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Technology Choice, Change of Trade Structure, and A Case of Hungarian Economy

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Abstract

In the IT industry, there has been a remarkable increase in the demand for system LSI. A system LSI must be tailor-designed for each electrical appliance, and then produced. It is said that in recent years, this production method has made the IC cycle ambiguous. It can be sought that the choice of whether the economy pursues a development path centering on technology which is tradable or technology which is embodied in labor, depends on the historical background. In this paper, the economic background is explained in order to analyze and capture movements in the IT industry and technology. Then, an econometric model for Hungary has been constructed to estimate the effect of technological progress on the economy.

Keywords: Technology Choice, IT industry, Trade Structure、Econometric　Model
JEL classification: O31, D24, E27

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Technology Choice, Change of Trade Structure, and a Case of Hungarian Economy

Hisao Yoshino

Introduction

IT (Information Technology) industry is growing rapidly and its scale in production and demand is also very large. Japanese IT industry has been in full flourish in 1980's. However, then, its share in the world market shrunk affected by the technology progress of CPU (Central Processing Unit) in the United States and the investment behavior of Korean IT firms like an intense deluge. The rapid progress of IT technology started to demand more salient function of IT products such as mobile phone digital camera and car navigation system. This phenomenon increased the demand for the system LSI (Large Scale Integrated Circuit) sharply. It is said that the business cycle caused by the IC (Integrated Circuit) become ambiguous because the system LSI is produced according to order. From 2003, Japanese IT firms started to recover rapidly by the increase in production of system LSI focusing on the digital household appliance. There are no scale merits in the production of system LSI and the technology embodied in labor is needed for it. It is produced by firms of Japan, Europe, and the United States. It is possible to categorize developments into two types. The first is the type which is promoted by the tradable technology and the second is the type which is promoted by the technology embodied in labor. It can be thought that the technology choice depends on the historical background. IT firms in the United States produce focusing on versatile products which can be manufactured by the method of mass production. IT firms of Japan and Europe produce focusing on the system LSI. Now, these two types of technologies are in the relationship of competition and the dominancy is alternated periodically. It is important to understand and predict the trend of IT technology to capture and analyze the economic development. In the next section, the trends of IT technology and industry, and the technology choice are explained. In the section 2, the process of production is explained to capture the trend of technology. Then, we consider what types of technologies will be developed and how these technologies will affect economies. In the section3, the trade structure, macro economy, and technology trend of Hungarian economy are explained. In the section 4, it is analyzed what will be brought about, when the technology progress promoted in Hungarian economy, using a macro econometric model.

1 IT Technology and an Economy

In the trade theory, until the 1980's, Heckscher-Ohlin-Vanek model was very popular. This model can be summarized as follows. In two economies, we have two factors of production, capital and labor, and they have different ratios of factor endowment. At the same time, factor endowments are fixed. It is assumed that we have two products such as agricultural and manufactured products. The production is conducted under the perfect competition with the production function which have the property of the constant return to scale. Then, it is assumed that the same technology is used in production in these two economies. The capital (labor) intensive good never change to the labor (capital) intensive good even if the price ratio of production factors change. In these two economies, the common and homothetic social welfare function which mean the share of consumption expenditure is determined when the relative price is determined, unrelated to the income level. The income elasticity of two goods is one. Factors of production can move inside economies with no costs, however, can not cross the border. Two goods are traded with no costs under free trade. Trade balance is always in equilibrium and there are no borrowing and lending between two economies. It is possible to summarize the conclusion which is brought by assumptions described above, as follows.

1. Stolper-Samuelson Theorem

When the relative price of labor intensive good increase, wage increases more and the price of capital service decreases under the assumption of production factors being constant.

2. Rybczynski Theorem

When prices of goods are constant and the endowment of labor increase, the production of labor intensive good increases more and the production of capital intensive good decreases.

3. Factor Price Equalization Theorem

When two economies produce two goods, prices of production factors are equalized in them.

4. Heckscher-Ohlin Theorem

The economy which is abundant in labor, exports labor intensive good and the economy which is abundant in capital, exports capital intensive good.

It seems like that the model described above have a shortage in explanation of change of trade structure caused by the rapid growth of IT industry from 1990's. In 1989, the production of Japanese IT industry shared 53% in the world. After that, with the breakdown of so-called "Babble Economy" its share started to decrease rapidly and this trend held more than ten years. IT firms of the United States, such as Intel [1] and AMD, monopolized the production of MPU(Micro Processing Unit) and they occupied the large shares in the production of semi-conductor. IT firms of the United States started to have the strategy as follows. they concentrated resources of management on invention, innovation, and designs of products to avoid risks accompanied by plant and equipment investment. They disassembled production process into two parts. The first is so-called "Fables" which is related to invention, innovation, and designs of products. The second is related to the real production. They started to take the latter on consignment. In Taiwan, IT firms such as TSMC [2] and UMC [3] which produce semi-conductor appeared. It is possible to find the effect of government policy on the background. A semi-government firm took the role of Research and Development for the production of semi-conductor and private firms could concentrate management resources on production process. It can be thought that IT firms of Taiwan could make rapid growth supported by introduction of technology from Japan and the United States, and government policy. Then, IT firms of Taiwan started to specialize into the consignment from the United States, that is to say, the foundry, They were started to be set in the business model of the United States. On the other hand, Japanese IT firms had the top share in the field of DRAM (Dynamic Random Access Memory) in the world, around 90 %, in the second half of 1980's. However, Korean IT firms such as Samusung repeated investments like intense deluges and increased shares. In 2004, Japanese share decreased to less than 10%. In this situation, Japanese IT firms changed the strategy and shifted from DRAM to the system LSI for the digital household appliance. The feature of Korean IT firms is to repeat large investments taking advantage of scale merits in the fields of LCD (Liquid Crystal Display) and DRAM. In this way, they succeeded to capture large share, however, they are below in the technology, compared with Taiwan [4].

According to Ikeda[20], it is said that horizontal division of labor will be more beneficial when needs for feed-backs of information in design and production become small, in a matured stage of technology. In this situation, outsourcing of parts should be beneficial. However, in it is not possible to find any superiority of horizontal division of labor in the growing stage of technology in which feed-backs of information in designs and productions are active. Formerly, it was said that the strength of Japanese IT firm is based on the sharing of intelligence and information in a firm. By the intensive exchange of information between the stages of design and production, problems in the stage of production were reported to the stage of design and the quality of products was improved. It is possible to find this type of technology structure in the industry which has complicated production process with large number of parts, like in the automobile industry. However, since 1990's, in industries such as the semi-conductor, design was started to be conducted using the computer language with modules. Then, it became possible to divide the production process into the fables and the foundry. Problems in the stage of production became controllable in the stage of design. They succeeded in shortening of period in production and reduction of costs. In the field of three-dimensional CAD (Computer-Aided Design), we can find same phenomena.

In 2003, Japanese IT firms started to show the rapid recovery. In 2004, they shared 28% of production in the world, which is next to 40% of the United States. Before, mobile-phone had only one function of talking. Now, it has other functions such as TV reception, photograph and television telephone. Then, the production of digital household appliances such as digital camera and DVD recorder increases rapidly. The production method of module mentioned above could not satisfy the needs in this kind of progress of function. To produce such kind of manufactured goods, the technology of system LSI is needed. It is to design LSI for each product item and assemble them. For the production of system LSI, frequent exchanges of information and adjustments between the stage of design and production, are necessary. The technology embodied in labor is observed in this field. Firms in Japan, Europe and the United States are producing system LSI (For example, Panasonic and Hitachi in Japan, ST Micro Electronics in France and Italy, Texas Instruments in the United States) Formerly, in the sector of semi-conductor, at first, firms estimated the demand of it , then invested and started to produce. It was rather hard to meet the demand and supply. Four-year cycle existed in the production of semi-conductor. However, the production of system LSI is conducted by tailor-design. It is said that the cyclical movement become ambiguous.

As mentioned above, in 2003 a large change in the IT industry occurred. In 2003 and 2004, Japanese IT firms increased productions and profits smoothly. Then, in 2005, profits decreased considerably by intensified competition. At the same time, development of the substitutable technology with the system LSI became active. It is so-called ASSP（Application Specific Standard Product）The tradable technology and the technology embodied in labor are in the relationship of competition and it seems like that the dominancy is alternated periodically. In the background of the development of ASSP, it is possible to find the effect of “Moore’s Law” which means the capacity of memory becomes twice by every one year and half. It seems that this periodical alternation of dominancy will be held for seven year from now on [5] [6].

Mainly, firms of the United States develop technologies based on invention and innovation. Firms of Japan and Europe are good in the system LSI. The fact that firms of the United States are good in tradable technology and firms of Japan and Europe are good in the technology embodied in labor, was pointed out before the start of IT industry already. It seems like that each economy has proper technology which depends on the historical background.. It is rather unrealistic that technology is chosen by the relative price of capital and labor, and envelopes of group of production functions.

According to the Heckscher-Ohlin theorem, each economy has the same technology and the economy which is abundant in capital exports capital intensive good and the economy which is abundant in labor exports labor intensive good. This theorem can not explain the trade and economic situation in this age with the rapid progress of technology. Leontief pointed out that the United States which should be the capital abundant economy exports labor intensive goods and imports capital intensive goods for 1960’s. Leamer[1980] argued against this contention with changing the calculation method. But, it is not an decisive argument. Trefler[1995] inspected this theorem with comparing the real trade and the trade which is estimated by factor endowments. The, he explained some points which is not consistent with that theorem, using the idea of home bias in consumption and the technology difference in each economy. He compared the real exports and exports capacity about 9 kinds of production factors and 33 countries. He pointed out that it is often that the real export is rather small even if the export capacity is large. He called it "the missing trade" [7]. The correlation coefficient of production factor which is contained in export and factor endowment from which domestic consumption deducted, is only 0.28. Then, he calculated the surplus capacity of export which is gained by deducting real export from export capacity by each country and each production factor. He found that if the country is poorer, it has more production factors of which surplus capacity of export is large [8]. If the country is poorer, it is more passive in export. He called it "the factor endowment paradox".

He explained "the missing trade" by the biased preference of consumer toward domestic product. For example, if a high tax rate is set for foreign product, domestic product is consumed a lot. Then, real export becomes very small. He explained "the factor endowment paradox" as follows. In the case of richer country, the share of investment in expenditure is larger. Therefore, if we recalculate with excluding investment, the difference disappears. Then, he presented the alternative explanation for that theorem, using technology difference. It is assumed that the technology of rich country is neutral and the technology of poor country is not neutral. For example it is assumed that France and Germany have the same capital-labor ratio, but, Bangladesh has the different capital-labor ratio in the agricultural sector. Maskus[1985], Brecher etc.[1988], and Bowen[1987] argued about the Heckscher-Ohlin theorem. However, only Arminton[1969] and Trefler[1995] presented the alternative explanation.

It is plausible that each economy has a proper combination of capital and labor which depends on the historical background. It seems like that Ricardian model is more preferable to Heckscher-Ohlin model, with assuming that capital labor ratio is constant and proper for each economy, and direction of technology progress is proper for each economy. In this background, labor is omitted in the estimation of potential production function in the macro econometric model for Hungary described below. In cases of Japan and Germany, they use more labor than capital. In the case of the United States, they use more capital than labor. In the case of Korea which pursues scale merit with introducing technology from Japan and the United States, they use capital most. In the case of Taiwan, they use a lot of capital, but, it is less than Korea. Generally speaking, in Western Europe, it seems like that technology is embodied in labor. However, in Eastern Europe it seems like that situation is different by each country. In the case of Czech, they experienced the development of machine and precise machine industries already before the World War II. It seems that the combination of capital and labor is similar to Germany. In the case of Hungary, the situation is different. Hungary has a small population, around 10 million, however, it is possible to find many famous scientists especially in the field of physics and chemistry. Foreign firms, such as IBM (International Business Machines Corporation), Nokia (Nokia Corporation), Siemens (Siemens AG), and Intel set up institutes for Research & Developments. Hungary became the base for research activity of IT in Eastern Europe. Especially, in the case of IBM, they have about one thousand researchers in that institute. Its scale is same with the Mitsubishi Research Institute in Japan. Recently, exports of IT industry are growing rapidly in Hungary. It may be plausible that such research activities are started to be linked with IT industry, in Hungary. On the other hand, in the case of Poland, it is impossible to find similar phenomena. In Poland, each sector of manufacturing is showing similar movement and the economy is showing the steady performance as a whole. It is important to capture the trend of technology when we analyze the economy which is driven by IT industry. According to the Moore's law, capacity of memory doubles by one year and half. Demands for functions are sophisticated more and the technology embodied in labor such as the system LSI obtains dominancy. In this condition, the economy which is good in this kind of technology increases production and export. However, then, scientists and engineers try to replace the technology embodied in labor to versatile technology brought b/y .invention and innovation. To predict the trend of IT technology and capture the effect to economies, the structure of IT technology is explained in the next section.

2. The Structure of IT Technology

Huge amount of investment is needed to produce semi-conductor. They cut out wafers as largely as possible from silicon mono crystal. They divide wafers and set up wiring on them. To build a factory which has a facility to cope with the newest 300 mm wafers, a fund, more than 200 billion yen is needed. Description of IT technology is based on Izumiya [2005] [2005].

After the completion of digital appliance, they proceed to the next process in which semi-conductor is designed. This process consists of function design, design of logic circuit, design of layout. After the completion of these designs, Circuits of digital appliance are transcribed to glass board. In the next, silicon wafer is used. To make silicon wafer they have to deoxidize carbon and silica stone in electric furnace and then make a metal silicon lump. They grind it and melt it by sulfuric acid and make polycrystalline in high purity. They make the seed crystal absorb silicon with hanging and rotating it by piano wire in a melting pot and obtain mono-crystal silicon. They slice off ingot of mono-crystal silicon in a shape of bar and obtain wafers. They complete the production of silicon wafers after polishing them.

The process of processing wafer is divided into transistor processing, gate terminal processing, and the wiring process.

In transistor processing, silicon oxidized film and silicon nitrogenized film are made on wafer board. Then, exposer is applied on silicon oxidized film and the mask pattern of glass board is transcribed on it by lithographical device. The useless parts are deleted by etching technology. The next oxidized film is made from the upper. For the isolation, material of impurity is injected. They finish this process.

In the gate terminal processing, they make silicon oxidized films and polycrystalline silicon films continuously and they applied exposer on them. The mask pattern is transcribed by lithographical device and the useless parts are deleted. After perfection step, they complete this process and obtain the transistor.

In the wiring process, they connect transistors by wiring. They make thick isolation films on transistors and make holes in them and fill in tungsten for wiring. In the next, they apply aluminum film on them. The mask pattern is transcribed by lithographical device and the useless parts are deleted. They complete the wiring parts. They make isolation film between layers on it and make holes in them and fill in tungsten for wiring. They have to repeat these steps.

By this method mentioned above, the mask pattern of glass board is transcribed on wafer. This is the completion of process of wafer, in other word, first half of the whole process.

The wafer on which the circuits of digital appliance have been transcribed, is cut and divided. Then, lead frames are attached. Each chip is attached to base. This process is the mounting. Then, they have the bonding process, which is to set wiring terminals. After that, they have the molding process which is to enclose them. The last is the inspection. They complete the second half of the whole process.

To decrease the price of semi-conductor, it is better to make the diameter of wafer as large as possible and increase the number of chips. Before, the 20 cm wafer was the mainstream, however, now, it is the 30 cm. Compared with 20 cm ware, it is possible to get chips twice in the case of 30 cm wafer. We find the scale merit in this phenomena.

The capacity of DRAM becomes twice every one year and half. It is realized by reduction of the width of wire (design rule). Because, they can reduce the size of circuit and increase the integrity, the capacity of DRAM increases. Now, the design rule is less than 90 nanometers [9]. The length of gate is, now, 37 nanometers, with decreasing similarly with DRAM.

Mr. Gordon Moore, The Honorary President of Intel, predicted that the capacity of memory would become twice every year in 1965. He modified the prediction in 1975. After 1975, the pace of progress was rather constant. However, some specialists mention that this pace is slowing down now and this progress of technology will become much slower in 2010's. They have background in this opinion. At first, about the lithographic technology, this is to print design of semi-conductors on silicon wafer. The technology now in use is mainly the optical lithography. This is to print the circuits design on chip of wafer with reducing the size to 25%. To make the production process of semi conductor more precise, it is needed to obtain more precise resolution. For the precise resolution, they have to make the wavelength of ray at exposure as short as possible. Until now, exposure device on which has Fluorine-Krypton Excimer Laser as a light source, was in use. But, this device is not useful in the case of the design rule less than 90 nanometers. Recently, a new technology, Immersion Lithography which is to increase the refraction index and reduce the width of wavelength of ray using water, appeared. By this technology, they obtained a solution for the impasse to some extent. However, they can not have the realistic technology after that.

Secondly, they have an issue in the thickness of isolation film in the gate of transistor. If it is not thick enough, the gate will have leak of electricity and consumes electricity a lot. Now, the thickness of the isolation film is in the level of molecules. It is very difficult to solve this problem by improving current technologies. For the solution, they think that development of new material (High-k) with high induction is hopeful as the isolation film in the gate. Compared with current material (SiO2), High-k is said to decrease the leak 99%. But, this material has been said to be adopted in the stage of 90 nanometers in the design rule. They have not yet realized this new material. Other than this technology, they have topics of new technologies such as tri-gates transistor which has a three-dimensional structure and perfect empty SOI. But it seems like that it takes a lot of time to realize these new technologies.

In 1971, Intel has been still a small firm, then, it has created the MPU which has a function to drive the personal computer. Since that time, a market of MPU has been monopolized by firms of the United States. MPU are categorized into two items. First is the type of CISC which is for office-works and Second is the type of RISC which is to be set in machines. Around 1980, IBM started to sell personal computer and Intel released 8086 at the same time. In the age of 16 bits, 86 series of Intel and 68000 series of Motorola (Motorola Inc.) competed. Finally, Motorola left the market. Now, personal computers in use are type of 32 bits and 70% of the market is occupied by Intel, 20% is by AMD and the rest is by several firms such as Freescale (Freescale Semiconductor, Inc.).

MCU (Micro Control Unit) is a chip which contains a part of functions of CPU, programs, and data. MCU is set as a main part in the electrical home appliance and the manufacturing good. The scale of the market in the world is about 20 billion US dollars. It is rather big, compared with the semi-conductor market as a whole, about 250 billion US dollars. About 60% is shared by Japanese firms in this market. In the case of Game-Appliances, Japanese firms have big share and they are producing CPU. TOSHIBA (TOSHIBA CORPORATION) and SONY (SONY CORPORATION) developed the EMOTION ENGINE for the Play Station2. Then, in the case of CELL ENGINE for the Play Station 3, IBM joined. CELL ENGINE is different from CPU in the past and has three cores which contribute to large scale calculation. Now, it is used for the game machine and the medium size computer.

Now, the production of FPD (Flat Panel Display) such as LCD and PDP (Plasma Display Panel) are expanding. The semi-conductor industry has maintained the growth rate of 14% more than 50 years. In the case of FPD market, it has maintained the growth rate of 17% for 25 years. Some specialists predict that the market of FPD reach to 250 billion, which is same with the present semi-conductor market, in 2015. Many firms in some countries started to increase investments in this field. LCD shares 80% of FPD market and this is divided into two categories. First is Active-Matrix Method and second is Passive-Matrix method. The former has TFT (Thin Film Transistor) and Thin Film Diode. Almost of LCD market is shared by TFT. LCD is used for devices such as Personal computer, mobile phone, and TV. It consumes electricity less than the CRT (Cathode Ray Tube). However, it has some problems in luminance and calibration of moving pictures. On the other hand, PDP has a mechanism as follows. At first, Mercury gas is enclosed to glass tube and plasma discharge is conducted. Then, ultraviolet rays which are maid by the discharge, collide with material of fluorescence and emit light. Compared with CRT, it has the same level of functions in calibration of moving pictures and sight. But, compared with CRT, it is worse in luminance and efficiency of light emission. In electricity consumption, it has been much worse than CRT, but it has improved a lot. Especially, in the case of FPD larger than 37 inches, PDP shares 90% of the market. Then, TOSHIBA and Canon (Canon Inc. Corporate) plan to produce SED (Surface-conduction Electron-emitter Display). SED has the same mechanism with CRT basically. They set many small electronic guns and they emit electronic beams and then, pictures are made. SED consumes electricity less than CRT and has a good quality in picture. Some specialists predict that it monopolizes the market within several years, if the production is realized. In the field of FPD, it is possible to monopolize the market by the scale merit, if firm conduct aggressive investment. Korean firms started to capture the large shares by aggressive investments in the LCD market. Recently, firms of Taiwan started to have aggressive attitudes. It is expected that the completion is made by 2015 if the market is captured by aggressive investment or it is gained by the new technology.

IT industry not only has a large growth rate but also has a huge size of market. The trend of this industry has a large impact on macro economies. In this sense, it is important to analyze the trend of this industry, especially the trend of technology and how it will affect macro economies. In the analysis of the technology trend, it is interesting that two types of technologies are in the relationship of competition and the dominancy is alternated periodically, as mentioned above.

We had better to pay attention how and how much they can proceed to make more precise MPU and DRAM. It is important to predict how long the "Moore's law" survives. It will be a large factor to affect macro economies. In cases of DRAM and liquid crystal, it is possible to capture the scale merit which is brought by the "Moore's law". Then, there is a possibility of appearance of new technology in the field of TV and high level of technology is needed in developments of devices related to MPU. These points are also important.

It is needed to predict the trend of technology and analyze how it affects trades and economies. In the next section, Hungarian case is adopted. It can be found that exports in IT industry are growing rapidly in Hungarian economy. We analyze how the technology trend affect the economy using the macro econometric model.

3. The Hungarian Case

In 1980's, the liberalization had been started already in Hungary. Then, in 1990, it was accelerated especially in the field of capitalization. In the case of Poland, a neighbor country, they had big confusions. Growth rates of GDP recorded Minus 12% and Minus 7% in 1990 and 1991. This phenomena is according to reforms such as privatization of national firms, reforms in financial sector, the departure from COMECON (Council for Mutual Economic Assistance). Similarly with Poland, Hungarian economy recorded large decline. GDP growth rate recorded Minus 3.5% and Minus 12% in 1990 and 1991[10]. However, because Hungary had started the liberalization much earlier than Poland, reforms such as privatization of national firms and reforms of financial sector could be completed in a short period. It kept the negative growth until 1993 (Minus 0.8%), but, the growth rate became positive in 1994 (3.2%). After that, this economy maintained steady growth rates, around 5 %. Under the old regime, it had an economic structure in which they import energy and raw materials, and export manufactured goods. It recoded always surplus in trade toward COMECON countries and deficit toward Western countries. At that time, the metal industry which use ironstone, bauxite, and coal produced in this country, and the machine industry were active. According to Figure 1, the general machine shared around 13 % in exports in 1980's. In 1992, This share decreased to about 6%, then, it started to increased 1997. It shared 22.6% in 2003. At the same time, the electric machine shared around 10% stably in 1980's and started to increase its share from 1997. It shared 30.9% in 2003. These industries are related computer. It seems that industries related to IT appeared in Hungary and they drove the economy. In Hungary which is the agricultural country, traditionally, the share of the export of agriculture was around 15% and export of food was less than the former in 1980's. In the adjustment period of the early 1990's, they increased shares and drove the economy. However, they started to decrease their shares rapidly from the second half of 1990's. In 2003, both of them shared only 5%.

According to Figure 2, in the case of imports, the electric machine was stable, showing share of 6% in 1980's. From 1989 it started to increase and reached to 25.2% in 2003. The share of general machine in imports was between 15% and 20% in 1980's. It showed the decreasing trend until 1996 and increased sharply in1997, then it shared 19.2% in 2003.

The most remarkable change of the trade structure in Hungary is the rapid growth of the share of electrical machine in exports (Figure 1) It started to increase monotonously from 1999. Now, the electrical machine and the general machine share more than half of exports. The growth rate was kept at around 5% in this period. It seems like that the electrical machine and the general machine drove this economy. As mentioned above, Foreign firms, such as IBM, Nokia, Siemens, and Intel set up institutes for Research & Developments. It seems like that such research activities are started to be linked with IT industry, in Hungary.

Figure 1 Shares of Main Industries in Export (%, Source See 11)

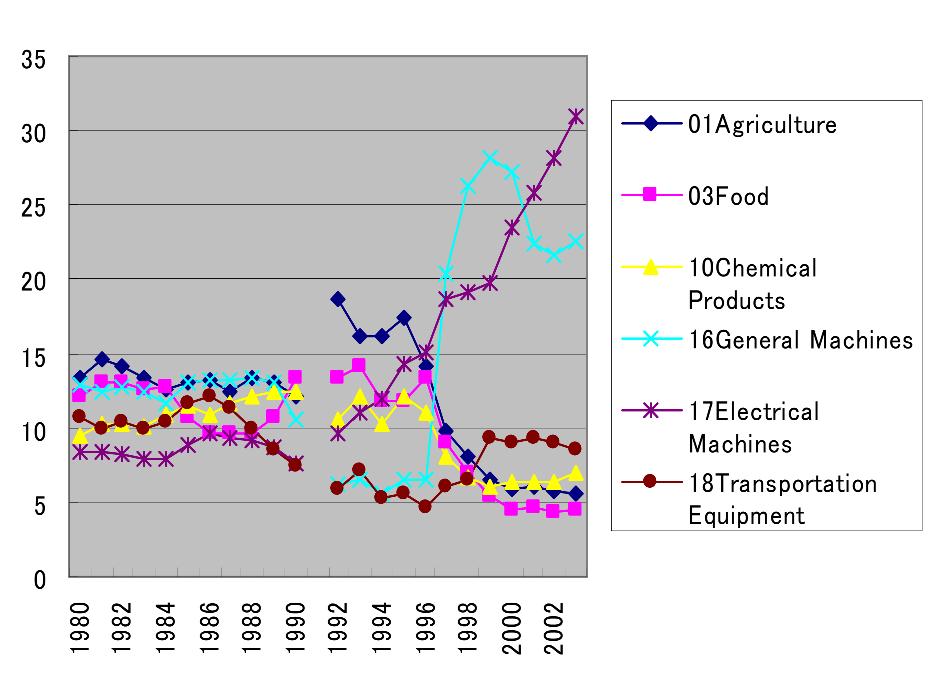
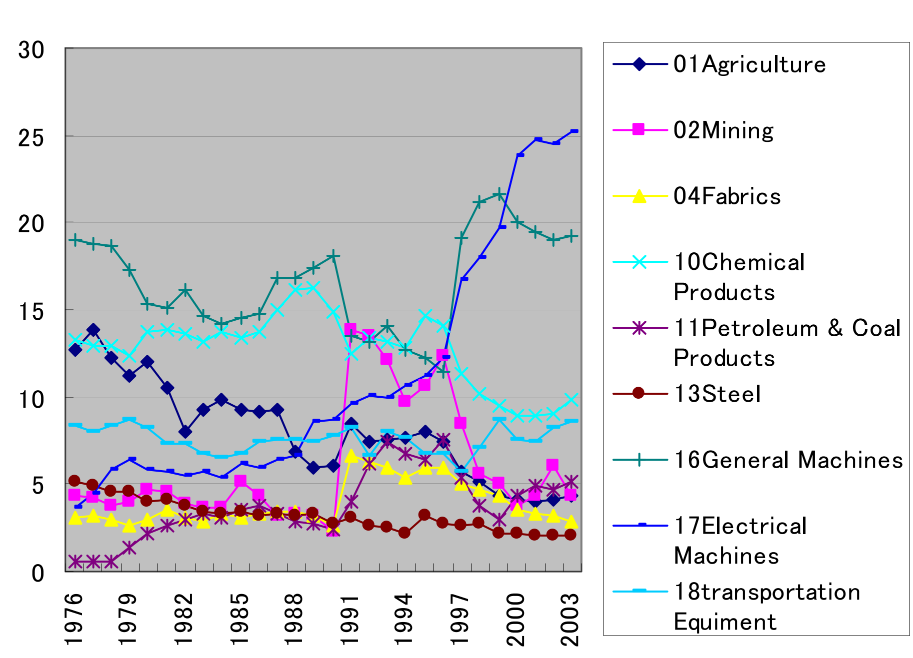


Figure 2 Shares of Main Industries in Imports (%, Source See 11)



It is possible to find many famous scientists especially in the field of physics and chemistry in Hungary. According to [15], the level of research activity is high in the world. In the Institute of Mathematics and Roland University are famous in the field of Combinatrix in Mathematics. It is possible to find basic products of Mathematics such as Random Graph Theory. In the field of Physics, we can find products as follows. Roentgen Holography was found by the Institute of Physics in the Hungarian Academy of Science. The linkage of Bose Condensation with Quantum Chaos was found by Hungarian researcher. It contributed to the analysis of issues in the group behaviors of individuals and the transportation of molecules in cells. In this circumstance, in the field of IT technology, inventions, entrepreneurings of venture business, establishments of R&D centers of foreign IT firms, are quite often. In the field of IT, we can find some examples such as Graphisoft R&D Rt., which is producing 3 dimensional auto-CAD for personal computer in the field of architectural design, Dermo Trade Rt., which has developed the function to accumulate information of finger prints on memory chip using print identification system based on Biometrics., and the Institute of Computer and Automation in Hungarian Academy of Science, which has created visual micro processor, named ACE4, based on the study of Wave computing algorism. Then, in the field of communication, we can find examples such as Faculty of Telecommunication Telemax in the Department of Electrical Engineering Information in Budapest Engineering University, which is good in the analysis of IP (Internet Protocol) network, automatic voice identification, handling of signal and sound, language acoustics, handling of digital sound, and voice identification, Ericson Hungary which is specialized in the analysis of traffic and performance, the network design and optimization of mobile system, applied study in the field of communication system, Nokia Hungary which is developing the software for the function of conversion of a new mobile phone, network design tools, and software related to telecom such as mobile internet service, and the venture business named Laserbit Communications kft, which has been developed the unique system which has a function of communication for information between two points with clear visibility.

Originally, Hungary had a good circumstance in invention, and accepted FDI (Foreign Direct Investment) around 3 billion US dollars every year, until 1997. It was said it may be the limit because Hungary has the small population, only ten millions. However, it increased sharply to 4.2 billion US dollars in 2004. It seems that the progress was promoted supported by this inflow of FDI and it linked the sharp increase of exports, in the field of IT industry. A macro econometric model is estimated considering these conditions and a simulation is conducted. In the next section, they are explained.

4. A Macro Econometric Model for Hungary and a Simulation

Hungarian economy recorded large decline. GDP growth rate recorded Minus 3.5% and

Minus 12% in 1990 and 1991. However, after that, this economy maintained steady growth rates, around 5 % (Figure 3). The consumption showed the trend of decrease until 1996, but, started to grow by around 5% from 1997. Then, also, the investment started to show the steady growth rate from 1996. Exports and imports showed the similar movements with other macro variables until 2002. However, they showed two digits growth rates in 2003 and 2004, continuously. In the case of FDI, it showed the trend of increase until 1995 (4.8 billion US dollars), and after that, it showed the trend of decrease. In 2004, it increased sharply to 4.2 billion US dollars (Figure 4). In exports and imports in this country, shares of electric machines and general machines increased rapidly it drove the economy.

Figure 3 Growth Rates of Macro Variables in Hungary
(Source: IFS)

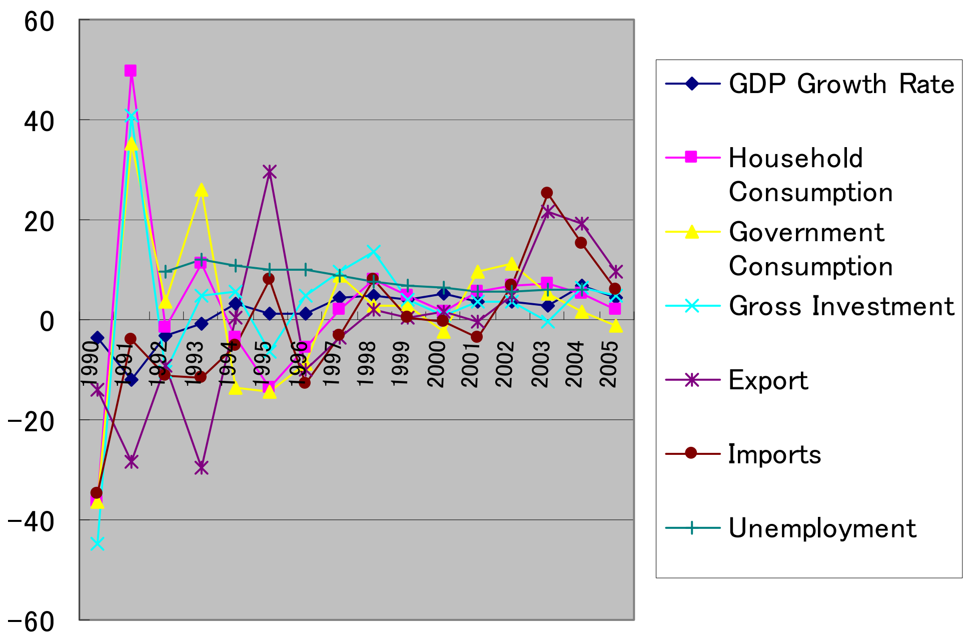
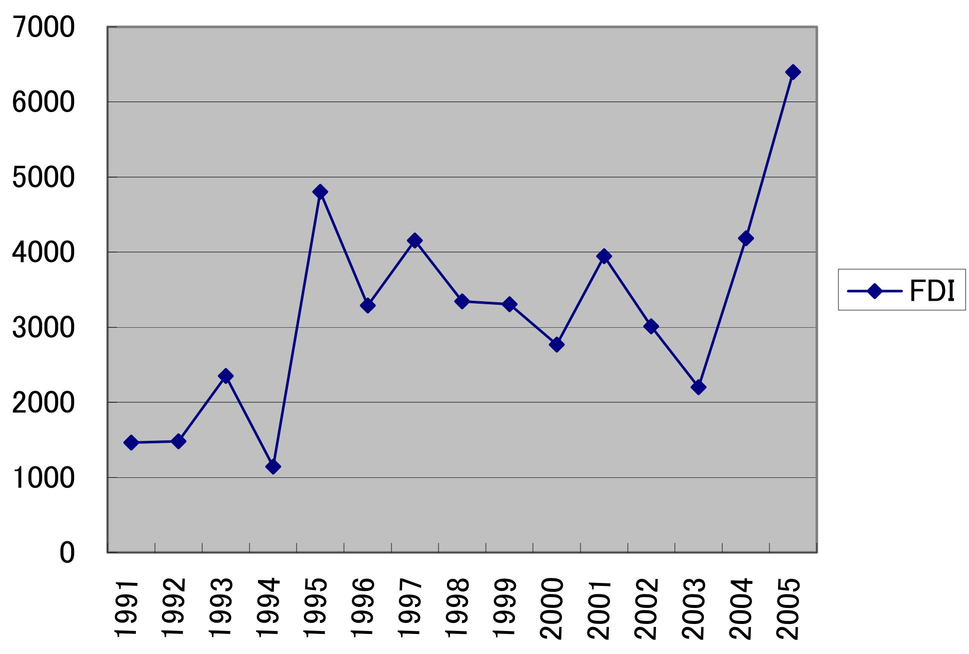


Figure 4 FDI in Hungary (Source: IFS)



Hungary has a good circumstance in inventions and, recently, IT industry is growing rapidly. Setting up of Research institutes of foreign IT firms and entrepreneuring of venture business are quite often. It seems like that such activities are started to be linked with in the IT industry of Hungary. It can be said that the tradable technology, not the technology which is embodied in labor, is always chosen in the choice of technology in Hungary, The technology choice is conducted by the historical background not by price mechanism. The capital labor ratio is assumed to be constant and the potential production function is estimated omitting the variable of labor. Ricardian model is applied. It is possible to think that the progress of technology is explained by the accumulation of FDI. In the potential production function, it is added as an explanatory variable. It is assumed that the production of each industry changes based on the condition of it, which is .according to progress of technology in each industry. By the restriction of availability of data, it is impossible to get data of investment and capital stock in each industry. The rapid growth of electric machine is explained by the export. The export is divided into the electric machine, the general machine, and the other. The rapid growth of electric machine is explained by the income factor of the United States, the export price, and the technology progress indicated by the accumulation of FDI.

Table 1 Variables List

PC	Private Consumption	GC	Government Consumption
GDP	GDP	J	Inventory
GFCF	Gross Fixed Capital Formation	R	Interest Rate
K	Capital Stcock	D89	Dummy Variable of 1989
POTGDP	Potential GDP	D90	Dummy Variable of 1990
FDISTCK	FDI Stock	D91	Dummy Variable of 1991
M	Imports	D92	Dummy Variable of 1992
MDFLTRPGDP	Ratio of imports price and GDP Deflator	D93	Dummy Variable of 1993
EXR	Exchange Rate	D94	Dummy Variable of 1994
ENMSMN	Current Surplus	D95	Dummy Variable of 1995
RR	Real Interest Rate	D96	Dummy Variable of 1996
E16	Export of General Machine	D97	Dummy Variable of 1997
GDPUS	GDP of the United States	D98	Dummy Variable of 1998
E17	Export of Electric Machine	D99	Dummy Variable of 1999
EDFLTR	Export Deflator	D00	Dummy Variable of 2000
EOTHR	Export of Other Sectors	D01	Dummy Variable of 2001
PGDP	GDP Deflator	D02	Dummy Variable of 2002
GAP	Gap of Demand and Supply	D03	Dummy Variable of 2003
M2	Money Supply (M2)	D04	Dummy Variable of 2004
MDFLTR	Imports Deflator	D05	Dummy Variable of 2005

4.1 Estimated Equations And Definitions

4.1.1 Consumption Function

Sample period 1989 to 2005

LOG(PC)= 0.446141 + 0.9109LOG(GDP) - 0.4075*D90 + 0.2385*D93

T 値 0.4245 8.210 -7.575 4.0249

+ 0.1726*D94 - 0.0733*D97 + 0.1240*D92

2.996 -1.33 2.1157

DW 値 1.5186

R2 0.9024

4.1.2 Investment Function

Sample period 1990 to 2005

GFCF = -1557.68 + 0.2442GDP + 0.0259*K(-1) + 294.139*D98 + 284.842*D99

T 値	-8.026	18.678	10.178	2.962	2.874

DW 値 1.399

R2 0.9717

4.1.3 Potential Production Function

Sample period 1992 to 2004

POTGDP = -4693.66 + 0.29997*K + 0.6407*FDISTCK

T 値	-1.3534	4.2861	17.7305

DW 値 2.3034

R2 0.9811

4.1.4 Import Function

Sample period 1989 to 2005

M	= -167.653	+ 1.3544*GDP	-8223.31*MDFLTRPGDP
T 値	-0.16015	13.6402	-11.1559
		+7.039.62*D89	+ 1827.59*D91
		10.5129	2.9391

DW 値 1.9864

R2 0.9713

4.1.5 Exchange Rate Function

Sample period 1989 to 2005

EXR	= 220.142	- 0.1110*ENMSMN	- 1.2017*RR
T 値	13.3263	-3.433	-6.787
	+32.6592*D90	- 75.8313*D93	-71.5729*D94
	1.053	-2.8262	-2.6941
	+76.001*D01		
	2.7978		

DW 値2.277

R2 0.9339

4.1.6 Export Function of General Machine

Sample period 1992 to 2004

LOG(E16) =	-20.0175	+ 3.007*LOG(GDPUS)	- 0.4788*D94
T 値	-4.9212	6.7136	-1.484
	0.5483*D98	+ 0.4678*D99	
	1.7839	1.4847	
DW 値	1.6913		
R2	0.8424		

4.1.7 Export Function of Electric Machine

Sample period 1991 to 2004

E17 = -1542.75 – 24.8115*EDFLTR + 0.53917*FDISTCK

T 値 -0.9113 -6.7233 2.9126

	+0.4019*GDPUS	- 755.056*D91
	1.5526	-2.9198
DW 値	2.7233	
R2	0.97835	

4.1.8 Export Function of The Other

Sample period 1992 to 2004

EOTHR = 1991.68 -56.3885*EDFLTR + 0.838954*GDPUS

T 値 1.1928 -4.447 3.1872

+ 3104.56*D92	+ 1692.36*D95
5.047	2.9126
+ 867.959*D01	
1.3244	

DW 値	2.1632
R2	0.8901

4.1.9 GDP Deflator Determination Function

Sample period 1989 to 2005

PGDP = -79.9685	+ 101.831*GAP	+ 0.0071039*M2
T 値 -1.044	1.2983	6.702
	+ 0.4227*MDFLTR	- 14.3324*D89
	4.5916	-2.3462
	- 14.0943*D90	- 8.4267*D01
	-2.2015	-1.3012
	+ 7.1479*D97	
	1.24528	
DW 値 1.50378		
R2 0.9845		

4.1.10 Export Price Determination Function

Sample period 1991 to 2005

EDFLTR = -36.2054	+ 1.46981*PGDP	- 0.007736*FDISTCK
T 値 -2.952	4.547	-1.6422
	+ 26.8584*D01	- 13.1552*D04
	2.4016	-1.1039
DW 値 1.4435		
R2 0.9286		

4.1.11 Import Price Determination Function

Sample period 1989 to 2005

MDFLTR = -25.305	+ 0.4353*EXR	+ 10.349*D89
T 値 -13.032	48.023	2.9845

+ 9.996*D90 - 5.2222*D97

2.8956 -1.6411

- 3.4490*D98

-1.083

DW 値1.5769

R^2 0.9944

4.1.12 Definition of GDP

GDP= PC+GC+GFCF+J+E-M

4.1.13 Definition of Export

E=E16+E17+EOTHR

4.1.14 Definition of Capital Stock

K=0.95*K(-1)+GFCF

4.1.15 Definition of Current Surplus

ENMSMN=E*EDFLTR-M*MDFLTR

4.1.16 Definition of Real Interest Rate

RR=(R/PGDP)*100

4.1.17 Definition of FDI Accumulation

FDISTCK=0.95*FDISTCK(-1) + FDIFRT

4.1.18 Definition of Gap of Demand and Supply

GAP=GDP/POTGDP

4.2 Final Test

This model was run from 1997 to 2004. The calculation converged smoothly with the max iteration of seven. The result of calculation about main variables was shown below. The left is the output of calculation and the right is the observation.

Table 2 Result of Final Test

	GDPF	GDP	Error%		EF	E	Error%
1997	11144.92	11464	-2.78329	1997	8852.012	9437.244	-6.20131
1998	12604.03	12023.1	4.83178	1998	10119.61	9645.037	4.92041
1999	13141.91	12520.2	4.96563	1999	10909.5	9670.269	12.81487
2000	13359.63	13172.1	1.42373	2000	11512.17	9820.3	17.22824
2001	13948.99	13673.8	2.01252	2001	10370.26	9792.74	5.89746

2002	14182.86	14162.8	0.14164	2002	13117.53	10276.93	27.64047
2003	14497.84	14575.5	-0.53283	2003	12948.68	12504.7	3.55058
2004	15914.72	15572.8	2.1956	2004	16186.8	14887.59	8.72679

	E16F	E16	Error%		E17F	E17	Error%
1997	1233.968	1925.198	-35.9044	1997	1648.298	1755.327	-6.09741
1998	2536.583	2536.645	-0.00244	1998	1869.044	1851.847	0.92864
1999	2717.283	2717.345	-0.00229	1999	2305.596	1914.713	20.41471
2000	2043.574	2680.942	-23.774	2000	2937.222	2307.771	27.2753
2001	2244.502	2193.574	2.32169	2001	2648.151	2526.527	4.81388
2002	2479.933	2230.095	11.20302	2002	3940.612	2887.819	36.45636
2003	2846.531	2826.061	0.7243	2003	3906.51	3863.951	1.10143
2004	3474.878	3316.554	4.77375	2004	5069.07	4757.814	6.54199

	PGDPF	PGDP	Error%		MF	M	Error%
1997	72.06374	74.5	-3.27014	1997	8957.787	9557.299	-6.27282
1998	83.2003	83.9	-0.83397	1998	11034.58	10315.89	6.96677
1999	89.32481	91	-1.84087	1999	11753.52	10352.33	13.53505
2000	90.31948	100	-9.68052	2000	12380.62	10327.3	19.88247
2001	103.7138	108.6	-4.49926	2001	10762.73	9964.942	8.00599
2002	103.8018	118.2	-12.1812	2002	13461.07	10666.92	26.19456
2003	116.4861	126.3	-7.77032	2003	13456.05	13349.97	0.7946
2004	120.4759	130.6	-7.75203	2004	16403.2	15402.35	6.49806

4.3 Simulation

The simulation was conducted to understand what would happen if the progress of technology was promoted by 10%. Hungary accepted FDI around 3 billion US dollars every year from 1991 and 4.2 billion US dollars in 2004. It drove this economy. Foreign firms, such as IBM, Nokia, Siemens, and Intel set up institutes for Research & Developments. Hungary became the base for research activity of IT in Eastern Europe. It seems like that such research activities are started to be linked with IT industry, in Hungary. The accumulation of FDI was adopted as the indicator of the progress of technology.

When FDI increases by 10% and the progress of technology is promoted, the export of electrical machinery increases at first. In the reality, when technology progress is promoted, the potential production in this sector increases and the price of this sector decreases, and then the domestic demand and export demand in this sector increase. However, by the restriction of availability of data, it is impossible to estimate an investment function and potential production function for this sector. In this model, the progress of technology is added as the explanatory variable in the export function. It seems that the industry which is taking advantage most from the technology progress is the electrical machinery. By the technology progress, exports increases and GDP increases directory. Because the demand increases, the gap between demand and supply decreases, and the price increase. Then, this increase of the price restrains the increase of export through the increase of export price. Because the technology progress has a function to decrease the export price, it increases the export. This phenomena is also the factor to increase the price, restricting increases of the export and GDP. At the same time, because the technology progress increases the potential production, the gap between demand and supply increases. The increase of gap makes the price and export price decrease, and the export and other demands increase. .

This is the diffusion mechanism of the technology progress. In the next, the result of simulation about main variables is shown.

When the technology is promoted 10%, in other words, FDI increase by 10% every year, the export increase around 5%, and the price decreases by around 10%, and GDP increases by around 2%.

Table 3 Result of Simulation

	GDPI	GDPB	Increase%	EI	EB	Increase%
2005	16485.04	16348.2109	0.84	16027.97	15711.64	2.01
2006	17886.17	17657.4063	1.30	19388.38	18760.9	3.34
2007	19054.49	18722.0742	1.78	21616.69	20678.39	4.54
2008	20289.83	19855.541	2.19	24022.87	22749.57	5.60
2009	21584.58	21054.502	2.52	26606.78	24973.37	6.54
2010	22928.75	22314.7266	2.75	29368.3	27348.34	7.39
2011	24309.23	23630.9941	2.87	32307.84	29872.71	8.15
2012	25708.6	24996.9727	2.85	35427.07	32544.46	8.86
2013	27102.66	26405.0625	2.64	38730.44	35361.51	9.53
2014	28455.42	27846.1328	2.19	42228.23	38321.79	10.19

	E16I	E16B	Increase%	E17I	E17B	Increase%
2005	4181.12	4181.12012	0.00	5393.318	5232.884	3.07
2006	4072.442	4072.44189	0.00	6878.207	6572.633	4.65
2007	4511.918	4511.91846	0.00	7878.507	7426.944	6.08

2008	4981.963	4981.96289	0.00	8939.586	8333.742	7.27
2009	5483.609	5483.60938	0.00	10060.29	9291.643	8.27
2010	6017.888	6017.88818	0.00	11239.53	10299.18	9.13
2011	6585.832	6585.83203	0.00	12476.4	11354.83	9.88
2012	7188.473	7188.47314	0.00	13770.41	12457.02	10.54
2013	7826.844	7826.84375	0.00	15121.96	13604.19	11.16
2014	8501.979	8501.97852	0.00	16533.29	14794.82	11.75

	PGDPI	PGDPB	Increase%	MI	MB	Increase%
2005	141.4351	142.41959	-0.69	15960.32	15665.36	1.88
2006	122.4027	124.68624	-1.83	19403.47	18811.84	3.14
2007	123.4623	127.01743	-2.80	21509.76	20623.59	4.30
2008	123.6995	128.70538	-3.89	23785.38	22580.22	5.34
2009	123.1037	129.74829	-5.12	26231.37	24681.12	6.28
2010	121.6647	130.14848	-6.52	28849.27	26925.45	7.14
2011	119.3695	129.91196	-8.12	31641.77	29312.28	7.95
2012	116.1949	129.04749	-9.96	34613.66	31840.68	8.71
2013	112.0955	127.56558	-12.13	37773.82	34509.87	9.46
2014	106.9778	125.47706	-14.74	41139.28	37319.45	10.24

Conclusion

IT industry is growing rapidly and its scale in production and demand is also very large. In this paper, the recent trend of IT technology has been analyzed. The tradable technology and the technology embodied in labor are in the relationship of competition and it seems like that the dominancy is alternated periodically. It has been understood that the way of Trefler is preferable to the way of Heckscher-Ohlin to explain the trend of IT technology and the technology choice. It has been also analyzed what kind of technology will appear in the near future and how it will affect macro economies.

In the next, Hungarian case has been adopted, and the, the trade structure and the macro economy have been explained. After that, the simulation has been conducted, using macro econometric model. Hungary has a good circumstance in inventions and, recently, IT industry is growing rapidly. Setting up of Research institutes of foreign IT firms and entrepreneuring of venture business are quite often. It seems like that such activities are started to be linked with in the IT industry of Hungary. According to this phenomena, The share of electrical machine in the export is increasing rapidly. It can be said that the tradable technology, not the technology which is embodied in labor, is always chosen in the choice of technology in Hungary. Because the technology progress in this country is closely related to the accumulation of FDI, the accumulation of FDI was adopted as the indicator of the progress of technology. Then, the simulation has been conducted to understand what will happen if the progress of technology was promoted by 10%. As the result of simulation, GDP has increased by around 2% through the adjustment mechanism of the model.

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[1] Intel: Integrated Cooperation
AMD: Advanced Micro Devices

[2] TSMC: Taiwan Semiconductor Manufacturing Company, Limited

[3] UMC: United Microelectronics Corporation

[4] Compared with Taiwanese IT firms, Korean IT firms procure raw materials domestically more. However, Taiwanese IT firms is more advanced in the field of high technologies. Taiwanese IT firms have capacities to have consignments of productions from the United States.

[5] Mr. Gordon Moore, the honorary president of Intel, suggested this law. It is that the memory of IC doubles every one year and half. It is said that this trend will decline within ten years by some specialists.

[6] If we consider the trend of technology, it is rather natural that Moore's law survives seven years from now.

[7] The export means the export of production factor which is embodied in the product.

[8] The correlation coefficient is 0.87.

[9] One nanometer means 1 /1 billion meter.

10 See Figure 1.

11 The author processed the trade data which is from the reported Country, Hungary from UN Com-trade Database which was obtained from on-line. It was proceeded based on AID-XT data which was made by the Institute of Developing Economies.

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