MACROECONOMIC IMPACT OF IT ADOPTION AND DIFFUSION[1]

Masayuki Goto*
Izuru Kimura**
Hirotsugu Sakai***

Abstract

Since the latter half of the 1990s, Information Technology (IT) has been diffused dramatically all over the world in step with globalization. In the industrialized countries, especially, it is recognized that IT diffusion has had a positive impact on macro-economic performance. This study aims to investigate the mechanism of IT diffusion's impact on the macro-economy, and look into the possibility of adopting the same mechanism for the developing countries, particularly in Asia. In order to analyze the impact of IT diffusion, this study reviews the past relevant studies, applies some macro-economic analysis models, conducts interviews with private corporations, and simulates the impact by using a Computable General Equilibrium model.

The major findings of this study are as follows.

- IT has been adopted in the Asian developing countries and IT diffusion has had a positive impact on their macro-economies as well as on industrialized countries. Asian developing countries have not, however, reached the stage of progress where the capital deepening mechanisms increase labor productivity.

- The results of the interview surveys with private corporations imply the required factors for the developing countries to achieve an IT leading economy as follows: (i) construction of high-tech parks by the government, (ii) development of IT related human resources, (iii) expansion of venture capital resources, (iv) creation of domestic IT demand, and (v) establishment of basic infrastructure.

- Rapid growth of IT industries alone in the developing countries is insufficient to lead their sustainable macro-economic development. The overall economic structure should be upgraded to achieve IT-oriented economic growth.

If the developing countries succeed in accumulating human capital in line with IT adoption and diffusion, they may follow the capital deepening mechanisms, as the industrialized countries have

* Director, Remote Islands Development Division, City and Regional Development Bureau, Ministry of Land, Infrastructure and Transport (at writing: Senior Economist, JBIC Institute)
** Representative, Representative Office in Manila, JBIC (at writing: Development Policy Research Division, JBIC Institute)
*** Mitsubishi Research Institute, Inc.

1 This paper was summarized and added some contents based on the report "Macroeconomic Impact of IT Adoption and Diffusion" which was implemented as Development Policy and Project Assistance Survey (SADEP). (Commissioned members of the research team were Hirotsugu Sakai (Research Center for Policy and Economy), Akiko Higashi and Poh Soon Lim (International Project Department, respectively) from Mitsubishi Research Institute, Inc. as well as Toshihisa Iida (Research Associate) from Global Group 21 Japan, Ltd. Their belongings were at the time of their writing.) Refer to JBICI Research Paper No. 20 "Macroeconomic Impact of IT Adoption and Diffusion" for more in detail.
In the course of carrying out this survey, a research committee was established chaired by Professor Shujiro Urata of the School of Social Science of Waseda University, and invited Mr. Kazunori Minetaki, Research Fellow at the Economic Research Center, Fujitsu Research Institute, and Assistant Professor Yoko Takeda of the Graduate School of Environment and Information Sciences, Yokohama National University as participants. Furthermore, at the workshop which took place at the time of compiling this report, Mr. Norihisa Ando, Representative of the Japan Office for Satiyam Japan Inc., and Assistant Professor Masanori Kondo of International Relations Course, Department of Liberal Arts, International Christian University were also participated. Committee members and participants contributed to a great deal of appropriate guidance and beneficial comments for this survey.

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followed them, in the medium and long term. It is important to understand that IT diffusion itself is not a goal but a measure to activate an economy. Therefore, establishment of basic infrastructure, development of human resources, support for entrepreneurs, and improvement of the general market and trade environments are prerequisites to realize stable macro-economic development. However, it is difficult for developing countries to take concrete measures without support from the industrialized countries.

Chapter 1 Introduction

Since the 1990's the adoption and diffusion of Information Technologies (IT)[2] has progressed on a global scale, bringing about major social and economic impacts. Especially in the U.S., IT adoption and diffusion has brought about numerous positive effects for the macroeconomy such as an accelerated rise in productivity, stable prices and continued economic growth. Many other industrialized countries have also been able to utilize IT in the same manner to improve their macroeconomic performances. Some of the positive impacts from IT adoption and diffusion have also been realized in many developing nations. For example, India has seen tremendous growth for its software industry. Higher growth brought about by IT production also helped ASEAN countries escape some of the after-effects of the Asian financial crisis. However, the fact remains that the developing nations have not reached the same level of IT utilization enjoyed by the industrialized nations.

In general, it has been said that IT adoption and diffusion has brought about positive impacts for the macroeconomies of industrialized nations by raising IT-related production and improving efficiency through the use of IT. The question then is just what mechanisms are used to bring about these positive impacts. Another question is can we expect to achieve the same impacts in the developing countries.

While keeping these questions in mind, this study has tried to determine the best policies for achieving sustainable economic growth in developing countries, mainly for the private economic sectors, through the use of IT. Information was collected on IT adoption and diffusion in each of the target countries, macroeconomic impacts were analyzed based on economic models. Corporate behavior was analyzed based on interviews with various corporations and structural change simulations and other methods were employed to analyze the mechanisms by which IT adoption and diffusion impacts the macroeconomies. Tests were conducted to obtain quantitative and qualitative understandings of the results.

The main target countries for this survey were the industrialized nations of the U.S., Ireland, Sweden and Finland, and the developing nations of India, Malaysia, Bangladesh and China.

Chapter 2 Current Status of Global IT Adoption and Diffusion

IT spread rapidly from the second half of the 1990's in step with the spread of globalization. This was a period of solid global economic growth, which many have attributed to the growth of IT. This was particularly true in the U.S., the leading IT nation, which saw accelerated macro labor productivity from the latter half of the 1990's (Figure 1). Some of the past research has pointed to capital deepening[3] by the information service sector and the rise in Total Factor Productivity (TFP) as examples of direct impacts brought about by IT adoption and diffusion (Table 2).

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2 The term "IT" stands for Information Technologies, but it essentially refers to information processing technologies. Generally, this term includes the use of communication and network technologies, and therefore ICT (Information and Communications Technology) is probably the more suitable expression. ICT is becoming the generally accepted international term for information and communications technologies, but this study uses the term "IT", which is still commonly used in Japan. Thus, for this study the term "IT" is synonymous with "ICT".

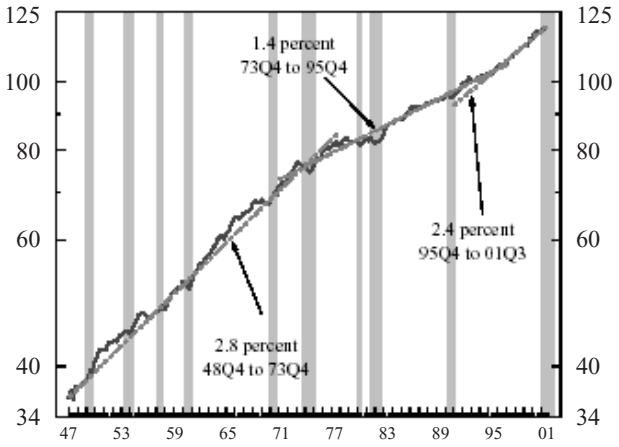
3 Capital deepening means, for example, IT introduction brings a labor saving effect thus capital amount per unit of labor input has increased. In line with this meaning, it can be viewed as the effect of utilizing IT.

IT adoption and diffusion helps to raise the efficiency of all economic activities and makes a major contribution to increased TFP outside of the computer sector as well.

Before providing an analysis of the impacts IT adoption and diffusion has had on macroeconomies, this chapter will first provide a general overview of the current status of IT adoption and diffusion around the world based on various statistical materials.

Figure 1 Growth of Non-agricultural Productivity in the U.S.

Index, 1992=100



Source: U.S. Department of Commerce (2002), Digital Economy 2002

1. Progress of IT Adoption and Diffusion

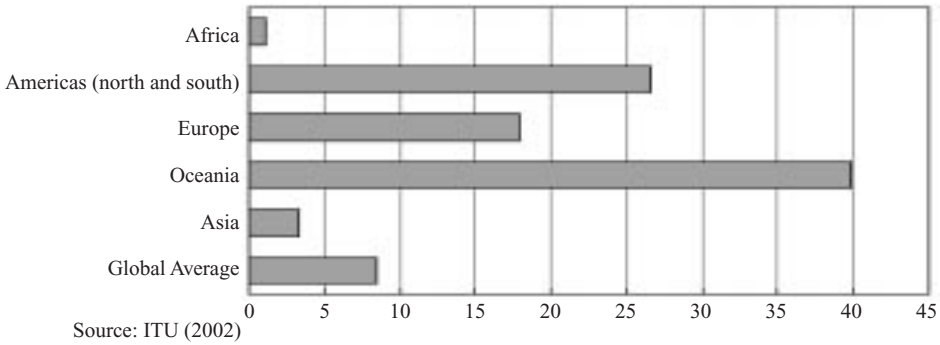
There are various indicators of IT adoption and diffusion such as the diffusion rate of fixed telephone lines, cellular phones, personal computers and Internet usage (number of users, number of hosts). Looking at all of these indicators it is clear that American, European and Oceanian countries have made great strides in terms of IT adoption and diffusion, while the level of diffusion has remained low among the developing countries in Asia and Africa (Table 1).

Table 1 Factors in Increased Productivity in the U.S.

	1973 ~ 1995	1995 ~ 2001	Acceleration (% points)
Labor productivity (%)	1.39	2.60	1.21
Contribution (% point)			
Minus: Cyclical effects	0.02	–0.46	–0.48
Equal: Structural labor productivity	1.37	3.07	1.70
Minus: Capital services	0.72	1.29	0.57
Capital deepening of information services	0.41	1.01	0.60
Capital deepening of other capital services	0.31	0.28	–0.03
Contribution by improved quantity and quality of labor	0.27	0.31	0.04
Equal: Structural TFP	0.37	1.44	1.07
Minus: Computer sector TFP	0.18	0.35	0.16
Equal: Structural TFP excluding computer sector TFP	0.19	1.09	0.90

Source: Council of Economic Advisors "Economic Report of the President" (2002)

Figure 2 Number of PCs per 100 Inhabitants (2001)



Source: ITU (2002)

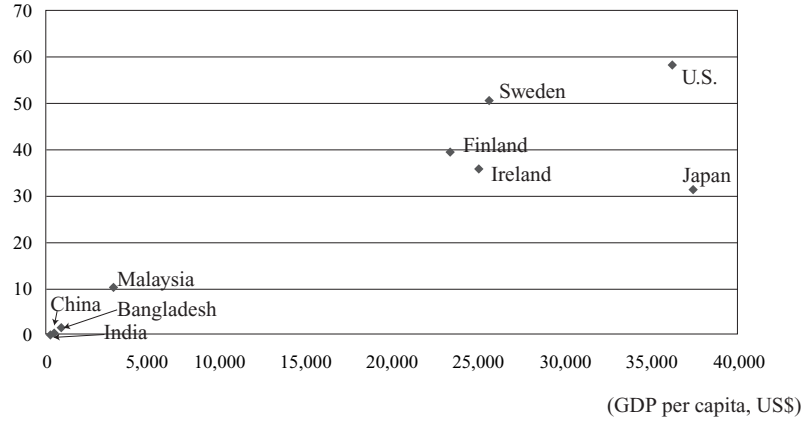
There are also clear correlations between income levels, education levels and IT environments (Figure 3). Looking at the target countries in this study, it can be seen that the gap between U.S./European countries and Asian countries was rather small at the start of the 1990's, but has since grown. Even though Malaysia has shown comparatively steady progress, India, Bangladesh and China still remain stuck at low levels of IT adoption and diffusion.

One very interesting point is that when comparisons are made using economic levels with a fixed GDP (in this case a per capita GDP of $1,000) (Figure 4), the country with the greatest PC profusion becomes Malaysia, followed by China, Sweden and Finland. On the other hand, the country with the lowest level of PC profusion is Bangladesh, followed by Japan. This would suggest that there are two types of countries, those countries that have seen a spread of IT after having already achieved economic growth and those countries that are now seeing economic growth along with the growth of IT (or possibly IT adoption and diffusion is the main driver behind their economic growth).

2. Overview of E-commerce

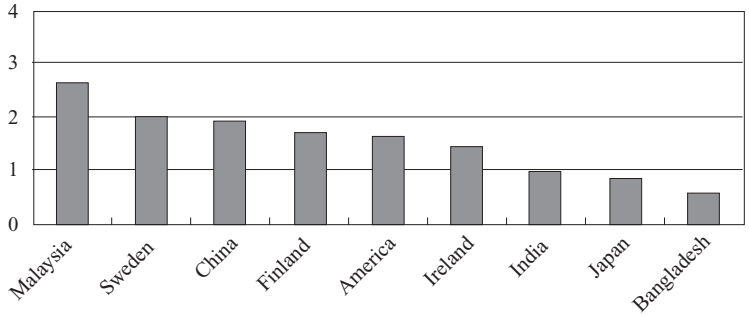
There has been tremendous growth in e-commerce in the past several years. Even though there has been a slowdown in the global economy and e-commerce has not grown as rapidly as first envisioned, e-commerce is still expected to continue growing steadily. A large portion of e-commerce is in the form of B2B (Business to Business) trades, and the scope of B2B trading is expected to continue growing rapidly. Regionally, e-commerce is expected to grow further in North America and Asia. In Asia e-commerce has

Figure 3 Correlation between GDP Per Capita and PCs Ownership (2000)



Source: Prepared from Yearbook of Statistics 1991-2000, ITU (2001)
Made from International Financial Statistics, IMF (2001)

Figure 4 PC Diffusion Status of US $1,000 GDP per Capita (2000)



Source: Compiled from Yearbook of Statistics 1991-2000, ITU (2001)
International Financial Statistics, IMF (2001)

seen strong growth in Singapore and China. The main reasons for their success are the fact that English is the official language, the high levels of infrastructure and Internet diffusion, and support from the government. However, B2B trade in the Chinese language has been flourishing in the Chinese region.

3. IT Plans of Various Countries

Governments of the advanced IT nations, such as the U.S. and many European countries, have enacted basic policies for the building of their IT infrastructures. However, support is also being provided for preparing the necessary legal system, research & development, education and training. Asian countries also began seriously addressing the building of IT infrastructures and the enactment of IT strategies in the 1990's. In some cases, a few countries in the Asian region have addressed these issues earlier than Japan. Many of the Asian countries that have seen economic growth promoted mainly by the government have aggressively enacted IT policies as part of their broader industrial policies. However, even though there are some countries like Malaysia that have adopted grand schemes, it can still be said that overall these countries are well behind Europe and the U.S. in terms of preparing the necessary legal system and support for research and development.

Chapter 3
Analysis of Macroeconomic Effects of IT Adoption and Diffusion

In addition to the improved productivity mentioned earlier, the macroeconomic effects of IT adoption and diffusion in developed countries also include price stability brought about by expanded supply capabilities and the elimination of some business cycles thanks to reduced economic swings derived from by better inventory management. In Asia the amount of analytical data is rather limited, but the available evidence points to different research results in terms of the degree of economic impact brought about by IT adoption and diffusion. This survey focuses on how the IT adoption and diffusion through various routes helps to promote growth in the developing nations. Therefore, the main consideration of this study will be productivity.

Another very interesting point will be the application of the endogenous growth theory, which stresses the importance of knowledge, in verifying IT impacts.

1. Review of Estimation Methods

The basic framework for making empirical analysis of the economic effects brought about by progress in IT adoption and diffusion has mainly been estimations based on Solow growth accounting[4] and the functional forms resulting from this growth accounting model. With the Solow model there is the "Solow residual", which cannot explain technical progress through capital and labor, and there is the premise of fixed yields for capital and labor. The basic line of thought is that

$$Y(t) = F\,(\,K(t), A(t)\,L(t)\,)$$

can be derived from the production function

$$\frac{Y(t)}{Y(t)} = a_k(t)\ \frac{K(t)}{K(t)} + a_L\,(t)\ \frac{L(t)}{L(t)} + R(t)$$

Here, Y is GDP with added value, K is capital stock, AL is efficient labor (A is the efficiency of knowledge and L is labor). $a_K\,(t)$ is capital elasticity of the production amount at time t. $a_L\,(t)$ is labor elasticity. The usual assumption is that $a_k(t) + a_L(t) = 1$. Based on the above equation, the "Solow residual" is interpreted as a mixture of all growth factors, excluding the contributions from capital and labor accumulations. As will be seen later, when there are no considerations of "technical advances that embody capital" and "labor that accounts for qualitative improvements", all of the contributions resulting from changes to the quality of capital and labor will be

4 Solow, R.M (1957). There are cases in which the term "growth accounting" is used to define factor analysis that is unrelated to coefficient estimations. However, in this report the term "growth accounting" is not limited in this manner and so also includes factor analysis based on coefficient estimations.

included in the Total Factor Productivity as the "Solow Residual", but will not be reflected in the elasticity coefficient[5]. The basic framework for this growth accounting can be expanded and applied in various ways. The most common method to be tried uses separation based on considerations of the differences in the types of capital and labor, and also takes into consideration qualitative changes and other such aspects. Specifically, estimations are conducted after separating IT capital from other "physical" capital.

In particular, Pohjola created an expanded model that include as new production elements the gaps in production levels and incomes between countries that could not be explained in the conventional Solow-type model, the Mankiw, Romer, Weil-type[6] model that attempted to make explanations that include considerations of human capital, and indexes related to IT investment. In this manner Pohjola made estimates using pooling data that includes developing nations.[7]

The Solow model assumed diminishing returns for the production elements. However, Minetaki and Kumasaki applied the CES (Constant Elasticity of Substitution) production function and measured the scale of economies brought about through M&A and other factors to suggest that the IT revolution resulted in increasing returns in the U.S. economy.[8] When such increasing returns are gained, knowledge creates more knowledge and the economy conforms to the characteristics of the endogenous growth model. Minetaki and Kumasaki suggested the existence of an endogenous economic growth mechanism in the U.S. economy by making calculations that indirectly introduced the impacts of IT into the endogenous economic model.[9]

2. Sequence for Appearance for IT Effects

As mentioned earlier, various methods have been used to try and verify the effects of IT adoption and diffusion in the U.S., which is seen as an advanced IT nation. When the IT adoption and diffusion started in the first half of the 1990's, there was no noticeable improvement in productivity and so it was believed that the IT revolution had brought about only a minor impact on the economy. However, estimations made using later statistics showed that IT made a major contribution to the accelerated production in the second half of the 1990's[10].

When the U.S. is used as an example for this type of empirical examination, the sequence for the realization of IT impacts can be arranged in the following manner (Figure 5). First there is a rise in IT-related demand, which is tied to realizing effects from the accumulation of IT-related capital. However, it has been said that hardware alone will make only a small contribution to the economy, while the spread of goods using IT like software and communications will help to increase this impact. After a certain period of time the various conditions needed for applying IT will be in place. At this stage the TFP for the IT manufacturing sector and the user sector will increase. After this the IT capital will replace labor and the effect of capital deepening tied to a rise in labor productivity will be realized. Once the various conditions are in place, the true impact of increasing returns through IT adoption and diffusion can be realized. Then the economy of scale brought about by IT adoption and diffusion can be achieved, and there will be conformity with the endogenous growth model in which knowledge creates more knowledge.

5 Oliner and Sichel (2000). This paper made the same point that in the analysis made by this type of model, the contribution to growth brought about by the use of IT capital (portion of economic growth attributed to the collection of IT capital) is included in each elasticity, but the portion of the collected IT capital that can not be measured (Ex.: improved efficiency achieved by manufacturing through the use of IT) is included in TFP.

6 Mankiw.N.G., D.Romer. And D.N. Weil. (1992)

7 Pohjola, M. (2000)

8 Kumasaka, Minetaki (2001)

9 Kumasaka, Minetaki (2001)

10 One example is shown in Table 1.

This suggests that a fair amount of time is needed before macroeconomic effects brought about by IT adoption and diffusion are realized. This also suggests that the overall socioeconomic environment will need to be prepared in order to realize these effects.

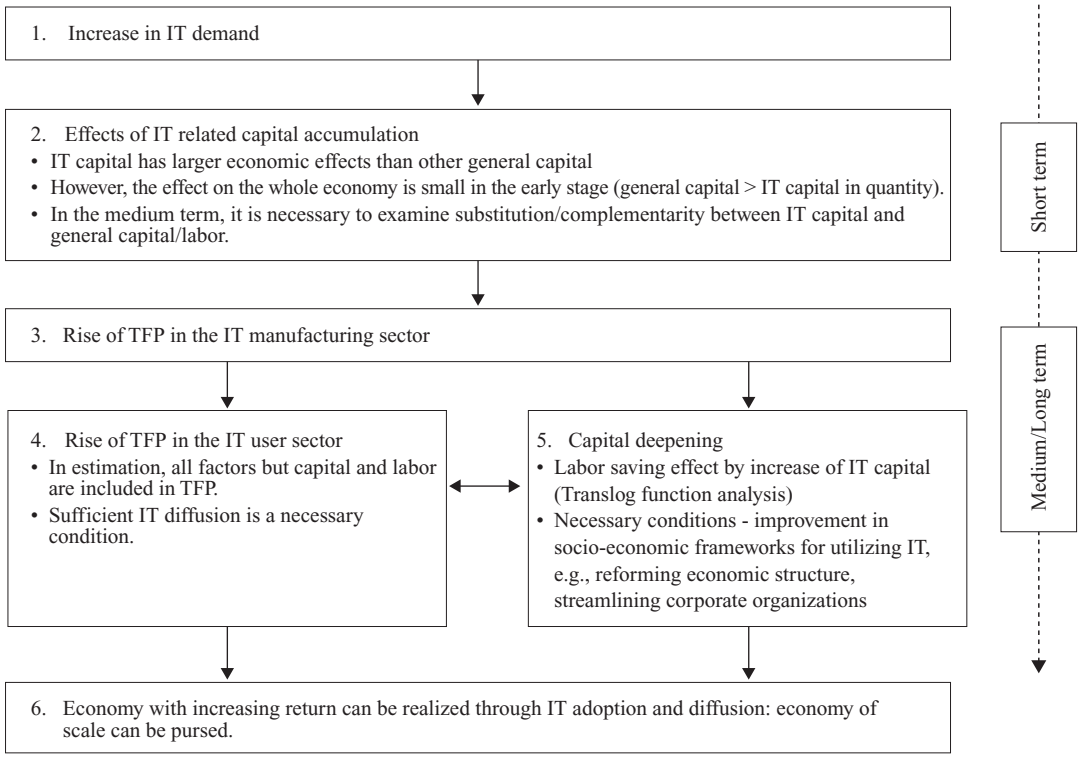
3. Verification by the Asian IT Adoption and Diffusion Macro Model

(1) Results of Pohjola Estimations

As mentioned earlier, the Pohjola estimations have been applied to the developing nations that have not reached the stage of increasing returns and for which there are many restrictions on the available data. The result was that while IT capital has made a certain contribution to economic growth in the industrialized nations, the same trend was not seen in the developing nations[11]. However, it is important to note that the statistics used by Pohjola, especially for the Asian region, were for only up to 1995, which was still just the eve of the true spread of IT. However, the estimations now being conducted are Pohjola-type estimations, but with up-to-date data being applied. In addition, a broad range of data from Asian countries has been used to diversify the IT elements (Table 2)[12]. The following conclusions were derived based on the results of these estimations.

- According to estimations based on the latest data on the progress of IT adoption and diffusion, progress in IT adoption and diffusion has a positive impact on GDP levels and growth rates even in the sample of only Asian countries. Among the various IT elements, the spread of personal computers is seen as having the biggest impact on the GDP level, followed by the spread of cellular phone use (seen as coefficients of determination). Telephones, personal computers and followed by cellular phones are also seen as having the biggest impacts in terms

Figure 5 Sequence of Appearance of IT-effects on Economy



11 Pohjola (2000)

12 Estimations in this report were made by pooling data from Asian, OECD and APEC countries and then comparing the estimates based on all samples (can be seen as the industrialized nations) with estimates based on samples just for the developing Asian countries.

Table 2 Results of Estimation of Pohjola-type Function

	Independent variable In: (Y/L)					Independent variable: In (Y (99)/L (99) - In (Y (97)/L(97))				
	Asian Samples									
	(1)	(2)	(3)	(4)	(Reference 1)	(5)	(6)	(7)	(8)	(Reference 2)
Constant	11.40***	11.49***	13.49***	12.29***	15.30***	1.51***	1.85***	1.18**	3.26**	1.03*
General Capital	0.43	–0.72	0.06	–0.66	1.32	–0.8	–0.11	–0.10	–0.07	0.06
Human Capital	0.56	0.84**	0.87*	0.84**	2.26***	0.18*	0.27**	0.08	0.25*	0.20
IT Capital (Tel.)	0.83***					0.11**				
IT Capital (Cell. Phone)		0.58***					0.07*			
IT Capital (Internet Host)			0.35***					0.05**		
IT Capital (PC)				0.80***					0.19***	
In (a+n+d)	–1.83	–0.71	–1.82	–1.97	–3.59*	–0.51	–0.23	–0.03	–0.37	–0.26
Initial Productivity						–0.09*	–0.12*	–0.08**	–0.23**	0.04
Adj$\hat{R}^2$	0.71	0.85	0.58	0.95	0.44	0.23	0.16	0.19	0.18	0.09

Notes
1. * is 10% level significance, ** is 5% level significance, *** is 1% level significance.
2. "General Capital" is ratio of fixed capital formation vs. GDP, "Human Capital" is the ratio of official expenditures for education vs. GNP, and "IT Capital" is the diffusion rate for each object. As for In(a+n+d), a is the exogenous technical progress rate, n is labor force increase rate, d is capital depletion rate, and here a+d = 0.05 is assumed. The numerical value for 1997 has been adopted as "Initial Productivity".

of elasticity. Personal computers and telephones are also seen as having high elasticity from the perspective of GDP growth rates. Here a direct relationship between these types of devices and economic impacts can not always be proven, but PCs make a contribution to the growth of information processing and telephones make a contribution to the growth of networks, which suggests the importance of their support.

- Basically, it is significant that estimates using mostly Asian samples have shown a positive correlation between human capital factors and IT factors. It is understood that these factors provide positive impacts for the GDP level and growth rates.

(2) Substitutability and Complementarity of Elements by the Translog Functions

Next, in order to study the mutual relationships between production elements, production functions were estimated using the general function form translog method that does not use any restrictions (Table 3). The following is an overview of these results (Table 4).

- When looking at the cross terms for the results of the estimates for all samples (Asia + APEC + OECD), IT and general capital coefficients have negative substitutional relationships and while IT and human capital coefficients have positive complementary relationships. Furthermore, there is a significant complementary relationship between IT and general capital stocks, and a significant substitutional relationship between IT and labor. While it has been seen that IT can lead to a reduction in labor (capital deepening), it can also be said that human capital is needed for IT activities.
- In terms of the cross terms in the estimations of the Asian samples, the IT and general capital coefficients are seen as having a negative substitutional relationship, while IT and human capital coefficients are seen as having a positive complementary relationship. On the other hand, IT and general capital stock have a significant substitutional relationship, while IT and labor have a significant complementary relationship. This finding runs counter to the results for all samples.
- This can be explained by the fact that in Asia IT has not really led to a reduction in labor and so under such conditions it is hard for the capital deepening mechanism to come into play. On the other hand, since there is complementarity between IT and human capital, it can be assumed from these results that development of human capital is indispensable for the IT activities.

Table 3 Results of Estimation by Translog Function

	In (Y/L)	InY	In (Y/L)	In Y
	All Samples		Asian Samples	
	(1)	(2)	(3)	(4)
Constants	–2.29	–1.88	7.24	–1.30
General Capital (primary term)	–1.47		8.84	
Capital Stock (primary term)		1.80***		1.57*
Human Capital (primary term)	–9.24*		–8.74*	
Labor Force (primary term)		–0.06*		–1.01*
IT Capital (primary term)	3.08***	–0.87**	2.88**	–1.04
General Capital (secondary term)	–1.28		0.77	
Capital Stock (secondary term)		–0.11***		–0.09
Human Capital (secondary term)	–2.09		–2.52	
Labor Force (secondary term)		–0.03		–0.07
IT Capital (secondary term)	0.06	–0.76**	0.11	–0.11**
(General) (Human) Cross term	1.16		2.76	
(Stock) (Labor) Cross term		0.17***		0.21***
(General) (IT) Cross term	–0.54		–1.24*	
(Stock) (IT) Cross term		0.21***		–0.22***
(Human) (IT) Cross term	0.84***		1.01**	
(Labor) (IT) Cross term		–0.10**		0.20**
Adj$\hat{R}^2$	0.90	0.95	0.96	0.96

Notes:
1. * is 10% level significance, ** is 5% level significance, *** is 1% level significance.
2. "General Capital" is the ratio of fixed capital formation vs. GDP, "Capital Stock" is the accumulation of the amount of low investment based on the numerical value from 1992, "Human Capital" is the ratio of official expenditures for education vs. GNP, "IT Capital" is the PC diffusion rate for In(U/L) as an explained variable, and telephone diffusion rate for InY as an explained variable. The choice of kinds of "IT Capital" is determined by the significance of the estimation. And as for diagonal terms, "(General) (Human)" is the diagonal term for General Capital and Human Capital, "(Stock) (Labor)" is the diagonal term for capital stock and labor force population, "(General) (IT)" is the diagonal term for General Capital and IT Capital, "(Stock) (IT)" is the diagonal term for General Capital and IT Capital, "(Human) (IT)" is the diagonal term for Human Capital and IT Capital, "(Labor) (IT)" is the diagonal term for labor force population and IT Capital.

Table 4 Summary of Translog Function Estimates

	IT/Human	IT/Labor	IT/General
All Samples	Complimentary	Substitution	Complimentary
Asian Samples	Complimentary	Complimentary	Substitution

Note: Compiled based on Table 3.

- In the results for all samples there was a significant complimentary relationship between general stock and IT capital. By comparison, there was a significant substitutional relationship between these two factors in the results for just the Asian samples. The manner in which general capital stocks and IT capital stocks are combined and used differs between Asian and industrialized nations.
- A significant complimentary relationship was seen between capital stocks and labor in both all samples and in just the Asian samples. An increase in the capital stock is tied to a simultaneous increase in labor. Therefore, it can be assumed that in many cases the capital factor will not be so significant from the perspective of the impact on per capita GDP in the Pohjola estimations.

(3) Propriety of Applying the Endogenous Model to Asia

Various considerations must be made when assessing the propriety of applying the endogenous model to Asia. These include the fact that there were limitations on data and a large volume of IT-related data has not been collected. The expected synergy effects are still small and the environment for IT adoption and diffusion and IT activities is still not completely in place. Therefore, considerations have been given to not making direct estimates of the endogenous growth

model, but instead apply the Jones technology propagation model (Figure 6)[13].

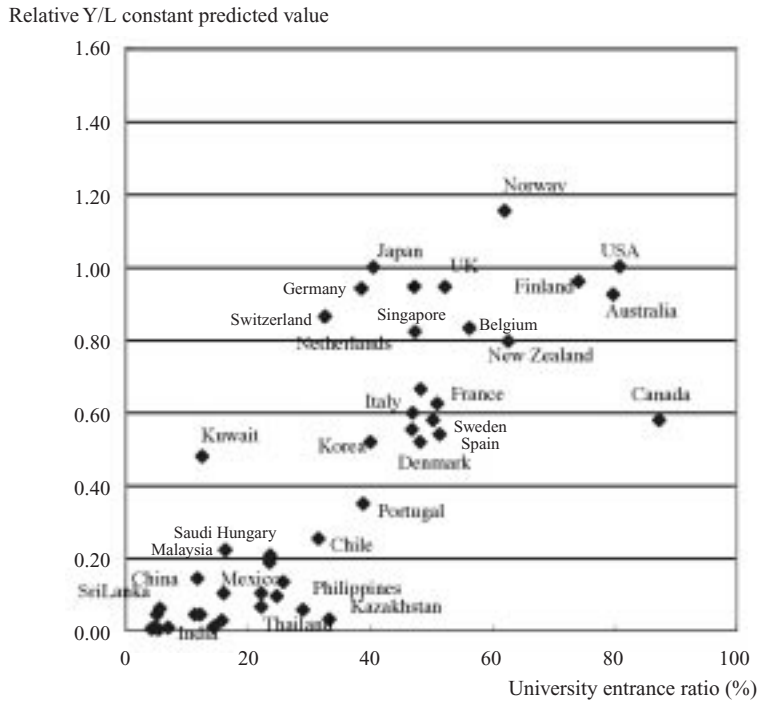
This model is based on the Solow model and incorporates the key ideas of the endogenous growth model and accounts for the importance of technology. However, this model also realizes that while advanced technologies can be accessed by all countries around the world, the degrees to which these technologies can be applied to production activities will vary depending on the education level of the workers and as such the economic growth for each country will differ. The figure shows the relationship between (relative value of unit acquisition for equilibrium efficiency) (U.S. = 100) and university entrance rates. While the industrialized nations are able to make use of progressing technologies, the developing nations lack the capacity to quickly learn the new technologies. This means that the developing nations have not been able to accumulate the technical expertise needed for applying IT and so there is the possibility that future income levels will remain low. Jones gave examples of how economies that are adept at using new technologies can quickly propagate new technologies. Such examples include the propagation of cellular phones in China, where a solid network of telephone lines is not in place, and India and the Philippines where multinationals have helped to build power distribution grids and power generators. However, in the economies that have low basic education levels, the range of new technologies that can be adopted through training is very limited. This analysis also confirmed that raising the ability to take in new technologies through education is very important for expanding human capital.

(4) Asian IT Adoption and Diffusion Derived from Macro Estimations

When the results for the various estimations of IT adoption and diffusion in Asia are all compiled, it can be said that progress of IT adoption and diffusion has had some positive economic impacts for this region. However, it is also clear that the industrialized nations are at different stages of IT progress.

Results from estimates using the Pohjola model were different from the Pohjola results that used data

Figure 6 Correlation between Predicated Value of Relative Income and University Entrance Rate



13 Jones, C.I. (1998)

only up until 1995. The 2000 estimations using a sample that included Asia showed that the IT adoption and diffusion factors could clearly explain GDP and growth rates. Basically, different results were obtained even though a model and statistical data similar to Pohjola were used. This is thought to be due to the fact that IT began to spread rapidly after 1995 even in Asia.

Results of the estimates of the substitution and complimentary relationships between the various elements using the Translog functions show that there are some disparities between the elements when comparing estimates for all samples (for which the industrialized nations have a strong influence) with the estimates for just the Asian samples.

A particularly important point is that there is a complementary relationship between IT variables and human capital variables, and a substitutional relationship between IT variables and labor in the overall sample including the industrialized nations. However, in the sample of only Asian countries there is the same complementary relationship between IT variables and human capital variables, yet the relationship between IT variable and labor is also complementary, not a substitutional relationship. This is opposite to the result seen for all samples. It can then be interpreted that the accumulation of human capital is needed for the IT adoption and diffusion in both the industrialized nations and Asian nations, and so the education of those using the IT is important. The sample including the industrialized nations showed that progress in IT adoption and diffusion resulted in reduced labor, but in the Asian sample IT adoption and diffusion was not tied to a reduction in labor. According to Minetaki capital deepening means that labor is substituted by IT capital[14]. From this perspective it is believed that the industrialized nations have been able to harness the capital deepening brought about by the progress in IT adoption and diffusion to raise the level of labor productivity, but in the Asian countries, progress in IT adoption and diffusion has not been tied to a reduction in labor and so these countries have not yet reached the stage where the capital deepening mechanism comes into play to raise the level of labor productivity. Analysis based on the technology propagation model show that the relative incomes for the developing nations would remain low unless the technology gap between the advanced and the developing nations can be narrowed. However, there are expectations that over the mid to long term the same mechanisms at work in the industrialized nations will also come into play for the developing nations provided that the people using IT are properly educated, human capital is accumulated and there continues to be progress in the diffusion of IT.

Chapter 4
Results of the Corporate Interviews

In order to gain a better understanding of the micro information that can not be obtained through the quantitative macro analysis, in other words the impact IT adoption and diffusion has had on corporate activities, the authors of this report conducted interviews with IT-related hardware and software firms, IT users, IT-related industrial groups and government agencies in four advanced and four developing nations.

1. Results of Survey of Industrialized Nations

The following is an overview of the four industrialized nations selected for this survey.

(1) U.S.: Has played a leading role in the IT adoption and diffusion around the world.
(2) Ireland: Promoted the introduction of foreign capital into its IT field in the 1990s and has achieved economic growth and a dramatic drop in unemployment.
(3) Sweden and Finland: Have giant mobile communications companies, active IT industries and IT has taken firm root in everyday life.

The following will provide a simple explanation of the situations in each country.

The U.S. IT industry entered a period of stagnation from the latter half of 2000. With the

14 Minetaki, K. (2001)

current IT slump, falling stock prices have resulted in poor financial situations and even bankruptcies for some Internet and communications companies. This in turn has hurt the finances of the manufacturers of system equipment that sell their products to these companies. Furthermore, the slowdown in the overall U.S. economy has resulted in weaker computer-related demand. On the other hand, corporate IT investment has fallen in terms of the amounts spent, but the actual amounts of equipment purchased has not fallen that much, as the prices for such equipment are lower. Many people in the interviews said that despite the current slump, they expect IT demand to remain strong over the long-term as corporations try to maintain their competitiveness[15].

In the early 1990s Ireland began to pull itself out of a deep economic slump by developing a policy to aggressively attract foreign IT corporations through various tax incentives, the high level of education held by its working force and the fact that English is the official language. As a result, the country saw a high annual rate of economic growth of 9% in the latter half of the 1990s. There has been an increase in the number of domestic software makers, but Ireland's IT industry is still primarily led by foreign corporations.

At the core of the IT industries in Sweden and Finland are two domestic communications giants, namely Ericsson and Nokia, respectively. These countries are both social welfare states, which means that the education needed for raising the level of IT literacy (basic education, technical education, English) is well in place.

Markets for procuring capital (venture capital and capital markets) are established and these countries traditionally invest aggressively in R&D. This means that various elements are already in place for IT adoption and diffusion. Other shared characteristics are the fact that both countries have small populations, but large land areas and so a communications infrastructure linking the dispersed houses was already in place, there are many local companies active internationally, and there is high domestic IT demand. The difference between these two countries is the contributions made by there respective governments. In Finland the telephone industry has been privatized for more than 100 years. Furthermore, the local companies had been exposed to international competitiveness due to the government's market liberalization policies of the 1980s and thus developed unique market competitiveness. The government has been providing support for improved competition of private companies through R&D investments. The origin of Sweden's IT industry, on the other hand, was demand from the Swiss Army and the government's prodding of Ericsson to enter the cellular phone market. The government covers 32% of R&D investments, which is much larger than the 11.2% covered by the Finnish government.

The results of the interview surveys of the four countries, as stated earlier, showed that although very different economic promotion policies were selected by Ireland, Sweden and Finland (led by foreign IT corporations in Ireland and local IT corporations in Sweden and Finland), all of the countries enjoyed high levels of economic growth in the latter half of the 1990s. The following section will summarize some of the reference points for IT adoption and diffusion in developing nations, focusing mainly on these three countries (Table 5).

(1) Elements for Developing an IT Industry

The basic elements for developing an IT industry are high levels of basic education, high degrees of skill in using the English language, infrastructure development, access to overseas sales markets and open markets.

All three of these countries have high levels of basic education, are skilled in using English, have the needed infrastructure in place, have access to sales markets and their markets are very open. Here the domestic markets are rather small and sales of IT

15 The main goals and impacts for corporate IT adoption and diffusion are large improvements in customer service, improved labor productivity, modernization of business processes and cost reductions. However, these goals and impacts vary greatly between the different industries and types of IT being introduced. The indexes used by corporations to measure the impacts of IT are ROI, improved speed in providing products and services and customer satisfaction.

Table 5 Characteristics of IT adoption and diffusion in Industrialized Nations and Lessons for Developing Nations

<table>
<tr><th></th><th colspan="4">Characteristics and Lessons</th></tr>
<tr><td>U.S.</td><td colspan="4">• Even though there has been a slowdown due to poor economic conditions, the main opinion is that corporations will continue adopting IT to improve their competitiveness.</td></tr>
<tr><td>Ireland</td><td>Economy led by an IT industry built by foreign companies.</td><td>Government policies encouraging foreign investment (tax system, others).</td><td>Issues of developing human resources and domestic companies.</td><td rowspan="3">Increased dependence on exports makes countries more susceptible to changes in foreign demand.</td></tr>
<tr><td>Sweden</td><td rowspan="2">Economy led by major domestic IT corporations.</td><td>Aggressive development policies from the government (defense, telecommunications industry).</td><td rowspan="2">• Communications environment already in place
• High level of IT literacy among students, citizens</td></tr>
<tr><td>Finland</td><td>The government itself prepares the trading environment (deregulation, opening markets)</td></tr>
<tr><td>Lessons for Developing Nations</td><td colspan="4">• Bolster education, develop basic infrastructures, prepare trading environments (deregulation, open markets), encourage the set-ups of new businesses, link hardware and software (balance)</td></tr>
</table>

products are dependent on other countries. That is why the English language and policies towards open markets are seen as being so essential. However, some disparities can be seen in such areas as abilities to develop technologies, level of technology education and the existence of domestic IT demand industries. Sweden and Finland have successfully developed domestic IT industries and this success has attracted foreign IT industries to make these countries major global players in terms of IT technologies. However, Ireland does not have such major domestic corporations and selected a development course that relies heavily on foreign corporations.

(2) Ties between Hardware and Software for Balanced Development

Looking at the two main sectors for the IT industry, namely hardware and software, balanced development is being achieved for both the hardware and software industries. In the case of hardware production, there is the need for domestic supporting industries and imports for the supply of parts and intermediate goods. However, in the case of Sweden and Finland the main hardware companies (Ericsson and Nokia) develop and use domestic subcontractors. The role of these subcontractors is not limited to just supporting these two companies, but rather they appear to be developing into global parts production companies. In the case of Ireland, hardware production is mainly by foreign firms and much of the demand for parts is covered by imports.

Foreign industries have also been developing back-office and other IT-enabled services that make use of Ireland's skill with the English language and high level of education.

(3) Bolstering Technical Capabilities through R&D Investment

In order to continuously develop an IT industry, the government needs to do more than simply provide short-term support for corporate R&D investments, but must also provide support for moving toward more advanced fields. The flourishing IT industries in Sweden and Finland are not simply the results of government policies, but the product of more than 100 years of infrastructure development, solid educations provided by these welfare states and the open economic policies of these small countries.

(4) Promoting the Application of IT Technologies

Bolstering the basic education for IT is the key element behind why these countries have become global top-class users of IT. In particular, access to PCs and the Internet in the early stages raise the ability to adapt to new technologies. Furthermore, each of these countries offers ample opportunities for lifelong education, through which education to raise the level of IT literacy is also available. This trend is particularly

evident in Sweden and Finland. This has helped to increase the rates of PC ownership and Internet usage in these countries. These two countries are also leaders in terms of PC and Internet usage spreading beyond the business level. This is due to not only the above-mentioned lifelong education helping to raise IT literacy among average citizens, but also due to an abundant amount of entertainment contents and Internet services like online banking. This is seen as one possible reason why the U.S. has lagged behind these two northern European countries in terms of Internet access and PC ownership rates.

2. Results of Survey of Developing Nations

The following is an overview of the four developing nations selected for this survey.

(1) India: Has become a major software exporter.
(2) Bangladesh: Planning economic development through the application of IT.
(3) Malaysia: Conducting industrial structural changes with the aim of promoting IT industries.
(4) China: has become a prominent hardware production base and is also becoming more active in the software fields.

Table 6 provides a quick overview of the situations and issues facing theses countries derived from the interview surveys.

Comparisons made through various pairings of these countries helped to clarify some of their unique characteristics.

(1) India and China

Comparisons were made of the IT-related industries in China and India, two very large countries. China has overall predominance in hardware fields such as personal computers and semiconductors, but its domestic software market lacks international competitiveness. The following are some of the differences in the software industries of China and India.

- Software industry customers: The Chinese software industry is mainly for the domestic market, while the Indian software industry is mainly geared towards exports.
- Language: in India English is taught from the primary school level and the nation has much stronger English skills than China.
- International quality recognition: Chinese software makers have not really established a software development process, but India has numerous corporations that have achieved SEI-CMM Level 5 certification[16], which demonstrates how they have successfully established a software development process.
- Positioning of IT education: In India IT education is thriving as a business (establishment of training organizations) and has made big contributions to personnel development. In China software-related education is not seen as a business.

(2) China and U.S.

The authors of this report interviewed a Chinese manager working for an IT software maker in China, but who was previously a technician in Silicon Valley. He pointed out the following three differences between the software fields in the U.S. and China.

- Legal protection: The IT market in the U.S. is not only large, but it is all legally protected.
- Venture capital: There is plenty of venture capital in the U.S. In China, however, venture capital is hard to find. Furthermore, inflows of foreign capital remain small due to credibility concerns and many IT firms have insufficient capital.

Domestic IT demand: America's high level of economic development has resulted in large domestic demand for IT products and services.

This disparity exists not only between the U.S. and China, but is believed to be a general disparity between most advanced and developing nations.

(3) India and Bangladesh

The following are some of the disparities between India and Bangladesh, two countries located in Southern Asia.

16 Software Engineering Institute - Capability Maturing Model. International quality recognition for computer software. Refer to <http://www.sei.cmu.edu/cmm/cmm.html> more in detail.

Table 6 Current Status and Issues for the IT Industries in the Surveyed Countries (items indicated from the surveys)

	Current situation and characteristics of IT industry	The challenges of the IT Industry
India	• Export-oriented software industry (mainly toward the U.S.) • High dependency on exports by top software manufacturers. • Shift from overbalanced onsite contracts to contracts with appropriately integrated onsite and offshore development. • Shift of industrial structure from hardware-led economy to software-led economy. • Domestic demand for IT industry driven by the government. • Building of communication infrastructure through the creation of STPI (Software Technology Park of India) • Low presence of hardware industry. • Existence of many IT human resources with high English and mathematical ability. • Existence of many IT human resources development institutions. • Linkage with NRI (Non-Resident Indian).	• To enter into high-value-added software business. • To diversify clients and countries for software export. • To expand domestic market. • To reinforce the linkage between hardware and software. • To develop information and communication infrastructure. • To compete with China's emerging software industry.
Bangladesh	• Delay of the building of communication infrastructure. • Increase in users of cellular phone faster than that of fixed phone users. • Lack of global optical fiber connection • Expensive communication costs and slow communication speed. • Oligopoly of communication sector by BTTB (Bangladesh Telegraph and Telephone Board). • Operation of cellular phone business by Grameen Telecom targeting women in farm villages. • Promotion by Grameen Phone of the use of cellular phones in farm village.	• To develop information and communication infrastructure. • To develop IT human resources. • To establish IT human resources development institutions. • To create venture capital. • To exert political initiative by the government. • To expand domestic market.
Malaysia	• Creation of MSC (Multimedia Super Corridor). • Building of information and communication infrastructure and the grant of favorable treatment through MSC. Promotion of IT related industries through legislation. • Promotion of MSC plan by MDC (Multimedia Development Corporation) • Development of IT human resources by newly established Multimedia University. • Provision of IT development environment through the promotion of 7 flagships of MSC. • Provision of venture capital through the establishment of a venture capital management corporation. • IT industry structure with an inclination for hardware exports. • Relatively developed information and communication infrastructure.	• To develop and reinforce IT human resources. • To expand domestic market and to exploit foreign markets. • To stimulate domestic software related needs. • To improve customer recognition of the products of domestic companies. • To improve the recognition of the effect of IT adoption.
China	• One of the largest IT related hardware production centers. • Insufficient domestic productivity in the area of semiconductors. • IT industry structure with too great an emphasis on hardware. • Strong implementation of a policy to promote the software and semiconductor industries. • Development of a semiconductor industry with the highest concentration of top-level management resources in the world. • Concentration of the software industry at Zhongguancun in Beijing. • Demand for a domestic software industry • The world's largest cellular phone market.	• To transfer high-end technologies from foreign companies. • To develop human resources and to train in the area of semiconductors. • To speed up the governmental procedures. • To standardize software development process. • To create venture capital. • To prevent the outflow of excellent human resource for high salaries. • To prevent the piracy of software • To improve the legal aspects. • To improve the recognition of the effect of IT adoption and awareness education on IT adoption and diffusion.

- Development status of infrastructure: Bangladesh has plans to build a high-tech park and it has started to build an information communications infrastructure. However, the country lags well behind India in terms of the number of fixed telephone lines and data transmission speeds.
- IT-related personnel: In 2001-02 India produced 66,494 graduates who had studied computer science and information technology. By comparison, Bangladesh had produced only 1,257 such graduates, which is less than 2% of the level achieved by India.
- International quality recognition: There are only 58 companies in the world that have been awarded the Level 5 SEI-CMM quality recognition and 36 are Indian companies (as of December 2001). This shows how the quality of the products produced by Indian software companies is recognized around the world. However, none of the Bangladesh companies have received such recognition.
- Marketing activities towards the international society: In India the public and private sectors have conducted aggressive market activities to promote the country within the international society. However, Bangladesh has not conducted such activities and international awareness remains low.

3. Implications for other Developing Nations

The following offers an overview of some of the general implications for developing nations based on the results of the interviews with companies in the developing nations mentioned earlier.

(1) Ripple effect from establishment of high-tech parks: The establishment of high-tech parks is an effective short-term method for establishing an information communications infrastructure that requires an enormous initial investment. A high-tech park, which is essentially a localized information communications infrastructure, helps to lower initial investment costs. In addition, the parks also attract participation by foreign firms, which in turn is expected to raise the level of technical skill domestically and create a knowledge cluster. According to the interviews, this effect is already being widely recognized. A government-led creation of high-tech parks is an important initial step in promoting IT adoption and diffusion. However, the government policies need to consider having IT parks eventually established and operated by the private sector, once a certain level of IT adoption and diffusion has been achieved. After seeing the successful establishment of IT parks by the government, the private sector will start to construct IT parks on their own. The important point will be to create this favorable cycle where the IT parks promote the IT adoption and diffusion, which promotes the creation of more IT parks, and so on.

(2) Development of IT-related personnel: The main key that will determine the success or failure of an IT business will be whether or not the business has skilled IT technicians. The development and strengthening of IT-related technicians is especially vital for the software industry. According to the interviews, the reasons behind the strong international competitiveness of the Indian software companies are the facts that the Indian people are skilled in English and mathematics, and the fact that the country produces large numbers of IT professionals each year. Specific policies for developing personnel is to in the short-term provide practical IT training for university graduates that majored in science, but over the middle and long-term IT training at all education levels is desirable. However, the proper development of IT-related personnel requires time and a large initial investment. Some of the participants in the interviews said that a temporary measure has been to allow for the hiring of foreign engineers and then start up businesses after attracting some of the top talent in the world.

(3) Bolster venture capital: In order to launch IT-related businesses there must be an environment where those with new technologies can start businesses and easily enter markets. In order to create just such an environment, a large amount of venture capital is essential. Software companies do not require as much initial capital as hardware companies, however, they cannot grow unless the have the necessary capital during the software development stage. It is very

difficult to raise venture capital in developing countries. However, recently some public organizations in the industrialized nations have started raising venture capital for developing nations. For example, in Malaysia a venture capital management public corporation has been established with support from the Japan Bank for International Cooperation.

This is helping to provide the funds needed by IT-related businesses, mainly software companies, for projects to develop and introduce systems using IT.

(4) Creating domestic demand through promotion of e-government: Many developing nations still have very weak domestic IT demand due to the delays in building information communication infrastructure, the high cost of hardware and poor awareness of the benefits associated with introducing IT. During the interviews it was frequently indicated that instead of policies promoting the introduction of IT by the private sector and society, the more effective approach would be to have the government take the initiative by promoting e-government. The promotion of e-government in developing nations helps to bring about greater fairness, transparency and efficiency for government procedures and transactions. It also contributes to the establishment of market conditions that are required.

(5) Lower communication costs through deregulation: It has been frequently stated that the main reasons for the low diffusion rates for information communications in developing nations are delays in building communications infrastructure and high communication costs. The communications sector in many developing nations is monopolized by public corporations under the jurisdiction of the government. As a result, the principles of competition do not come into play, which results in a high cost structure. Privatizing state-owned communications public corporations and enacting deregulation to encourage inflows of foreign capital into the domestic communications market would likely promote greater competition in the market and provide users with high quality, low-cost services. This would likely improve the accessibility to the communications infrastructure and promote greater application of IT.

(6) Acquire foreign capital and technologies through policies to attract foreign funds: In order to compensate for the lack of technologies and capital domestically, many developing countries have been adopting policies aimed at attracting companies from the industrialized nations. Such policies are essential for the IT sector in order to attract foreign IT companies with the aim of raising the level of domestic technologies and acquiring capital.

(7) Necessity of preparing basic infrastructure: The effects brought about by IT adoption and diffusion must be realized to the greatest extent possible, not only for the development of IT industries, but so that IT can be widely used both socially and economically, and so that the activities of existing industries can be expanded. To make this possible, it is essential that basic infrastructure such as roads, electricity, hydropower and ports are all in place before establishing IT high-tech parks. In many cases the developing countries have had delays in building this needed infrastructure due to insufficient finances and thus support from industrialized nations is very important. Ireland is one example of how support from foreign countries was used to build up the basic infrastructure and then tie this into the development of IT[17].

17 The EU Structural Fund is a system for providing subsidies to countries within the EU region that have had comparatively slower development. Ireland was the largest recipient of subsidies provided by this fund. Funds provided to Ireland in the 1994-1999 program were allotted in the following manner: 35% infrastructure, 30% development of human resources, 25% private sector, 10% revenue support. Based on Ireland's Financial Reconstruction Plan launched in 1987 public spending was drastically cut. Public investments between 1987 and 1989 were also cut by more than 10%. During this time funds provided from the EU were increased. Not only did this help Ireland to prepare infrastructure while improving its finances, it also greatly contributed to attracting foreign direct investment.

Chapter 5
GTAP Model-based Analysis of Economic Effects of IT Adoption and Diffusion

The economic effects of IT adoption and diffusion was analyzed in Chapter 3 using the macroeconomic index of per capita GDP and it was analyzed in Chapter 4 through a micro approach that studied the activities of individual corporations. This chapter will look at results from simulations using the GTAP (Global Trade Analysis Project), a CGE (computable general equilibrium) model used to understand structural changes on the industry level positioned between the micro and macro levels.

1. GTAP Model Characteristics and Considerations

The GTAP model used in this report is widely used by research institutions and public organizations around the world[18]. Before studying the results of the simulation, it is important to first understand the characteristic of the GTAP and clarify merits and points to consider.

The CGE model is an economic model based on the microeconomic general equilibrium theory. The model is a system of simultaneous equations with numerous variables and is written as a model equation targeting the behavior of all economic units. The aim of the model is to understand behavior when the system has equilibrium, no equilibrium, stability and shocks[19]. Three characteristics can be cited as follows. Firstly, the considerations are given to the economic rationality of family budgets, corporations and others to ensure that the economic theories are in place for the model and the results of the analysis. Then this is applied to the analysis of changes to family budgets, corporate behavior and others when there are changes to economic policies or the external environment. Secondly, the relationship between prices and goods (consumption and production amounts) are clearly defined, thus the effects of policy changes through price changes can easily be analyzed. Thirdly, the mutually dependent relationships in the economy has been considered and, as a result, markets and industries can be subdivided in the analysis, and analysis of the effects on the macroeconomy and on specified industries can be simultaneously performed.

The GTAP model used in this report is a multinational CGE model that consists of various countries and regions. The biggest merit of this model is that it offers comprehensive coverage of data for the entire world, which allows for analysis of global trade and capital flows. Furthermore, the collected data is based on industrial classifications common for each country. This means that analysis for each industry can be conducted along with the overall macro-analysis.

However, one point to consider when using the GTAP model analysis is that the time concepts are not clear. The simulation is based on "when there is a change to the initial equilibrium state, what types of changes occurred as compared to the initial equilibrium up until the point where this equilibrium could again be restored". The "change" here is expressed as a percentage. There is no concrete indication of just how much time processes took in reaching the resulting new state of equilibrium. This point needs to be fully incorporated when interpreting the results of an analysis using the CGE model[20]. Another point to consider is that the GTAP model, a general equilibrium model, was developed originally for use in static analysis. It cannot be used to analyze

18 The GTAP model, developed in 1992 by Purdue University professor Thomas W. Hertel, is a general equilibrium model that targets all regions of the world. The model was developed to measure the impacts on international trade resulting from the lowering and abolition of tariffs. The model has also been used to analyze the effects of the Uruguay Round and APEC. Data for the GTAP model has been continuously updated since 1992 and Purdue University is working to prepare a database for the GTAP model.

19 The CGE model and macroeconomic model are similar in the way they both handle the trading cycle within the economy. However, the CGE model is different in that it has a premise for economic behavior based on the economic rationality (maximizing effectiveness and profits) of economic units such as consumers and producers.

20 For example, it is assumed that there will be some actual problems in the world such as frictional unemployment up until the time that a new equilibrium resulting from the structural change is established. However, the CGE model does not account for such points.

the dynamic process in which increased income brings about increased savings, from which new capital is invested, resulting in increased income (used in the analysis of the effects on the reallocation of resources). Methods by which dynamic changes in capital stock can be incorporated into the GTAP model are now being developed. This report conducted a simulation using methods that incorporated the capital accumulation effect in order to analyze the impacts on investment resulting from improved economic efficiency due to IT adoption and diffusion, and the effect this increased investment has on capital accumulation[21].

However, the GTAP model currently has not internalized savings rates. Therefore, there will very likely be an overestimate for "savings amount = capital increase amount" and that the results of the simulation will be higher than the actual situation.

Generally speaking, simulations by the GTAP model are not intended for projecting future values for economic variables when external shocks bring about structural changes. Instead, the aim of these simulations is to compare the relative sizes of changes to economic variables between sectors[22]. The strengths and weaknesses of this model will need to be kept in mind when evaluating results obtained from simulations based on this model[23].

Table 7 Classification of Industries in the GTAP Simulation

	Classification	Industries Included
1	Agriculture	Rice, wheat, other grains, non-grains, wool, other livestock products industries, forestry, fishing and the like
2	Mining	Coal, crude oil, natural gas, other minerals
3	Construction	Construction
4	Manufacturing, Durable goods	Steel, nonferrous metals, metal products, transport equipment and parts, other manufactured industrial goods
5	Electronic Equipment and Machinery	Machinery and equipment, electrical equipment and products
6	Manufacturing, Nondurable goods	Textiles, apparel, petroleum/coal products, chemical/synthetic rubber, plastic products, ceramics/cement & glass, leather products, wood products, pulp/paper products, printing
7	Transport and Public Utilities	Electricity, gas, water supply, air transport, marine transport, other transport businesses
8	Communication	Communication
9	Wholesale and Retail trade	Wholesale trade, retail trade
10	Finance and Insurance	Financial services, insurance
11	Services	Recreation service, public services, housing and lease
12	Business Services	Software industry, back office, customer instruction, and the like

21 The active private sector capital investment in the U.S. in the 1990s was financed by capital inflows from foreign countries. Even for developing nations, analysis that takes into consideration capital inflows to countries with active IT adoption and diffusion and capital accumulation in addition to the capital inflows can be very effective.

22 All of the estimates are made through simulations covering multiple nations. An external impact on one region can impact the variables for all regions through changes to trade and investment. However, please note that due to space considerations this report covers only variables for regions that gave impacts.

23 These simulations used the GTAP Version 5.0 released in July 2001. The original data set for the GTAP Version 5.0 consists of 65 regional classifications and 57 industrial classifications. However, this report uses 10 regional and 12 industrial classifications to better clarify the target countries and IT-related industries.

Table 8 Classification of Regions in the GTAP Simulation

	Classification	Included Regions
1	Oceania	Australia, New Zealand
2	Japan	Japan
3	India	India
4	South Asia	Bangladesh, Sri Lanka, Other Southern Asia countries (Pakistan, Nepal, Maldives, Bhutan)
5	ASEAN	Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam
6	Other Asia	Hong Kong, Korea, Taiwan
7	China	China
8	U.S.A.	U.S.A.
9	Europe	Countries in the EU, Switzerland, other old EFTA nations
10	Other Regions	Canada, Latin American countries, Central European nations, former Soviet Union, Nations in Middle East and North Africa, Nations in Sahara Africa, others

2. Analysis of IT Adoption and Diffusion in the U.S.

First we studied the impacts of IT adoption and diffusion on the economy in America, which is seen as an advanced IT nation and for which a great deal of detailed information is available. This was done to verify to what degree the GTAP model can reproduce the actual structural changes in the world, while keeping in mind the fact the GTAP model does not have a time series concept, as well as the possibility that the calculated results will be bigger than the actual situation due to the introduction of the capital accumulation effect mentioned earlier.

This study conducted a simulation in which the impact of IT adoption and diffusion was limited to the improvement in labor productivity brought about by the rise in TFP. As mentioned earlier there are various routes for the actual impacts from the growth in IT adoption and diffusion such as growth in IT-related capital, rise in human capital and the labor substitution effect caused by IT capital. However, the GTAP model is comparatively static and there are various limitations such as the fact that the increase in production elements for each industry cannot be externally assigned. Thus contributions from increases in production elements must be abstracted when conducting the analysis. Of course elements other than IT adoption and diffusion contribute to the actual rise in TFP. However, in this case the entire rise is attributed to IT adoption and diffusion.

Specifically, the CEA (Council of Economic Advisory: a panel of economic advisors for the U.S. president) analysis shown previously in Table 1 was adopted to determine how much IT adoption and diffusion contributed to the rise in TFP. Here, capital deepening and computer production included in the rise in macro labor productivity and not contributing to the rise in TFP are assumed to be contributions by the successfully improved efficiency due to progress in IT adoption and diffusion. It is also assumed that the degree of contribution made by IT adoption and diffusion for improved labor productivity is the same for each industry. The degree of contribution made by IT adoption and diffusion in improving TFP, as determined by the above macro analysis, is then multiplied by the actual rise in labor productivity for each industry (nonagricultural sectors) to determine the impact of IT adoption and diffusion for each industry. However, for the electronic equipment production sector, the contribution from the rise in TFP for the computer production sector is added (Table 9).

The results of the simulation show big positive results in each area such as price, production and imports (Table 10, line 1). This is especially true for the machinery and electronic equipment sectors, which saw large growth in their production rates. Other IT-related industries saw lower prices and increased production due to IT adoption and diffusion. However, these effects were not limited to just the relevant industries, but spread to impact other industries as well. In this manner, positive impacts were passed on to the entire economy.

Table 9 External Conditions for the U.S. Simulation (average values for 1989~2000)

	Classification	Rate of Growth in Labor Productivity	Portion of Labor Productivity Growth Rate Attributed to TFP
1	Agriculture	–	–
2	Mining	1.85	0.66
3	Construction	-0.32	-0.11
4	Manufacturing, Durable Goods	1.07	0.38
5	Electronic Equipment and Machinery	12.43	8.70
6	Manufacturing, Nondurable Goods	1.57	0.56
7	Transport and Public Utilities	1.31	0.47
8	Communication	3.79	1.35
9	Wholesale and Retail Trade	3.15	1.12
10	Finance and Insurance	3.73	1.32
11	Services	-0.51	-0.18
12	Business Services	0.43	0.15

Table 10 Summary Table of Scenario 1

Disparate range from initial equilibrium variable (%)		Results from U.S Simulation	Results of Scenario 1				Rate of Increase in Labor Productivity for each Industry along with IT adoption and diffusion in the U.S. (external impact value for scenario 1)
			India	South Asia	ASEAN	China	
Production amounts by industry	Agriculture	0.01	0.16	0.13	0.05	0.21	0.00
	Mining	0.21	0.30	0.29	0.06	0.37	0.66
	Construction	1.24	0.64	0.28	0.40	0.56	–0.11
	Manufacturing, Durable Goods	0.51	0.89	0.61	0.29	0.77	0.38
	Electronic Equipment and Machinery	5.58	2.21	2.43	3.23	3.15	8.70
	Manufacturing, Nondurable Goods	0.52	0.42	0.24	0.16	0.27	0.56
	Transport and Public Utilities	0.62	0.64	0.42	0.40	0.61	0.47
	Communication	1.22	0.90	0.83	0.60	0.82	1.35
	Wholesale and Retail Trade	1.27	0.71	0.42	0.66	0.73	1.12
	Finance and Insurance	1.21	0.83	0.61	0.71	0.81	1.32
	Services	0.61	0.56	0.31	0.35	0.58	–0.18
	Business Services	0.99	0.72	0.43	0.14	0.55	0.15
Macro indicators	Price	0.24	0.00	–0.00	–0.05	0.09	
	Actual GDP	1.13	0.55	0.32	0.56	0.70	
	Imports	1.07	0.22	0.16	1.11	0.53	
	Exports	1.30	0.54	0.28	1.34	1.01	

Table 11 Summary Table of Scenario 2

		Rate of Increase in Labor Productivity for each Industry along with IT adoption and diffusion in the U.S. (same with external impact value for scenario 1)	India	South Asia	ASEAN	China
Methods for delivering the impact for each industry in scenario 2 (impact of increase in labor productivity for each industry along with IT adoption and diffusion)	Agriculture	0.00	–	–	–	–
	Mining	0.66	–	–	–	–
	Construction	-0.11	–	–	–	–
	Manufacturing, Durable Goods	0.38	–	–	–	–
	Electronic Equipment and Machinery	8.70	–	–	8.70	8.70
	Manufacturing, Nondurable Goods	0.56	–	–	–	–
	Transport and Public Utilities	0.47	–	–	–	–
	Communication	1.35	–	–	–	–
	Wholesale and Retail Trade	1.12	–	–	–	–
	Finance and Insurance	1.32	–	–	–	–
	Services	-0.18	–	–	–	–
	Business Services	0.15	0.31	0.15	–	0.15
Results of simulation for the scenario 2 (macro indicators)	Price		0.00	0.00	-0.02	0.09
	GDP		0.00	0.00	0.43	0.54
	Imports		0.01	0.00	1.03	0.46
	Exports		0.01	0.00	1.20	0.76

When the results of this simulation are compared to the actual results, the sections that do not account for the actual rise in capital and labor for GDP and other macro values tend to be lower than the actual results. However, it can be said that the direction in terms of the lively activities in IT-related industries can be ascertained when looking at the trends for each industry.

3. Analysis of IT Adoption and Diffusion in Developing Countries

This section will look at what form of economic impacts are generated when there is external technical progress in developing nations by IT adoption and diffusion. Here a simulation was conducted to measure the differences before and after the impact of higher labor productivity generated externally for each industry in just the relevant regions. The four regions covered by the simulation were India, the South Asian region including Bangladesh, ASEAN, including Malaysia and China. (For example, in the analysis for India there is the impact of the rise in labor productivity just for India, and it is assumed that this change does not occur in regions other than India.)

Furthermore, the following two methods are set as the ways in which the impacts of labor productivity for each industry are presented.

Scenario 1: The case in which the impact from the rise in labor productivity for all industries in the relevant regions is considered to be the same as with the above-mentioned U.S. simulation. For example, when analyzing India it is assumed that IT adoption and diffusion for each Indian industry is the same as in the U.S.

Scenario 2: The case in which the impact for the rise in labor productivity is applied only to a particularly strong industry in the relevant region (selected based on field surveys and data analysis).

For example, for India the considerations are that IT adoption and diffusion is seen only in the software-related industries (the "business service" classification in this survey). Here, the following is applied based on the assumption that the rate of production growth is the same as in the U.S. Characteristic of IT is the fact that profits for latecomers are big, and that countries late in introducing IT can still make active use of IT with the most up-to-date technologies, which can result in a high rate of technological progress (leapfrogging effect).

There is still a big gap between the level of productivity in the U.S. and in the developing nations. However, the developing countries targeted by this survey are for the most part experiencing continued economic growth due to the progress in IT adoption and diffusion, and it is not out of the question to establish a scenario in which the rate of growth in productivity is the same as with the U.S.

Therefore, scenario 1 uses the U.S. example and the same external conditions are applied to all industries (except agriculture) and not limited to just IT-related manufacturing sectors. In other words, the differences in the responses for each country when the same external impacts are applied to just one country were checked. Scenario 2 takes a more realistic viewpoint in which the same production rise impact for the corresponding industry in the U.S. is in principle applied only to the particularly strong fields in each country.

When evaluating the results of the simulation, special consideration will need to be given to the fact that actual impacts from labor and capital increases are not accounted for, the model does not sufficiently reflect actual institutional and operational problems, and that there is the possibility of no movement of goods and production elements between industries and countries (Table 10 and 11).

In the case of India, when progress in IT adoption and diffusion results in the same rate of productivity growth as the U.S. (scenario 1), India can be expected to have roughly half the GDP growth rate of the U.S., while controlling price rises. However, almost no macroeconomic effects can be expected when the rate of growth for just the "service business" sector (including the software industry) is twice the level as for the U.S. (scenario 2). The conclusion then is that the rise in the capability to develop software technologies has stalled and there are limits to what effects it can have for the Indian economy.

Even though the degrees of change in the South Asian region are small, the same trends as with India were seen for both scenarios[24]. The conclusion then is that the IT adoption and diffusion will not be able to contribute to sustainable economic growth with software alone, but rather the accumulation of IT capital will also be necessary.

For the ASEAN countries the differences in the results for scenarios 1 and 2 (rate of production increase just for machinery and electrical equipment on par with the U.S.) are comparatively small. Therefore, the conclusion here is that there is already an industrial structure making full use of the comparative advantageous and hopefully development will continue in this direction. However, there is the trend that as the machinery and electrical equipment industries in the ASEAN nations continue to grow, they tend to import more. Therefore, in order for this region to continue growing it will be important to develop the domestic production of capital goods and parts.

According to the results of the calculations for China, there is the strong possibility of growth (without higher prices) and larger trade surpluses due to the promotion of IT adoption and diffusion. However, there is also the possibility of the promotion of IT adoption and diffusion resulting in a bottleneck whereby prices in the agriculture sector rise and exports decrease, while imports increase. From the perspective of the macro level it will be important to promote the diffusion of IT while arranging measures to protect the agriculture sector, which is easily influenced by the impacts from the spread of IT.

When the results for the developing countries were compared against those for the U.S. it was seen that the amount of increase in production for the developing countries was smaller than the amount for the U.S. and almost no price increase trends were seen. It is assumed that this is because the developing countries have much more labor than the U.S. and lower wage increase rates. On the other hand, the developing countries tend to have low land productivity and the rate of increase in land prices is high. To summarize, even when the developing nations achieve higher production due to the promotion of IT adoption and diffusion, they will not be able to enjoy the same degree of IT-led economic growth as the

24 Scenario 2 for the South Asian region was for when the rate of production growth for just the business service sector is the same as the U.S.

U.S. and economic growth will be limited unless a certain degree of sophistication is first brought to the overall economy. In order for the developing nations to enjoy the IT-led economic growth seen in the industrialized nations, it will be important to arrange IT capital and plan for capital deepening. This is the same as the result obtained from the macro analysis.

Chapter 6 Summary

The IT adoption and diffusion discussed in this report is not just limited to the rapid growth in IT-related software and hardware industries, resulting in increases in production. In other words, attention has been focused on improving efficiency and creating networks in various economic aspects through the use of IT to provide new services and through the broad use of IT by companies. This IT adoption and diffusion has been taking place around the world since the 1990s. Overall this IT adoption and diffusion has brought about positive economic effects on both the micro and macro levels.

Recently more and more attention has been given to "knowledge", which has the characteristic of increasing returns, from the perspective of economic development for the developing nations. IT adoption and diffusion is an important constituent element of this "knowledge". At the same time IT adoption and diffusion is a key element in the spread of a more broadly defined "knowledge".[25]

However, it has become clear that IT is not the panacea that can paint a rosy future for the overall economy as was first believed. For example, in the U.S. IT was expected to eliminate economic cycles, but it has actually invited an economic downturn. Even in other industrialized nations, as well as in developing nations, changes in IT-related demand have made the overall economy even more vulnerable. Increased global competition is always threatening the positions of those countries and corporations that have already succeeded through IT adoption and diffusion.

IT adoption and diffusion has also drawn on information and income gaps on various levels from individuals to countries. This has resulted in a vicious cycle in which information gaps lead to large income gaps.

Under these conditions, the most important point when considering the economic impacts of IT adoption and diffusion is to confirm that IT adoption and diffusion itself is not seen as the goal, but rather as the means for achieving other goals. In other words, first the goals that must be met should be set and then considerations should be given to what form IT should take in order to reach these goals.

For the developing nations the promotion of IT is tied to raising the economic level of the country and region over the long term. However, a broad environment for achieving this goal needs to be in place, and the building of this environment is something that the developing countries cannot do alone. Therefore, industrialized nations and international organizations need to provide support on various fronts so that the developing countries can realize the spread of IT and the resulting economic benefits.

1. Preparing Information Infrastructures and Industrial Bases

In order for everyone to enjoy the benefits of IT, it will be important to first prepare a communications infrastructure and create an environment where information can be accessed. From the results of the macro estimates it is clear that personal computers contribute to the growth of information processing and telephones contribute to the growth of information networks. This results also point to the importance of supporting these areas. The results of the analysis by GTAP also show that an environment without the proper communications infrastructure will result in restrictions being placed on the economic impacts derived from IT adoption and diffusion. The macroeconomic estimation has also shown that the persuasiveness of the net host argument for economic growth is rather weak. Conversely speaking, this

25 Refer to Easterly, W. (2001). "The Elusive Quest for Growth: Economists / Adventures and Misadventures in the Tropics" in terms of the importance of "Knowledge" in the economic development of developing countries.

suggests that the network effects can be fully realized only after priority is placed on preparing telephone networks and personal computers.

The spread of personal computers is a basic condition for improving access. In the developing countries this cannot be achieved on a commercial basis as easily as in the industrialized countries. Therefore, an effective solution would be to provide free personal computers on a large scale through support from industrialized nations.

In order for the communications network to truly function, it will be essential to lay the communication lines, which will serve as the backbone, through cooperation with support agencies from the industrialized nations. Advances in information technologies means that the laying of wired channels might not always be the best option. Easy access can quickly be established through wireless channels that can be more affordably installed. Furthermore, liberalization of the communications sector through deregulation and the introduction of competition principles is expected to help lower communication rates and promote the spread of Internet usage. Therefore, it is very important for the industrialized nations to provide support and advice in these areas.

It will also be necessary to continue to develop the industrial base. The promotion of IT adoption and diffusion should not stop at simply bolstering the IT production sectors, but should be intended for raising productivity for the overall society through the use of IT. Therefore, it is extremely important to expand all industrial bases that serve as the infrastructure. This includes the electric power sector, which is essential for IT, and transport networks that are essential for domestic and international distribution. The fact is that even the countries that are receiving capital from Europe to promote IT adoption and diffusion have first focused their efforts on building the needed infrastructure. So it is desirable for the industrialized nations and support organizations to provide the developing nations with various types of support in addition to financial support, such as support for the improvement of systems and operations for introducing private participation activities and foreign capital.

2. Human Investment in the Information Technology Fields

The effects of IT usage depend greatly on the level of skill of the IT users. This means that it is very important to raise the level of IT literacy on various levels. The macro estimations showed that there is a complimentary relationship between human capital factors and IT factors. It has been said that the development of IT adoption and diffusion and human capital produces synergy effects that can bring about economic growth. In other words, an economy that offers the proper training using new IT-related technologies will very likely be able to quickly promulgate these technologies. On the other hand, the range of new technologies that can be learned in economies with low educational levels is very limited. Currently Asian human capital has not reached the same level as the industrialized nations in terms of IT utilization and so these countries have not been able to bring forth the capital deepening mechanism (labor saving effect) seen in the industrialized nations.

Many regions in the developing world are not only without the introductory level knowledge of IT, but they still have low basic literacy rates. For such regions it will be important to first expand basic education (reading, writing and mathematics) and then provide many chances for contact with IT, and allow for them to learn the basic understanding and applications of information technologies. Also, lifelong education should also be promoted to raise the level of IT literacy for all age brackets, and not just for the young. It is expected that raising the level of IT adaptability at various educational levels in this manner will raise the level of interest in IT among the citizens, which in turn would generate greater demand for IT products.

Providing better technical training at the higher education and vocational education levels can be an effective means for fostering new technicians and raising the IT-related technical skill levels of existing employees. An analysis of education and income levels shows that even among the industrialized nations, those countries that realized strong IT effects were those that bolstered their IT educations at the university level. Therefore, mechanisms need to be

in place to provide a wide range of opportunities to get a college level education. The U.S. example shows the importance of having universities that can produce excellent technicians and new technologies and the Sweden, Finland and India examples show the importance of being skilled in English in terms of developing IT-related businesses. This suggests that developing personnel in the IT field is extremely important for raising the potential of the developing nations. It is expected that the fostering of such personnel would further raise productivity, which in turn would further raise the economic effects brought about by IT profusion.

It is still important to note that even if human capital that can effectively use IT is developed, the impacts will be decreased unless there are also mechanisms in place to make effective use of this human capital. This means that there must be liquidity on the labor market, support for matching labor supply with demand, the establishment of a reliable labor market and the creation of a market that places the right person in the right job.

Taking this into consideration, the industrialized nations and support agencies need to provide support to the developing nations in bolstering IT-related education at various educational levels.

3. Support for Entrepreneurs

This report has attempted to measure and analyze results on both the macro and corporate levels. However, recently OECD also released a report measuring and analyzing the impacts of IT adoption and diffusion on the corporate level[26]. This report estimates the impacts on the macro-level productivity of corporate productivity. The items having an impact on the rise in macro productivity are rises in productivity within existing corporations and the entry of new corporations. The former impacts macro productivity through capital intensification and cutting labor on its own, while the latter achieves this through technical progress (TFP increase).

The results of the corporate interviews conducted by this report show that IT adoption and diffusion in the U.S. was accelerated by the establishment of many new corporations and IT adoption and diffusion in European countries was helped along by putting to work large domestic capital and direct investment by foreign firms. As IT adoption and diffusion progressed, technicians from some of the IT firms set up their own companies, which helped to broaden the scope of the domestic IT industry. Even in the developing nations there has been an increase in the number of such entrepreneurs, mainly in the software field.

When this point is considered along with the previously mentioned macro analysis, it is believed that support for IT-related entrepreneurs, even in the developing world, would be desirable. In other words, since the developing countries have not been able to achieve the same level of industry-led labor cost reduction effects as seen in the industrialized nations, technical progress (increased TFP) can play a much bigger role in terms of increasing the effects of IT adoption and diffusion and thus this needs to be promoted. This is especially true in the software fields, where talented people are needed, but large amounts of capital for equipment is not needed and businesses can be easily started even in developing countries.

During our interviews with corporations in the developing countries many people said that the problem in starting a new business is that it is difficult to raise capital. Therefore, an effective measure would likely be to have industrialized nations and support agencies support a fund for raising venture capital. In fact, the Japan Bank for International Cooperation has already started providing support for venture capital in Malaysia. The experiences gained here will likely be useful for expanding such efforts to other countries.

4. Improving the Economic Environment

In order for the developing nations to link IT to sustainable economic development, it will be very important to make general improvements to their economic environments. In particular, the following

26 OECD Working Paper No.329 (2002)

four points will need to be addressed.

First, progress in globalization and IT adoption and diffusion will need to go forward hand in hand. In order for IT adoption and diffusion to make progress, there needs to be capital and there must be regular buyers for the products and services. However, in the case of the developing countries, domestic capital reserves are insufficient and the domestic markets are too small. In addition to these obstacles, most developing nations are also confronted with the problems of insufficient personnel and technologies. It is hoped that globalization will help to ease some of these limitations by bringing about deregulation, the trade barrier reductions and smoother flows of capital, goods, personnel and technologies.

With this type of internationalization of trade, industrialized nations will be able to make contributions in numerous ways outside of just economic support. One example is that with the adoption and diffusion of IT, more corporations in the industrialized nations will turn to the developing nations for the procurement of hardware and software. There have been cases in which Japan's different language and business customs have obstructed smooth trade with other nations. Hopefully these problems can be overcome through the provision of information, Japanese language instruction overseas and English language instruction in Japan.

The second point is to prepare a market-trading environment. There is the fear that trouble arising while conducting business over the Internet will result in large costs if the proper procedures are not in place. Software development is a classic example of a "knowledge" application whereby the development costs are high, but the production costs are very low. In this case development can be seriously undermined if intellectual property rights are not respected and illegal copies are allowed to spread.

In order for the developing nations to expand IT-related production, start new services using IT and participate in international trade (corporate supply chain, others), they will need to protect intellectual property rights, have secure trading, prepare and operate a reliable trading environment, and make business practices fair and transparent.

The IT adoption and diffusion results in trade that reaches beyond national borders and thus developing countries need to consider just what social regulations and taxes should be imposed on this trade. Comprehensive advice from the industrialized nations will surely be needed. In addition, international debates on these matters must provide opportunities for participation by the developing nations, and efforts should be made to create systems that take into consideration the interests of the developing nations.

The third point is to promote e-government. Developing nations generally have abundant supplies of cheap labor and it is hard for very small businesses to recognize the benefits offered by IT in terms of reducing labor. This is one of the main reasons why IT-related demand has not grown very much in the developing nations.

However, the governments in countries such as India and Malaysia have taken the lead in developing domestic IT demand by enacting policies for the investment in e-government on the national and regional levels.

The promotion of e-government goes well beyond the simple procurement of hardware. There should be plenty of room for participation by local companies that are well aware of the national and local laws and regulations. This is expected to help develop software and foster software companies.

During the interviews with corporations in the developing countries, it was often indicated that generally the government procedures are not very transparent and result in a great deal of lost time, both of which have proven to be big obstacles to business. However, it is believed that e-government will make procedures more fair, transparent and efficient, which in turn would make a big contribution to establishing the necessary trading environment. The industrialized nations and support organizations need to provide both financial and technical support for the developing nations and regions trying to implement e-government.

The fourth point is to stabilize the macroeconomy. Even in the U.S. it took a great deal of time before IT adoption and diffusion could be linked to economic growth. Therefore, it will be important for the governments of the developing countries to build consensus among its citizens regarding the long-term

promotion of IT through the government's IT plans. The IT plans should not be over ambitions and should not try to placate everyone. Instead the plans should take into consideration the socioeconomic situations of the country, as well as the country's relative strong points, and then clarify priorities and adopt goals that are attainable. In this case the IT adoption and diffusion should be promoted along with the long-term growth for the overall economy. In terms of macroeconomic management, financial policy management with certain regulations should be used to stabilize prices, long-term interest rates and currencies.

The various industrialized nations need to adopt suitable policies in order to stabilize the international macroeconomic environment. Efforts should also be taken to avoid major shocks like the Asian currency crisis, and consideration should be given to a crisis management system for international currencies in the event that just such a crisis occurs.

Chapter 7 Conclusion

In concluding this report, we would like to briefly touch on the impact IT adoption and diffusion has had on Japan.

The analysis provided in this report focused on the advanced IT nations, mainly the U.S., and some of the developing countries in Asia. Japan also saw a steady expansion of IT from the 1990's. However, it has been said that the speed of this growth lagged behind the growth seen in the other industrialized nations, and even some of the developing nations. During this period Japan's economy stagnated due to the aftershocks of its bubble economy bursting, and clear relationships between IT adoption and diffusion and economic growth could not always be seen.

Still, the progress in IT adoption and diffusion has had a major impact on the Japanese society and economy. For example, in the past few years e-mail has played a major role in the business field by fostering connections both inside and outside organizations. This has revolutionized the mechanisms for decision-making and for reaching shared understandings. This has also led to increases in the provision of information and the conducting of transactions over the Internet. IT adoption and diffusion has helped the manufacturing sector to diversify production bases and led to the creation of production clusters that have revolutionized relationships between companies. It can be inferred that these changes would not have been possible without the spread of IT.

IT adoption and diffusion has also had a profound impact on daily life in Japan. The use of cellular phones for sending e-mail and accessing the Internet has become commonplace. Fierce competition among telecommunications companies has resulted in lower prices and the rapid spread of broadband services. The increased convenience of networks has also been changing the forms of individual employment. For example, "Essay Contest for Working Women"[27] sponsored by the Ministry of Land, Infrastructure and Transport in 2001 showed that it has become very common to use IT to work at home, which has come to be known as SOHO (small office / home office).

However, the important point to remember is that these changes in employment options were not brought about simply by the fact that PCs and the Internet can now be freely used. There is still the need to bolster the expertise required for each type of employment. One woman in the above example of SOHO workers said that she is employed as a transcriber of audiotapes. This woman said that she needs to have strong skills in the mother tongue and a technical understanding of the contents on the tapes to raise the accuracy of her work and win the confidence of her customers. This example reconfirms that even in Japan the IT adoption and diffusion in itself is not the goal, but rather it should be seen as an effective tool for achieving some other goals.

27 Refer to <http://www.mlit.go.jp/crd/daiseitelework/h13sakuhin.htm>

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