16.2	13.2
Contribution to Growth Rate of Group-4FIRE			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.12	0.51		-0.21		1.10	2.72	

(8) Group-9: Public Activities

We removed Public activities from the Stages of Developing Ladder. Group-9 of public activities includes the mail industry (79), other public services (84) and Education (public) (98) ~ Other (nonprofit) (107) in table 3.6. TFP could not be explained by Time.

<u>Estimation Results for Group-9:</u>

Log(G) = 5.657206 + 0.119326*log(cu*K) + 0.115392*log(LH*L_Q) + 0.499688*log(M)

(t=10.2) (t=5.7) (t=2.4) (t=16.0)

…………………………………………………eq.3.17a

Sample: 1973-2006, D-W:1.72, R_2:0.99, ma(1)

Sum of Coefficients: 0.734

Log(G) = 6.703913 + 0.168836*log(cu*K) + 0.187572*log(LH*L_Q) + 0.313634*log(M)

(t=5.9) (t=5.1) (t=2.3) (Factor share)

+ 2.62384*{(KIT/L)*(KIT/K)}…………………………………………eq. 3.17b

(t=2.3)

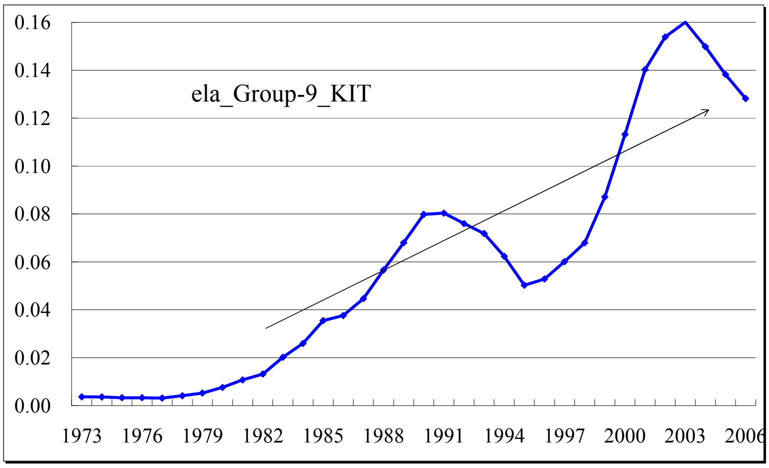
Sample: 1974-2006, D-W:2.05, R_2:0.99, ar(8), ar(2), ma(2)

Sum of Coefficients: 0.670

<u>Findings</u>:

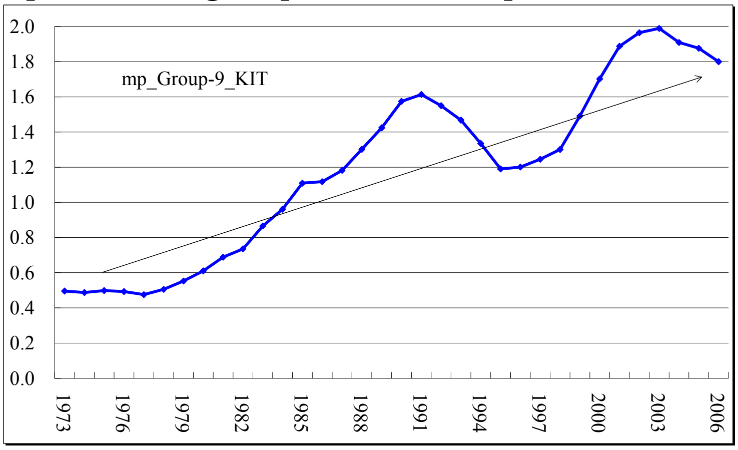
- Both equations show very small returns to scale (see sum of coefficients), because the estimated coefficient of labor input is much lower than the average factor share of labor input during the sample period, 0.613. This implies too much salary but too little output in public activities, suggesting inefficient industries.
- Disembodied technical progress was not found (eq. 3.17a).
- Multiplier of IT capital intensity and Quality of capital explains TFP (eq. 3.17b).
- Output elasticity w.r.t. IT capital stock (KIT) has been on an increasing trend (graph 3.26) since the early 1980s. Its value is 0.13 in 2006, almost the same as that of the manufacturing sector, 0.12.

Graph 3.26: Output elasticity w.r.t. IT capital stock for Grpup-9 (ela_Group-9_KIT)



- Marginal product of IT capital stock also has been on an increasing trend since the 1980s (graph 3.27).
- Group-9 can increase output significantly by increasing IT capital intensity as well as improving the quality of capital because both output elasticity w.r.t. IT capital stock and marginal product of IT capital stock are increasing.
- There is a lot of room for this Group to raise potential growth by utilizing IT such as e-government and e-education.

Graph 3.27: Marginal product of IT capital stock in Group-9 (mp_Group-9_KIT)



Simulation Studies for Real Output Growth for Group-9

- Contribution to output growth by TFP (IT variables) increases from 0.18% in the Pessimistic case to 1.89% in the Intensive IT Investment case.
- As the Standard case in table 3.14b shows, we can conclude that this group can achieve 3% output growth, although it may be somewhat difficult for this group to reach the average growth rate of output during the pre-bubble period.

Table 3.14a: Simulation Studies for Group-9: Case of TFP (None)

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	3.42	6.20	11.59	1.45	0.63	4.39	9.99	4.86
	1975-1992	4.50	7.73	17.44	1.46	0.56	5.74	15.71	8.72
	1993-2006	2.20	4.47	4.96	1.43	0.72	2.86	3.50	0.48
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M		
			4.0	4.0	1.0	0.5	2.0		
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (none)	
		1.63	0.49		0.17		0.99		
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			5.0	10.0	1.3	0.6	3.0		
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (none)	
		2.30	0.61		0.22		1.48		
Assumed Growth Rate (%) **Optimistic Case**		G	KO	KIT	LH	L_Q	M		
			6.0	15.0	1.5	0.7	5.0		
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (none)	
		3.43	0.74		0.25		2.44		
Assumed Growth Rate (%) **Intensive IT investment Case**		G	KO	KIT	LH	L_Q	M		
			4.0	17.5	1.0	0.5	2.0		
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (none)	
		1.70	0.54		0.17		0.99		

Table 3.14b: Simulation Studies for Public Activities: Case of TFP (KI*KQ)

History		G	KO	KIT	LH	L_Q	M	KIT/LH(KI)	KIT/K(KQ)
Average Growth Rate	1975-2006	3.42	6.20	11.59	1.45	0.63	4.39	9.99	4.86
	1975-1992	4.50	7.73	17.44	1.46	0.56	5.74	15.71	8.72
	1993-2006	2.20	4.47	4.96	1.43	0.72	2.86	3.50	0.48
Simulations									
Assumed Growth Rate (%) **Pessimistic Case**		G	KO	KIT	LH	L_Q	M	2.9	0.0
			4.0	4.0	1.0	0.5	2.0	3.0	0.0
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		1.75	0.66		0.28		0.62	0.18	
Assumed Growth Rate (%) **Standard Case**		G	KO	KIT	LH	L_Q	M		
			5.0	10.0	1.3	0.6	3.0	8.6	4.5
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		2.98	0.86		0.35		0.93	0.83	
Assumed Growth Rate (%) **Optimistic Case**		G							
			6.0	15.0	1.5	0.7	5.0	13.3	8.1
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		4.37	1.05		0.41		1.53	1.39	
Assumed Growth Rate (%) **Intensive IT Investment Case**		G	KO	KIT	LH	L_Q	M		
			4.0	17.5	1.0	0.5	2.0	16.3	12.3
Contribution to Growth Rate of Group-9			K(=KO+KIT)		L(LH+L_Q)		M	TFP (KI*KQ)	
		3.55	0.76		0.28		0.62	1.89	

4.3 Summary of Estimation Results and Implication of S-Shape Production Functions for ASEAN Countries

We tried to quantitatively study the following things by estimating traditional and new production functions for the Japanese industrial groups classified by the Stages of Development Ladder which shows characteristics of ASEAN countries:

- Whether or not the effect of IT on the economic (output) growth through TFP increases as the economic development advances.
- Whether output elasticity w.r.t. IT capital stock is increasing or decreasing over a certain range.
- How much is the value of output elasticity w.r.t. IT capital stock?
- Whether marginal product of IT capital stock is increasing or decreasing.
- What kind of IT variables can explain TFP best?

- Whether each group in Japan can achieve the pre-bubble output growth by increasing IT capital intensity or improving quality of capital.
- Whether each group in Japan can achieve at least 3% economic growth by increasing IT capital intensity or improving quality of capital. A 3% growth rate is a reasonable target for the Japanese economy, refuting the potential growth rate of about 1.5% that prevails among the Japanese economist and policy-makers.

We summarize the estimation results regarding the above in table 3.15.

The primary findings include the following:

- IT does not play an important role in the very early stage of the development ladder (Group 1a).
- Improving the quality of IT capital plays a more important role in the early stage of the development ladder than increasing IT capital intensity (Group 1bs ~ Group 2a).
- IT capital intensity also becomes important as industries (countries) move up to a higher stage of the development ladder (Group 2b ~ Group 4FIRE).
- Both output elasticity w.r.t. IT capital stock and marginal product of IT capital stock have increasing trends in Group 1c and Group 2a ~ Group 4FIRE. Once a country moves up to the general manufacturing stage, it can benefit from improving the quality of capital as well as increasing IT capital intensity.
- Wholesale and retail trade industries can reap significant benefits from the IT revolution. Their output elasticity w.r.t. IT capital stock was about 0.6 in 2006.
- The average output elasticity of IT capital stock for the total Japanese manufacturing sector was 0.1 ~ 0.15 after 2005.
- If we use a traditional production function to calculate potential growth, it will miss the possibility of higher potential growth brought about by TFP (IT variables).
- As for Japanese potential growth, only the primary products group (Group 1a) and labor intensive group (Group 2a) have difficulty achieving a 3% growth rate of output, but all other industrial groups can achieve at least a 3% growth rate or

even the average growth rate of output during the pre-bubble period. As a result, we can conclude that Japan's potential growth is definitely more than a 3%.

Table 3.15: Summary of Estimation Results

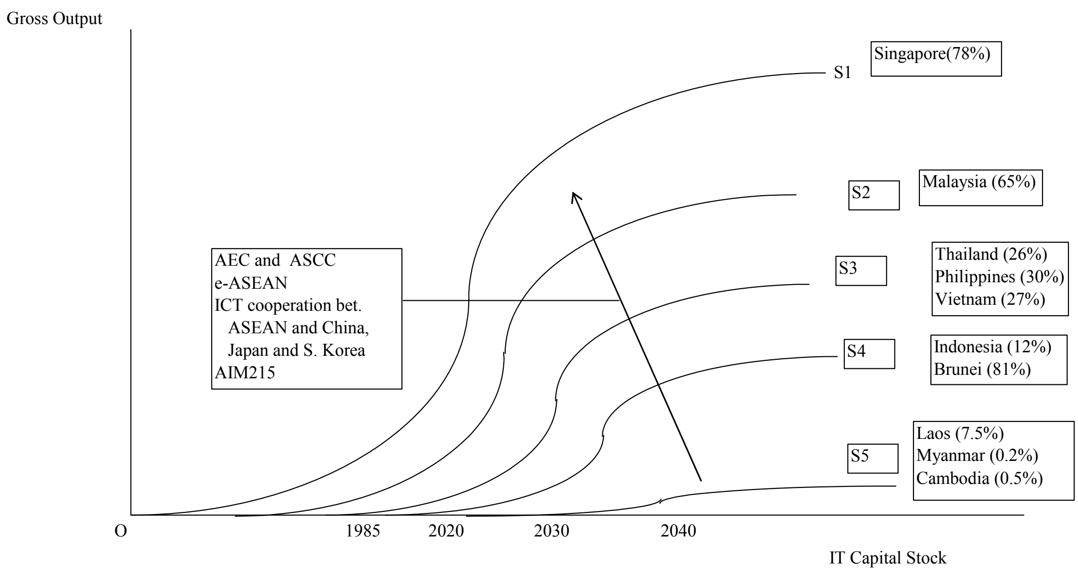
		Stages of Development Ladder										
		1				2		3	4			
	Industries	Primary Products (1a)	Resouce Related (1b)	Resouce Related (1b) Service Sector (1bs)	Lcal Services (1c)	Labor Intensive Mfg. (2a)	General Mfg. (2b)	High-Tech. Mfg. (3)	High-Level Services (4) 60,61, 69~71 76,78,	High-Level Services (4) FIRE	Public Activities	Manufac-turing
	JIP Industries	1 ~ 7	8~14 30, 31 62~66	62~66	67,68, 73~75, 83 94~97	15~17, 19, 21,22, 32~39,47	18, 23~25	20, 26~29 40~59	80~82, 85~92	69~71	79, 99~107	8 ~ 59
1	TFP (Time) % per Year in a traditional production function	NA	NA	0.92%	0.86%	0.74%	0.61%	0.76%	NA	0.53%	NA	0.76%
2	TFP(IT variables) KI: IT capital Intensity KQ: Quality of Capital	NA	NA	KQ	KI*KQ	KQ	KI*KQ	KI*KQ	NA	KI*KQ	KI*KQ	KI*KQ
3	Output Elasticity w.r. Capital Stock											
3a	Decreasing or Iincreasing			Increasing	Increasing	Increasing	Increasing	Increasing		Increasing	Increasing	Increasing
3b	Value at 2006	Almost 0		0.14	0.25(*)	0.15	0.14	0.25		0.18(0.35**)	0.13	0.12
4	Marginal Product of IT Capital Stock	Decreasing		Decreasing	Increasing	Decreasing	Increasing	Increasing		Increasing	Increasing	Increasing
5	Possibility to Achieve Economic Growt of the Pre-Bubble Peiod	x		△	◎	X	○	◎		△	△	△
6	Comparison of Output Growth in Intensive IT investment Case in Time (TFP) and Time (IT variables)											
6a	by TFP (Time)	na		2.02%	1.25%	2.02%	0.29%	1.44%		1.94%	1.70%	0.43%
6b	by TFP (IT variables)	na		3.08%	4.22%	3.08%	1.44%	4.67%		4.12%	3.55%	1.49%
	The Economy of Scale											
	a traditional production function	0.909		0.746	0.942	1.102	0.930	1.121		0.941	0.734	1.096
	a new production function			0.874	1.295	1.099	0.930	1.171		1.032	0.670	1.162

*	*: When we aggregate Wholesale trade and Retail trade industries only, the output elasticity w.r.t. IT capital stock is 0.6.
**	**: 0.35 is the case for financial industry only.
X	X: It is difficult to achieve neither the average growth rate of the pre-bubble period nor a 3% growth.
△	△: It is difficult to achieve the average growth rate of the pre-bubble period but possible for 3%.
○	○: It is possible to achieve the average growth rate of the pre-bubble period but difficult for a 3% growth.
◎	◎: It is possible to achieve both the average growth rate of the pre-bubble period and a 3% growth.

When we consider our empirical results from a viewpoint of the Stages of the Development Ladder including Internet dispersion, we may assume the S-Shape production functions for ASEAN countries (figure 3.1). Once each ASEAN country can formulate time series data such as real gross output, real net IT capital stock and real IT service flow, we can verify which S-Shape production function fits with each ASEAN country. For ASEAN to raise potential output and achieve higher economic growth ASEAN needs to introduce the right mix of policies that will shift the S-Shape production function upward through TFP. To this end, IT policies and human development policies designed particularly in the ASEAN Economic Community (AEC) Blueprint, ASEAN Socio-Cultural Community (ASCC) Blueprint, e-ASEAN Framework Agreement, ICT cooperation or collaboration between ASEAN and other East Asian countries such as China, Japan and S. Korea and AIM215, will be very effective.

Figure 3.1: Hypotheses of ASEAN Countries' S-Shape Production Functions

(%): Internet penetration among population



Appendix A:

IT capital intensity (KIT/LH) and Quality of Capital (KIT/K) for 108 Japanese Industries

JIP #		IT capital Intensity (KIT/LH) (Yen/ Man-hours)	Quality of Capita (KIT/K) (%)
1	Rice, wheat production	0.002	0.010
2	Miscellaneous crop farming	0.003	0.042
3	Livestock and sericulture farming	0.011	0.147
4	Agricultural services	0.142	2.018
5	Forestry	0.017	0.066
6	Fisheries	0.066	0.789
7	Mining	0.059	0.575
8	Livestock products	0.065	1.218
9	Seafood products	0.034	1.447
10	Flour and grain mill products	0.013	2.261
11	Miscellaneous foods and related products	0.049	1.311
12	Prepared animal foods and organic fertilizers	0.025	0.930
13	Beverages	0.169	1.124
14	Tobacco	0.782	1.427
15	Textile products	0.025	0.675
16	Lumber and wood products	0.021	0.641
17	Furniture and fixtures	0.036	1.481
18	Pulp, paper, and coated and glazed paper	0.242	1.378
19	Paper products	0.060	1.070
20	Printing, plate making for printing and bookbinding	0.062	1.643
21	Leather and leather products	0.024	1.117
22	Rubber products	0.055	1.136
23	Chemical fertilizers	1.147	2.454
24	Basic inorganic chemicals	1.140	3.226
25	Basic organic chemicals	0.537	1.234
26	Organic chemicals	0.365	1.031
27	Chemical fibers	0.262	0.751
28	Miscellaneous chemical products	0.191	1.490
29	Pharmaceutical products	0.624	3.749
30	Petroleum products	1.002	0.744
31	Coal products	0.195	0.767
32	Glass and its products	0.129	1.304
33	Cement and its products	0.052	0.806
34	Pottery	0.072	1.983
35	Miscellaneous ceramic, stone and clay products	0.062	0.705

(Continued)

36	Pig iron and crude steel	0.317	0.644
37	Miscellaneous iron and steel	0.265	0.921
38	Smelting and refining of non-ferrous metals	0.238	2.202
39	Non-ferrous metal products	0.117	0.844
40	Fabricated constructional and architectural metal product	0.054	1.861
41	Miscellaneous fabricated metal products	0.060	1.827
42	General industry machinery	0.104	1.296
43	Special industry machinery	0.127	1.668
44	Miscellaneous machinery	0.062	1.090
45	Office and service industry machines	0.125	1.992
46	Electrical generating, transmission, distribution and industrial apparatus	0.357	3.562
47	Household electric appliances	0.774	5.527
48	Electronic data processing machines, computer equipment	1.145	11.394
49	Communication equipment	0.652	6.956
50	Electronic equipment and electric measuring instruments	0.722	11.602
51	Semiconductor devices and integrated circuits	0.276	2.573
52	Electronic parts	0.291	7.382
53	Miscellaneous electrical machinery equipment	0.256	4.298
54	Motor vehicles	0.202	1.253
55	Motor vehicle parts and accessories	0.140	1.265
56	Other transportation equipment	0.148	1.620
57	Precision machinery & equipment	0.182	2.254
58	Plastic products	0.036	0.549
59	Miscellaneous manufacturing industries	0.129	2.560
60	Construction	0.037	2.268
61	Civil engineering	0.041	2.072
62	Electricity	1.955	0.921
63	Gas, heat supply	0.873	1.532
64	Waterworks	0.394	0.214
65	Water supply for industrial use	0.309	0.062
66	Waste disposal	0.018	0.394
67	Wholesale	0.132	3.357
68	Retail	0.097	4.615
69	Finance	0.482	9.934
70	Insurance	0.389	10.436

(continued)

71	Real estate	0.063	0.175
72	Housing (Imputed rent)	NA	0.000
73	Railway	0.633	0.536
74	Road transportation	0.055	0.625
75	Water transportation	0.167	0.612
76	Air transportation	0.593	1.348
77	Other transportation and packing	0.133	2.581
78	Telegraph and telephone	10.471	13.558
79	Mail	0.216	13.574
80	Education (private and non-profit)	0.128	1.323
81	Research (private)	0.130	2.717
82	Medical (private)	0.113	1.955
83	Hygiene (private and non-profit)	0.019	5.119
84	Other public services	0.049	6.747
85	Advertising	0.660	7.202
86	Rental of office equipment and goods	9.346	17.274
87	Automobile maintenance services	0.029	1.056
88	Other services for businesses	0.141	9.716
89	Entertainment	0.232	2.238
90	Broadcasting	2.588	7.509
91	Information services and internet-based services	0.394	15.518
92	Publishing	0.132	2.373
93	Video picture, sound information, character information production and distribution	0.024	1.942
94	Eating and drinking places	0.007	0.516
95	Accommodation	0.035	0.396
96	Laundry, beauty and bath services	0.009	1.000
97	Other services for individuals	0.038	1.819
98	Education (public)	0.057	0.997
99	Research (public)	0.433	1.904
100	Medical (public)	0.075	1.549
101	Hygiene (public)	0.038	2.785
102	Social insurance and social welfare (public)	0.086	3.841
103	Public administration	0.790	4.047
104	Medical (non-profit)	0.078	2.014
105	Social insurance and social welfare (non-profit)	0.045	3.414
106	Research (non-profit)	0.046	0.949
107	Other (non-profit)	0.089	3.046
108	Activities not elsewhere classified	0.214	2.741

5. The Case of Thailand[12]

We apply a new production function to the Thai economy in Stage 2 of the development ladder because time series data of real net IT capital stock are available, since the National Economic and Social Science Development Board (NESDB) has prepared Input-Output data. Although nominal gross output data series are available, real gross output data are not yet available. So, we use real GDP as a dependent variable instead of real gross output, though a production function of gross output is preferable than that of value added particularly for analyzing the IT revolution as well as oil crises. This is because IT input, like energy input, plays an important role as an intermediate input such as B2B. However, IT plays a more important role in TFP so we introduce IT variables to explain TFP in a value-added production function.

IT capital stock in the Thai economy consists of the following three investments:

- Office, computing and accounting machines.
- Radio, television and communication equipment and apparatus.
- Scientific, measuring, controlling equipment, n.e.c.

We estimate a traditional production function with TFP (Time) and a new production function with TFP (IT variables) and compare their simulation results to judge the effect of IT on the Thai economy. Time series data such as capacity utilization and work-hours are not available for the whole sample period. We had to assume constant returns to scale in order to obtain reasonable parameters.

<u>Estimation Results for the Thai Economy:</u>

Log(GDP) = -21.88939 + 0.489052*log(K) + (1-0.489052)*log(L)

(t=-2.0) (t=3.9) (constant returns to scale is assumed)

---

[12]We could obtain the time series data of real net IT capital stock only for Thailand. We thank Dr. SurapolSrihuang and Ms. WannapaKhlaisuan at NESDB for providing IT capital stock data.

+ 0.01186*Time - 0.045151*D9798 ……………………….………eq.3.18a

(t=2.1) (-2.2)

Sample: 1987-2009, D-W:2.02, R_2:0.99, ar(1,2)

Sum of Coefficients: 1.0

where

GDP: Real gross domestic product

K: Real Net capital stock

L: Employment

Time: a proxy of disembodied technical progress.

D9798: Financial crisis dummy (=1 for 1987 and 1988, 0 for else)

Log(GDP) = 2.388570 + 0.320615*log((K+K(-1))/2) + (1- 0.320615)*log(L) +

(t=3.5) (t=2.2) (constant returns to scale is assumed)

+ 0.247936*(KI)*(KQ)*(1-UR/100) – 0.058167*D9798 ……..eq. 3.18b

(t=2.7) (t=-3.4)

Sample: 1987-2009, D-W:1.83, R_2:0.99, ar(1,2)

Sum of Coefficients: 1.0

KI: IT capital intensity (= KIT / K)

KQ: Quality of capital (= KIT / K)

UR: Unemployment rate (%)

Findings:

- We tried to use (1-unemployment rate/100) as a proxy of capacity utilization when it worked.
- We assumed constant returns to scale because estimated parameters for labor or capital input often exceeded 1.0.
- Disembodied technical progress is 1.186% per year (Eq. 3.18a).
- Multiplier of IT capital intensity and Quality of capital explains TFP (eq. 3.18b).
- Output (GDP) elasticity w.r.t. IT capital stock is calculated from eq. 3.18b. This had an increasing trend in the 1990s but turned into a decreasing trend in the 2000s (graph 3.28). Its value, 0.8, in 2009 is still quite high, suggesting more significant effect of IT on the Thai economy than the Japanese economy.
- Output (GDP) elasticity w.r.t. IT capital stock (≡ela_GDP_KIT) will be precisely compared to output (gross output) elasticity w.r.t. IT capital stock (≡ela_G_KIT) as shown in eq.s 3.19a ~ 2.19c.

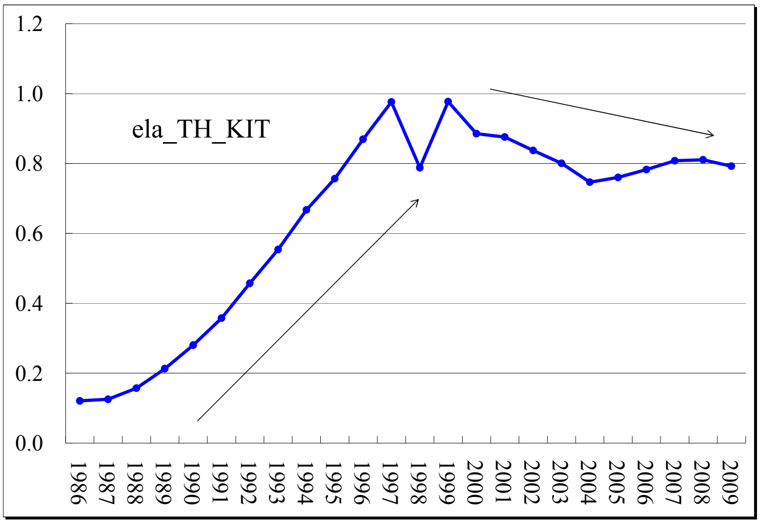
ela_G_KIT≡{d(G)/G}/ {d(KIT)/KIT} …………………………………. Eq. 3.19a

where G: gross output and KIT: IT capital stock.

ela_GDP_KIT≡{d(GDP)/GDP}/ {d(KIT)/KIT} ………………………. Eq. 3.19b

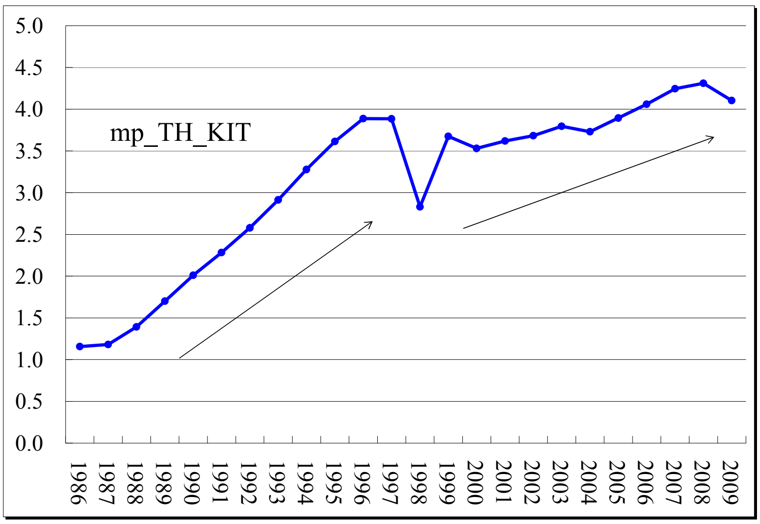
ela_GDP_KIT / ela_G_KIT = {d(GDP)/d(G)}*(G/GDP) ………………. Eq. 3.19c

Graph 3.28: Output (GDP) elasticity w.r.t. IT capital stock for Thai Economy



- The marginal product of IT capital stock enjoyed a sharp increasing trend before the financial crisis in 1997 and a moderately increasing trend in the 2000s (graph 3.29). Thai economy had much benefits from the IT revolution before the 1977 financial crisis than after that.

Graph 3.29: Marginal product (GDP) of IT capital stock for the Thai economy



Simulation Studies for Real Output (GDP) Growth for the Thai Economy

- Contribution to output growth by TFP (Time) is always 1.19% while that of TFP (KI*KQ) changes from 0.38% in the Pessimistic case to 6.17% in the Intensive IT investment case.
- A traditional production function shows only a 0.13% increase for output growth from the Standard case to the Intensive IT Investment case (table 3.15a) while a new production function shows a 3.05% increase for output growth from the Standard case to the Intensive IT investment case (table 3.15b). We assumed that KIT increased by 8.0% in the Standard case and by 12.0% in the Intensive IT Investment case. Namely, a traditional production function misses the effect of IT variables on output through TFP.
- If we apply the Peak-to-Peak approach to measure potential output, the potential output after the 1997-98 financial crisis is about 6% (graph 3.30).
- One of the most serious concerns about the recent Thai economy is the sharp decline in investment after the financial crisis. The average growth rate of IT capital stock fell from 17.4% during 1986-96 to 1.3% during 1997-2009 and that of non-IT capital stock from 10.2% to 2.5% for the same period.
- The simulation studies from the Standard case to the Intensive IT Investment case in table 3.15b illustrate how the Thai economy can maintain a potential output of much more than 6% by increasing IT investment.

Graph 3.30 Potential Output (%) for Thai Economy by Peak-to-Peak

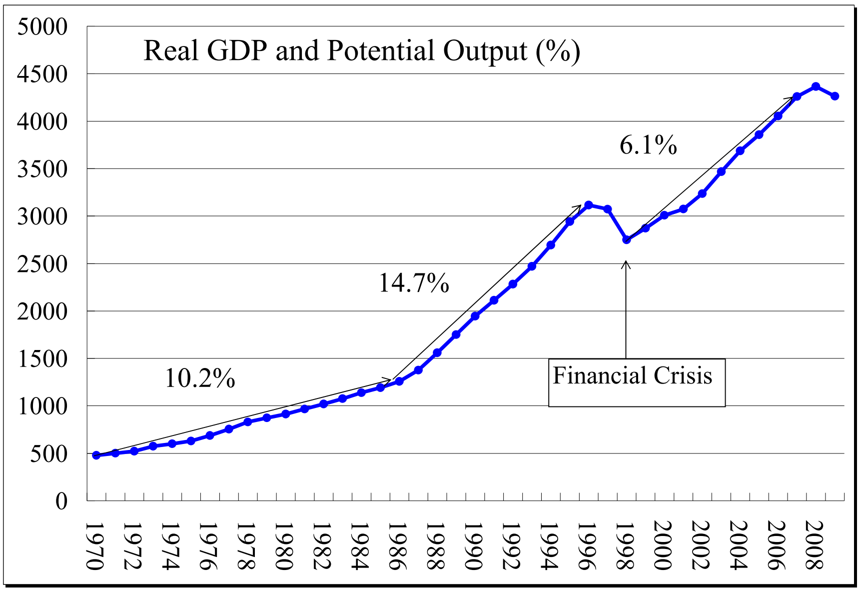


Table 3.15a: Simulation Studies for the Thai Economy: Case of TFP (Time)

History		GDP	KO	KIT	L	
Average Growth Rate	1986-2009	5.58	6.05	8.69	1.60	
	1986-1996	9.16	10.18	17.38	2.05	
	1997-2009	2.55	2.55	1.34	1.22	
Simulations						
Assumed Growth Rate (%) **Pessimistic Case**		GDP	KO	KIT	L	
			2.0	1.0	1.0	
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (Time)
		2.63	0.93		0.51	1.19
Assumed Growth Rate (%) **Standard Case**		GDP	KO	KIT	LH	
			6.0	8.0	1.5	
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (Time)
		4.86	2.92		0.76	1.19
Assumed Growth Rate (%) **Optimistic Case**		GDP	KO	KIT	L	
			8.0	10.0	2.0	
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L(LH+L_Q)	TFP (Time)
		6.03	3.83		1.01	1.19
Assumed Growth Rate (%) **Intensive IT Investment Case**		GDP	KO	KIT	LH	
			6.0	12.0	1.5	
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (Time)
		4.99	3.05		0.76	1.19

Table 3.15b: Simulation Studies for the Thai Economy: Case of TFP (KI*KQ)

History		GDP	KO	KIT	L	KIT/LH(KI)	KIT/K(KQ)	UR
Average Growth Rate	1986-2009	5.58	6.05	8.69	1.60	6.97	2.19	2.19
	1986-1996	9.16	10.18	17.38	2.05	15.05	6.10	2.29
	1997-2009	2.55	2.55	1.34	1.22	0.13	-1.11	2.11
Simulations								
Assumed Growth Rate (%) **Pessimistic Case**		GDP	KO	KIT	L			
			2.0	1.0	1.0	1.0	0.0	2.0
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (KI*KQ)		
		1.76	0.7		0.68	0.38		
Assumed Growth Rate (%) **Standard Case**		GDP	KO	KIT	L			
			6.0	8.0	1.5	6.4	1.7	2.0
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (KI*KQ)		
		5.53	1.35		1.01	3.16		
Assumed Growth Rate (%) **Optimistic Case**		GDP	KO	KIT	L			
			8.0	10.0	2.0	7.8	1.7	2.0
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (KI*KQ)		
		6.70	1.66		1.35	3.71		
Assumed Growth Rate (%) **Intensive IT Investment Case**		GDP	KO	KIT	L			
			6.0	12.0	1.5	10.3	5.2	2.0
Contribution to Growth Rate of Thai Economy			K(=KO+KIT)		L	TFP (KI*KQ)		
		8.58	1.40		1.01	6.17		

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CHAPTER 4

How to Create IT Capital Stock

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IT economic variables such as IT capital stock and investment play an important role in the new production function. We find, however, very little officially published IT time series data in most countries because many historical input–Output (I-O) tables are needed to create the IT time series data. If ASEAN countries can create uniform IT time series data and share the IT database, it will be very useful for ASEAN to assess the effect of IT on their economies. Since this is one of our purposes, in this chapter we show how to start creating IT capital stock.

1. Methodology of Data Building

1.1. Basic framework of data building

We present the methodology and procedures for accumulating statistics related to IT investment and IT capital stock. An outline of the actual process follows:

[Overall process for obtaining IT investment and capital stock time series data]

(1) Define IT investment and measure benchmarks using the I–O table

(2) Calculate annual time series data

– Nominal time series data using supplemental statistics

– Real-term time series data using price indices

(3) Calculate the IT capital stock

First, the item codes of hardware and software products related to IT are defined and measured based on the input–output table. Unfortunately, although more frequent time series data (e.g. annual datasets) are necessary for relevant empirical studies, the input–output table is published only once every five years in Japan. Secondly, annual time series data between I-O tables are calculated using the growth rate of domestic demand for each product defined above, with such supplemental statistics as industrial production and international trade. This process can be divided into two steps: calculating nominal time series data, and then converting them to real-term data by using the price deflator of each product. Thirdly, IT capital stock data are calculated with real-term annual IT investment data, the depreciation rate of each IT asset, and estimated figures of initial endowments.

Using these steps of data building—definition and benchmark measurement, calculation of flow-based time series data, and creation of capital stock— valuable IT-related macro statistics will become available. We discuss each process more precisely in the following subsections.

2. Benchmarks based on the Input–output Table

2.1. Definition

The first step of data building is to define IT investment. For the definition, product codes or industry codes in the I–O table are useful and relevant. In the case of Japan, a fixed-capital matrix is available in the official input–output table. The fixed capital matrix provides all relevant domestic fixed-capital formation data in the benchmark year, according to the industrial sectors for which capital goods of each type, shown in Figure 4.1.

Figure 4.1. Configuration of Fixed-capital Formation

item codes	capital goods \ industry codes / industries	010000 agriculture	- -	160000 automobile industry	- -	260000 communications and broadcasting	- -	private sector total
:	:							
3111011	photocopy							
3111099	other office equipment							
:	:							
3331011	personal computers							
3331021	computers except personal computers							
3331031	computers peripheral equipment							
:	:							
3321011	wired telecommunications equipment							
3321021	cellular phones							
3321031	other wireless telecommunications equipment							
3321099	other telecommunications equipment							
:	:							
4132031	construction of telecommunications facilities							
:	:							
7331011	software							
:	:							
total amount of capital formation								

In light of international comparisons and precedent studies[1], we use the product code in the fixed-capital matrix for definition. We choose the following 11 items as components of IT investment. They are: personal computers (3331011), computers, excluding personal computers (3331021), computer peripheral equipment (3331031), wired telecommunications equipment (3321011), cellular telephones (3321021), wireless telecommunications equipment, excluding cellular telephones (3321031), other telecommunications equipment (3321099), photocopiers (3111011), other office

[1] In the United States, IT investment is defined as “Information processing equipment and software”, classified into three categories, “computers and peripheral equipment,” “software,” and “other.” The “other” includes “communications equipment,” “photocopy and related equipment,” “office and accounting equipment,” “medical equipment and instruments,” and nonmedical instruments.”

equipment (3111099), construction of telecommunication facilities (4132031), and software products (7331011).

As described in the next subsection, we then categorize the 11 products above into five items because of the limited nature of available statistics for creating annual time series data. The five are: (1) computers and peripherals (3331011, 3331021, 3331031), (2) telecommunications equipment and peripherals (3321011, 3321021, 3321031, 3321099), (3) construction of telecommunication facilities (4132031), (4) office equipment and peripherals (3111011, 3111099), and (5) software products (7331011) (Figure 4.2).

Figure 4.2. Categories Classified for IT investment

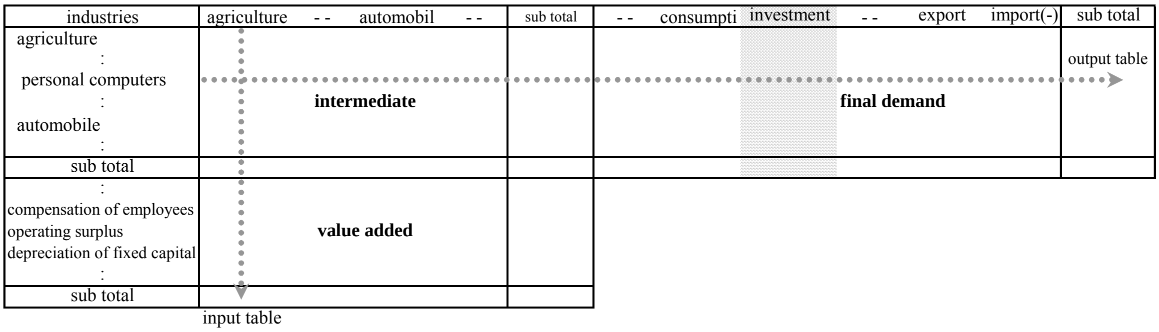
classification of categories			item codes	capital goods	purchaser's price (a)	producer's price (a)	(b)/(a)
hardware	computer related	computers and peripherals	3331011	personal computers	1,354,633	1,036,491	0.7651
			3331021	computers except personal computers	1,079,775	852,830	0.7898
			3331031	computers peripheral equipment	1,388,459	1,126,531	0.8114
	telecom related	telecommunications equipment and peripherals	3321011	wired telecommunications equipment	1,077,001	693,128	0.6436
			3321021	cellular phones	59,334	32,980	0.5558
			3321031	other wireless telecommunications equipment	686,986	575,684	0.8380
			3321099	other telecommunications equipment	314,892	265,255	0.8424
		construction of telecommunication	4132031	construction of telecommunications facilities	311,873	311,873	1.0000
	office related	office equipment and peripherals	3111011	photocopy	434,248	316,358	0.7285
			3111099	other office equipment	836,983	593,846	0.7095
software	software	software	7331011	software	7,277,117	7,267,071	0.9986
total IT investment					14,821,301	13,072,047	0.8820

2.2. Benchmark measurement

Annual figures calculated once every five years are measured as benchmark components of IT investment through evaluation of the amount of defined products in the private sector's fixed-capital matrix. In case a fixed-capital matrix is unavailable, the benchmark can be measured using an "output table" in the I–O table, rather than an "input table." The output table describes where and how each product is demanded and used. Take computer peripheral equipment, for example. Some of this equipment is purchased and used as an intermediate input by a wide range of industries while other equipment is consumed by households or invested by firms as final demand (Figure 4.3). Figures of defined products for investment in the final demand are measured as benchmarks of IT investment. Using these procedures, we can create benchmarks of IT investment for every five years[2].

[2] In case the value of each IT related item is measured in terms of producer's price that excludes delivery cost, broker commissions, and installation cost, it is necessary to convert the value into the purchaser's price that includes those costs to avoid an underestimation of IT investment. See Figure 4.2.

Figure 4.3. Configuration of the Input output Table



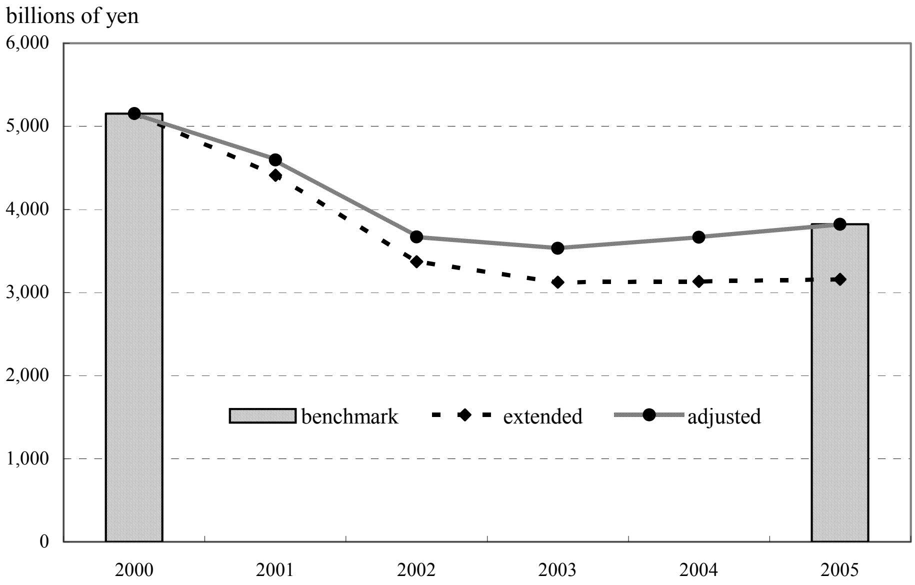
3. Time Series Data of IT Investment

The next step is to annually bridge over the five-year benchmarks. One of the greatest difficulties with this process is a shortage of precise annual data. In other words, missing or imperfect data become apparent, especially tracking back before the 1990s. To address the limitation of available statistics for creating annual time series data, 11 product categories used in the input–output table are integrated into five item components, as described in the previous subsection, which are then calculated annually using supplemental statistics.

The process to bridge over the five-year benchmarks for obtaining annual data is divisible into two steps: (1) calculating nominal time series data and (2) converting them to real-term data. For nominal data, we adopt the annual rate of change of domestic demand for each category. The amount of domestic demand is formulated by subtracting the value of exports from those of domestic production and adding the value of imports using supplemental statistics related to industrial production and international trade.

It is noteworthy that some discrepancy might occur in this process for the benchmark year because the values accumulated for the annual change of domestic demand and the values of benchmarks in the I–O table are not identical. For example, for the process of bridging over benchmarks between 2000 and 2005, the figures simply extended to 2005 by accumulating the annual rate of change of domestic demand from 2000 differ from the figures in the 2005 input–output table (Figure 4.4).

Figure 4.4: Benchmarks, simply extended, and adjusted data.



Source: Ministry of Internal Affairs and Communications, *2005 Input–Output Tables*.

To adjust such discrepancies, we use the "linking coefficient", which smoothly corrects the annual gaps. The formula of the "linking coefficient" is

$$IO05 = IO00 * (1 + DC0005 + ADJ),$$

where *IO*05 represents the benchmark figure from the 2005 input–output table, *IO*00 represents the benchmark figure from the 2000 input–output table, *DC*0005 represents the accumulated rate of change of domestic demand during 2000–2005, and *ADJ* represents the adjustment factor. Then, this formula can be transformed to

$$io0005 = dc0005 + adj ,$$

where *io*0005 represents the annual rate of change of the I–O table benchmark figure during 2000–2005, *dc*0005 represents the annual rate of change of domestic demand, and *adj* represents the annual rate of change of adjustment factor, i.e. the "linking coefficient."

Accordingly, the annual rate of change with no discrepancy is obtained from the annual rate of change of domestic demand and the "linking coefficient (*adj*)." This procedure is conducted for each item for the years between benchmarks. Linking these rates of change in succession produced the nominal annual IT investment value for each item of the five categories. We can convert these nominal time series data into real-term annual data using price indices as deflators. The steps up to this point tabulate the nominal and real values of IT investment annually (Tables 4.1a and 4.1b).

Table 4.1a Nominal IT investment data

(billions of current yen)

year	(1)	(2)	(3)	(4)	sub total	(5)	total
75	663	292	469	313	1,737	46	1,783
76	715	315	499	343	1,872	51	1,923
77	811	335	531	385	2,062	84	2,146
78	927	349	565	474	2,316	97	2,412
79	1,143	353	602	424	2,521	140	2,661
80	1,264	375	641	423	2,702	167	2,869
81	1,423	477	653	318	2,870	247	3,117
82	1,647	593	665	385	3,289	326	3,615
83	1,736	787	677	644	3,844	395	4,240
84	2,426	1,042	690	739	4,898	556	5,453
85	3,173	1,271	703	888	6,036	714	6,749
86	3,656	1,347	640	1,006	6,650	990	7,640
87	4,056	1,562	583	1,149	7,350	1,198	8,548
88	4,766	1,731	531	1,570	8,598	1,951	10,549
89	5,480	1,822	484	1,728	9,513	2,725	12,238
90	5,452	2,233	440	1,487	9,613	3,751	13,363
91	5,576	2,376	492	1,563	10,008	4,665	14,673
92	4,618	2,119	537	1,423	8,697	4,660	13,356
93	4,040	2,243	604	1,275	8,163	4,136	12,299
94	4,789	2,434	621	1,186	9,030	3,781	12,811
95	5,514	3,169	781	1,156	10,620	4,010	14,630
96	6,345	4,403	1,065	1,159	12,973	4,620	17,593
97	6,146	4,028	1,151	1,262	12,588	5,064	17,652
98	4,988	3,125	1,213	1,150	10,476	5,413	15,889
99	4,847	2,961	1,255	1,214	10,277	5,739	16,016
00	5,154	3,074	1,445	1,402	11,075	6,015	17,090
01	4,594	3,111	795	1,073	9,573	6,755	16,327
02	3,671	2,128	502	1,759	8,060	6,969	15,028
03	3,532	2,387	415	1,298	7,632	6,929	14,562
04	3,665	2,075	340	1,275	7,356	7,208	14,563
05	3,823	2,138	312	1,271	7,544	7,277	14,821
06	3,792	2,258	323	1,168	7,540	7,464	15,004
07	3,284	2,298	307	1,099	6,988	7,817	14,805
08	3,212	2,119	318	781	6,430	7,887	14,317
09	2,441	1,682	304	553	4,979	7,366	12,345

(1) computers and peripherals
(2) telecommunications equipment and peripherals
(3) construction of telecommunications facilities
(4) office equipment and peripherals
(5) software

Table 4.1b Real IT investment data

(billions of 2005 constant yen)

year	(1)	(2)	(3)	(4)	sub total	(5)	total
75	70	123	807	63	1,062	73	1,135
76	76	134	802	89	1,101	74	1,176
77	90	141	797	111	1,138	114	1,252
78	112	147	792	151	1,202	125	1,327
79	145	149	787	141	1,222	175	1,397
80	161	156	782	149	1,248	194	1,443
81	190	196	793	121	1,301	274	1,575
82	236	243	805	164	1,449	351	1,801
83	267	324	816	301	1,709	417	2,126
84	395	427	828	371	2,021	571	2,592
85	581	531	840	468	2,420	720	3,140
86	820	631	746	579	2,776	999	3,776
87	1,086	801	662	748	3,297	1,212	4,509
88	1,344	936	588	1,124	3,991	1,955	5,946
89	1,542	990	522	1,252	4,306	2,603	6,909
90	1,576	1,235	463	1,081	4,354	3,442	7,796
91	1,683	1,350	503	1,165	4,701	4,130	8,831
92	1,455	1,212	540	1,084	4,291	4,100	8,391
93	1,322	1,290	605	999	4,216	3,708	7,924
94	1,679	1,423	622	953	4,676	3,561	8,237
95	2,115	1,895	781	955	5,746	3,906	9,652
96	2,582	2,705	1,072	964	7,322	4,511	11,833
97	2,548	2,500	1,148	1,061	7,256	4,782	12,038
98	2,157	1,990	1,241	994	6,382	4,986	11,368
99	2,158	2,054	1,304	1,113	6,630	5,251	11,880
00	2,481	2,262	1,494	1,307	7,545	5,490	13,034
01	2,487	2,430	837	1,011	6,765	6,298	13,063
02	2,397	1,801	535	1,660	6,393	6,621	13,014
03	2,769	2,178	439	1,252	6,638	6,854	13,492
04	3,250	2,002	352	1,243	6,846	7,161	14,008
05	3,823	2,138	312	1,271	7,544	7,277	14,821
06	3,989	2,346	299	1,226	7,861	7,369	15,230
07	3,785	2,631	278	1,181	7,875	7,642	15,517
08	4,072	2,545	292	845	7,753	7,611	15,364
09	3,514	2,097	288	628	6,526	7,323	13,850

(1) computers and peripherals
(2) telecommunications equipment and peripherals
(3) construction of telecommunications facilities
(4) office equipment and peripherals
(5) software

Indeed, Japan's real IT investment enjoyed an increasing trend until 2007, as seen in figure 4.5. But if we compare Real IT investment – Real Total investment ratio between Japan and the U.S.A., then the ratio has been almost flat in Japan since 1995 while the ratio has been accelerating in the United States since 1995 (figure 4.6). These differences imply the different IT effects on their economies.

Figure 4.5: Japan's Real IT Investment (Billions of 2005 constant yen)

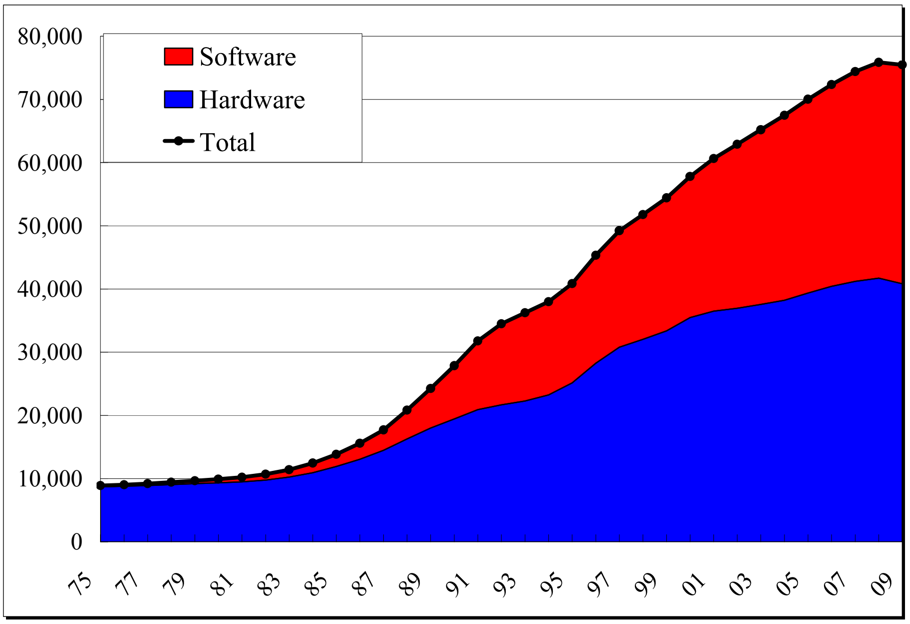
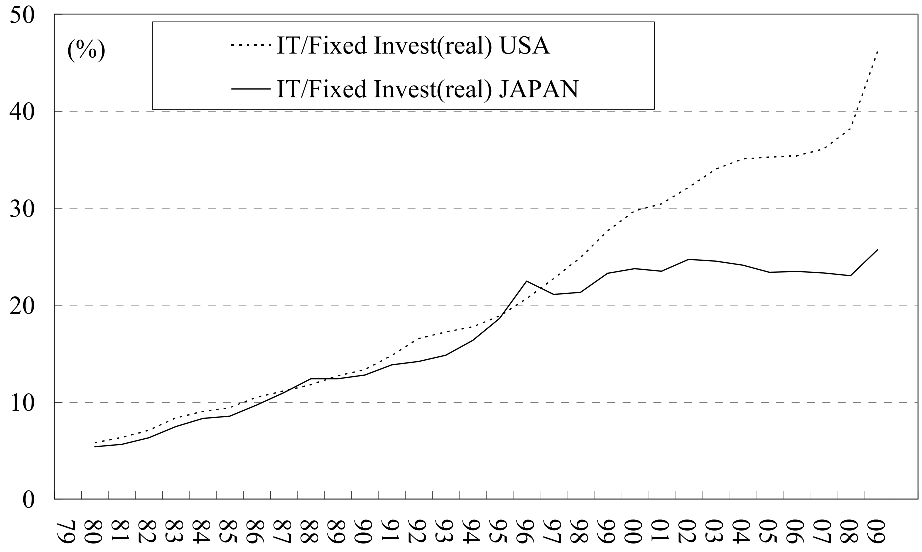


Figure 4.6: Real IT investment – Real Non-residential fixed investment Ratio between Japan and the United States (%)



4. Time Series Data of IT Capital Stock

The time series of capital stock data is what we need for empirical studies to analyze the impact of IT on economic growth and development. Using investment flow data, depreciation rate, and initial endowment of assets, we can create the time series data of IT capital stock according to the following formula:

$K_t = I_t + (1\text{-}\delta) * K_{t\text{-}1}$ ………………………………………………………. eq. 4.1

In eq. 4.1, K stands for capital stock, I represents the investment flow, δ denotes the depreciation rate, and t signifies the year or time series. Given that the annual growth rate of investment (g) and depreciation rate (δ) are constant for the years before t, the following formula is obtained[3]:

$K_{t\text{-}1} = I_t / (g + \delta)$ ………………………………………………………………… eq. 4.2

Therefore, on the assumption that the first several years' growth rate and depreciation rate are maintained until the initial benchmark year, the initial IT capital stock endowment can be calculated. Here, the missing figure for calculating the time series IT capital stock is the depreciation rate, which is obtainable from Fraumeni (1997) for hardware. Although the figures presented by Fraumeni (1997) are derived from IT investment in the United States, it is reasonable to assume that the depreciation rates of IT-related products are almost identical around the world because of the nature of the technology: it diffuses rapidly and globally. As for the depreciation rate of software, we assume 20%, or 5 years' duration, in light of precedent studies.

Figure 4.6: Depreciation rate

	Hardware			Software
	Computer related	Telecom related	Office related	
Depreciation Rate	0.31190	0.11000	0.18000	0.20000
Duration (year)	3.2	9.1	5.6	5.0

Source: Fraumei(1997), Japan Center for Economic Research(2000)

[3] This formula is commonly adopted for creating capital stock from investment flows.

Finally, we have the time series data of real net IT capital stock (table 4.2). We have demonstrated the importance of IT capital stock data in revealing the influence of technology on macroeconomies from the Industrial Age to the Information Age. World-wide collaboration for data building and collection is necessary because IT investment and capital stock data enable economists to conduct international comparisons related to the economic impact of IT based on relevant macroeconomic statistics.

Table 4.2: Real Net IT Capital Stock

billions of 2005 constant yen

year	total (a)=(b)+(c)	Net IT capital stock				
		hardware capital stock（b）	of which computer related	of which telecom related	of which office related	software capital stock（c）
75	8,911	8,698	168	8,328	202	214
76	9,039	8,794	192	8,348	255	245
77	9,219	8,909	222	8,367	320	310
78	9,436	9,063	265	8,386	413	373
79	9,680	9,206	328	8,399	479	473
80	9,915	9,342	386	8,414	542	573
81	10,232	9,500	456	8,478	566	732
82	10,709	9,772	550	8,594	628	937
83	11,418	10,251	646	8,788	817	1,167
84	12,462	10,957	840	9,077	1,041	1,505
85	13,853	11,929	1,158	9,449	1,322	1,924
86	15,606	13,067	1,618	9,786	1,663	2,539
87	17,727	14,483	2,200	10,172	2,112	3,243
88	20,839	16,290	2,857	10,576	2,856	4,549
89	24,269	18,027	3,509	10,925	3,594	6,242
90	27,874	19,438	3,990	11,420	4,028	8,436
91	31,793	20,914	4,429	12,018	4,467	10,879
92	34,500	21,698	4,502	12,448	4,747	12,803
93	36,236	22,286	4,420	12,974	4,891	13,950
94	37,997	23,275	4,720	13,592	4,963	14,721
95	40,844	25,160	5,363	14,772	5,025	15,683
96	45,338	28,280	6,273	16,923	5,085	17,058
97	49,232	30,803	6,864	18,710	5,230	18,428
98	51,774	32,045	6,880	19,883	5,282	19,729
99	54,425	33,391	6,892	21,055	5,444	21,034
00	57,807	35,490	7,224	22,495	5,772	22,317
01	60,640	36,488	7,457	23,287	5,744	24,152
02	62,902	36,960	7,528	23,062	6,370	25,942
03	65,174	37,567	7,949	23,142	6,475	27,607
04	67,470	38,223	8,720	22,950	6,553	29,247
05	70,018	39,343	9,823	22,876	6,644	30,675
06	72,337	40,428	10,748	23,005	6,675	31,909
07	74,388	41,219	11,181	23,383	6,655	33,169
08	75,861	41,715	11,765	23,648	6,302	34,146
09	75,476	40,836	11,610	23,431	5,795	34,640

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CHAPTER 5

Conclusion: ITC's Contribution to ASEAN Development

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The Leaders of ASEAN adopted the Declaration of ASEAN Concord II (Bali Concord II) in 2003 as "the ASEAN Vision 2020," which would establish an ASEAN community by 2020 (this date was later accelerated to 2015). The ASEAN Community consists of three pillars: the "Political and Security Community (APSC)", the "Economic Community (AEC)" and the "Socio-Cultural Community (ASCC)." The purpose is to ensure durable peace, stability and shared prosperity in the region. Particularly from a viewpoint of economics, the promotion of sustainable economic growth and development in the region is key. Since ASEAN countries are in different stages of the development ladder, the "rising tide lifts all boats" concept is relevant and will benefit all participants in the region. In other words, ASEAN has to aim at sustainable higher economic growth by raising potential output because it cannot distribute wealth without first producing it.

The e-ASEAN Framework Agreement, ICT cooperation or collaboration between ASEAN and other East Asian countries such as China, Japan and Korea, and the ASEAN ICT Master Plan 2015 (AIM2015) suggest that the IT revolution and human development play an important role in achieving sustainable higher economic growth and development. Since "Openness" and "Globalization" are key concepts of the IT revolution, "free flow of information and knowledge[1]" is a critical factor for effectively utilizing the IT revolution for ASEAN's economic development.

Indeed, the ASEAN ICT Master Plan 2015 (AIM215) considers ICT as an engine of growth for ASEAN member States in one of four AIM2015's targets[2], but there is no quantitative evidence about the effect of the IT revolution on ASEAN economies. There are two main reasons for this. The first is the lack of IT time series data such as net real IT capital stock. The second reason is that a new production function has to be introduced to analyze the effect of IT revolution on the economy because the use of a traditional production function will result in a misleading conclusion.

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[1] A distinction is sometimes made between information and knowledge (Wade, 2001). Information is available on an impersonal basis and is communicated through books, the Internet, television, for example. Knowledge includes more complex ideas that require learning and that typically rely on personal relationships to communicate.

[2] The four key targets include ICT as an engine of growth for ASEAN member states, recognition for ASEAN as a global ICT hub, enhanced quality of life for the people of ASEAN and contribution towards ASEAN integration.

Indeed, the effect of the IT revolution on the economy depends on the IT infrastructure, including network, software and hardware. Other factors, however, such as culture, language and politics also play important roles in utilizing the IT revolution effectively. Therefore, the effects of IT are quite different not only among countries but also among industries. Although many people admit that the IT revolution is integral to economic growth, there has been little quantitative evidence about the effect of IT on the economy. In addition, it is possible to miss the chance to raise potential IT-propelled growth if a traditional production function or growth accounting method is used. By introducing a new production function in this study, we focused on quantitative analysis of the effect of IT on economies or industries at different stages of the development ladder. Since time series data of IT variables such as IT capital stock have not been prepared yet in most ASEAN countries, we used the time series data of 108 Japanese industries by classifying them into several groups based on the Stages of Development Ladder in East Asian countries.

We conclude and recommend from our study as follows:

Conclusions

- There is little effect of IT on Primary Products industries in Stage 1 of the development ladder. IT does not play an important role in industries in Stage 1.
- As industries move up the Stages of Development Ladder, the effect of IT on their output becomes larger. This is judged by (1). the size of output elasticity w.r.t. IT capital stock; and (2). whether there is an increasing or decreasing trend in output elasticity w.r.t. IT capital stock as well as the marginal product of IT capital stock as IT capital stock increases.
- Although output elasticity w.r.t. IT capital stock showed an increasing trend from the Resource related service sector in Stage 1 of the Development Ladder to High-level services in Stage 4 of the Development Ladder, marginal product showed a decreasing trend for the Resource-related service sector in Stage 1 of the Development Ladder and for Labor-intensive manufacturing industries in Stage 2, suggesting that IT has a limited role in industries in these Stages. In particular,

quality of capital plays a more important role than IT capital intensity in Stages 1 and 2.

- Industries in Stage 3 can utilize all dimensions of IT such as quality of capital and IT capital intensity.
- IT capital intensity and global network may be more important than quality of capital for industries in Stage 4.
- Output elasticity w.r.t. IT capital stock in the Japanese aggregated manufacturing sector increased as IT capital stock accumulated. Its value was 0.10 ~ 0.15 in the mid-2000s.
- Wholesale and retail trade industries belonging to Local-services in Stage 1 of the Development Ladder had very high output elasticity w.r.t. IT capital stock, 0.5 ~ 0.6, in the mid-2000s. IT can be utilized very effectively in these industries.
- Output elasticity w.r.t. IT capital stock for High-tech manufacturing industries in Stage 3 of the Development Ladder was 0.25 in 2006 while that for Labor-intensive and General manufacturing industries in Stage 2 of the Development Ladder was about 0.15. These results imply from a viewpoint of Stages of the Development Ladder that Malaysia, Taiwan and S. Korea may benefit more from the IT revolution than might Indonesia, Philippines, Vietnam, Thailand and China (figure 3.1). However, not only stages of the development ladder but also other factors such as culture and English capability are important determinants of the S-Shape production function.
- Financial, insurance and real estate industries, so-called FIRE, in High-level services in Stage 4 of the development ladder had output elasticity w.r.t. IT capital stock of 0.18 in 2006. If we calculate output elasticity w.r.t. IT capital stock for only the financial industry, its value was 0.35 in 2006. These results imply that Singapore and Hong Kong, in Stage 4 of the Development Ladder where the financial industry has a large share of economic activity, may benefit the most from the IT revolution.
- We can prove that Japan’s potential growth is more than 3% by using the new production function where IT variables explain TFP. Only Primary products

industries and Labor-intensive manufacturing industries have difficulty achieving a 3% output growth.

- If economists stick to a traditional production function where a proxy of Time explains TFP, they will miss the possibility of raising potential output resulting from the IT revolution.

Recommendations:

- ASEAN countries should prepare a common IT database such as the time series data of IT capital stock and flows from Input-Output tables based on the common definition of IT investments. This will be very advantageous for analyzing ASEAN economies as globalization continues to advance.
- In addition to the idea of ASEAN IT database, ASEAN countries should prepare ASEAN Input-Output tables which will be very useful to analyze the economic development of ASEAN through the globalization due to the IT revolution.
- Policy-makers should consider various factors such as culture, politics and language in order to respond to the IT revolution effectively since the IT innovation is quite different from traditional innovations such as the invention of the steam engine. For example, English capability and computer usage are basic skills in an IT Economy.
- Since “Openness” and “Globalization” are key concepts of the IT revolution, “free flow of information and knowledge” should be added as one more core element to the following five core elements for an ASEAN single market and production base: (i) free flow of goods; (ii) free flow of services; (iii) free flow of investment; (iv) freer flow of capital; and (v) free flow of skilled labor.

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