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A COMPARATIVE STUDY ON SOCIAL SYSTEMS OF INNOVATION BETWEEN KOREA AND GERMANY

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Neoclassical economics assumes homogeneity in technological capabilities and institutions among nations. Contrary to that, Evolutionary economics sees their differences in technological, institutional and cultural aspects. Drawing on the concept of Evolutionary Economics as a new idea in the field of Economics, this article empirically investigates the differences or specificities in a social system of innovation between Korea and Germany, including the technological and institutional varieties, especially related to the 'noneconomic' variables. According to the empirical study, it is evident that the systems of two countries are not homogeneous, but quite different and even asymmetrical. From the theoretical point of view, those results highlight the erroneous features of the neoclassical assumption on "internationally homogeneous production functions". Key political implications follow from these results. Firstly, to improve the international economic relationship between Korea and Germany, it is necessary to make a different international cooperation policy from that relevant to, for instance, the United States. Secondly, beyond the strategy of curtailing the labour cost, Korean social system of innovation is required to pay more attention to the strategy of making technological efforts, reforming institutional settings and constructing sociocultural atmosphere based on the cooperation and trust.

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I. INTRODUCTION

Neoclassical economics assumes homogeneity in technological capabilities and institutions among nations participating in trade and asserts that existing technological and institutional differences as 'transitionary by-products' are supposed to

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be cleared out by the law of market and finally converge among countries. Contrary to this point of view, we identify the differences among nations in terms of technological and institutional aspects. "Evolutionary economists" who are paying attention to country-specific varieties have developed the concept of "technological gap", "national system of innovation" and "social system of production". Additionally, they show empirically the enduring existence of national differences.

In principle, this paper is based on the evolutionary view of permanently existing country-specificities. However, I attempt to develop the mixed concept of a "social system of innovation" from their concepts, for in this way I may understand the innovation in terms of a social relationship. Drawing on this concept, I empirically investigate the differences or specificities in a social system of innovation between Korea and Germany, including the technological and institutional varieties, especially related to the 'noneconomic' variables. The empirical study in this paper is based more on the "appreciative" than "formal" method(Nelson 1994)[1]. This is confined to the periods from the end of 1980s to the mid of 1990s, that is, the period prior to the recent economic crisis[2]. In the examination of their clear differences it is reasonable to eliminate the effects of the latest "exceptional" case. I strongly suspect that these specificities should be related with the different economic performances among nations, as shown by many empirical studies. Due to the limited space, however, I confine my work to identifying just the country-specificities in terms of technologies, institutions and cultural aspects. This empirical study on the country-specificities should finally contribute to correcting erroneous neoclassical assumption on "internationally homogeneous production function".

This work is organized in the following ways. The second section introduces the research results from the evolutionary economics, focusing on the topics concerning the country-specificities, and is used to set up the research model. I deal with country-specificities in terms of technological activities, institutional arrangements and the cultural aspects, especially concerning 'innovations'. The third section is devoted to empirically differentiate Korean and German social systems of innovation. To this end, I rely on existing various evolutionary literature about these issues. In the fourth section, I derive the theoretically significant implication based on the work in the foregoing sections, and

[1] According to analytical method, Nelson classifies economic theory into the appreciative and the formal. The former is close to the qualitative and at best statistical, while the latter uses the quantitative and further econometrics method. One would recommend the prevailing econometrics method, but such precision may be inappropriate to the quality of available data. Moreover, it is not required to apply the econometrics method to this research.

[2] In the face of the emergence of new techno-economic paradigm, on the other hand, and considerable social shocks such as German reunification, on the other hand, German economy has reformed the existing system into a new one that is more aware of the radical innovations and flexible production. To remove effects of these recent changes in German economy, it would be necessary to confine the empirical study to those periods. Moreover, it is inevitable due to limits on available resources.

additionally I suggest any political implications concerning the international cooperation between Korea and Germany.

Ⅱ. VARIOUS CONCEPTS ON THE COUNTRY-SPECIFICITIES

For the purpose of the set-up of the model for empirical study, I introduce various concepts on the country-specificities from the evolutionary economics' point of view. It is necessary to survey the literature concerning the technology gap, the national system of innovation and the social system of production. The first term is related to a quantitative specificity, while the last two terms are related to a qualitative one. This section would be helpful to free us from a neoclassical biased view of "representative, homogeneous agents" and to draw our attention to the existence of "different agents", thus being instrumental in realizing the existence of the national specificities.

1. Technology gap between countries

After Leontief suggested his 'paradox', many empirical studies found the relevance of technology-related variables to trade(Krugman 1982). They concluded that technological differences among nations turn out to be a fundamental force which shape 'comparative' advantages. More generally, a recent stream of analysis(Grossman and Helpman 1991) tentatively links trade theory with increasing returns growth theories, which is based on the country-specific knowledge-externality(Romer 1990; Lucas 1988). Despite many limitations, the importance of technology in international trade, the role of technology 'gaps' and the importance of 'various' types of learning have been acknowledged from the start; even neo-classical economists do so(Dosi *et al.* 1990).

Similar to the technology gap theory, evolutionary economics determined the cause of different economic performances in the different national capabilities to innovate, imitate and generally exploit innovation efforts competitively(Dosi *et. al* 1990). This relationship is confirmed by many other empirical studies. Magnier and Toujas-Nernate(1994) for five OECD countries found innovation(proxied by R&D expenditure) to be an important factor in affecting market shares in the long run. Amable and Vaspagen(1995), and Fagerberg(1997) supported these results using patents as proxy for innovation. Dosi *et. al.*(1990) explored some 'stylized' and 'less stylized' regularities in the international distribution of innovative capabilities, international differences in input coefficients and the trends and characteristics of trade patterns. R&D expenditure, major innovations and international patenting are and have remained highly concentrated, with five major OECD countries responsible for more than 94 % of the total in 1987. Moreover, the number of participants to the 'club of innovators' is not only small but also relatively stable through time. These studies allow us to conclude that there are relatively stable and asymmetrical technology gaps among the

nations and, in accordance with that, nationally different 'production functions'. Technological capacities are internationally different, and these differences are not to converge.

2. Different national system of innovation

Much research on invention and innovation had amply demonstrated that many factors other than formal R&D were important for innovative success. Gradually, evidence accumulated that the rate of technical change and economic growth depended more on efficient 'diffusion' than on being first in the world with radical innovation and as much on 'institutional' innovations as on technical innovations(Abramobitz 1986). The institutions of technology transfer which connect inventive results into markets might be more significant than the R&D expenditures itself. Lundvall(1992) takes examples such as interaction with market and inter-firm relationship like user-supplier linkages(Lundvall 1992). Nelson(1988) stresses the linkages of government as a guiding institution and universities as purveyors of basic scientific knowledge to commercial fields. Tylecote(1994) claims that financial institutions and their specific relations with innovation activities play a critical role in the innovation process. The educational system is also not exceptional case. These institutional factors and "bridging institutions" (Dosi and Orsenigo 1988) play a critical role in the overall socioeconomic 'tuning' of the system(Dosi *et. al* 1990) as well as in the process of generation and diffusing knowledge through their various combinations and interactions[3]. In their study on the diffusion of Swedish factory automation, Carlsson and Jacobsson(1993) indicate that what makes Sweden unique, is the existence of well-functioning networks consisting of smaller firms, academic institutions, government agencies, and even more importantly, institutions which provide bridges among these various types of units.

But it must be brought to the forefront that these institutional variables differ from country to country. Abramson(eds.)(1997) identify the national varieties of technology transfer system between in USA and in Germany. Nelson and Winter (1993) and Freeman and Soete(1997) make clear the national differences in some of these variables. All these institutional components contributing to the generation, diffusion and utilization of technology constitute "national system of innovation"(Lundvall 1992) and the ways of their combination are also highly 'country-specific', and impact on the nationally divergent economic performances. The historically shaped national systems of innovation, including the various institutional forms, are not only different but also even contrasted and asymmetric among countries.

[3] Patel and Pavitt(1988) understand innovations as institutional change.

3. Different social system of production

The concept of systems of innovation deals mainly with 'technological' innovation. In principle, I accord comparable importance to innovation in areas such as management, marketing and finance as I do to technological innovation. The definition of innovation includes both technological and "nontechnological innovation". That is in accord with Schumpeter's view[4]. However, the importance of nontechnological innovation has been barely explored(OECD 1996) except in the literature of national systems of innovation as discussed in the previous section.

Even the concept of national systems of innovation does not come to an extensive analysis on the nontechnological innovation. I describe the system by the linkages among its members, and the flows of information and inspiration that flow across the links. Human linkages function best when the interaction is social(Rycroft and Kash 1994), where there is trust and cooperation(Sabel 1994; Lundvall 1993; Lorenz 1992) and where as a result the participants are attentive to one another. It is, therefore, likely that the social quality of a particular connection will affect the innovation process. The specific social relationship originates from the cultural specificities in a certain society, including customs and traditions as well as values. As a result, the cultural environment expressed often by "industrial culture" may also exert a deep effect on the innovation process(Rasmussen and Rauner(eds). 1996). The cultural aspects most closely linked to an innovation system include "culture of cooperation, associative culture, learning culture, experience and ability to carry out or incorporate institutional changes, coordination and public/private consensus, productive culture ....., existing interface mechanisms ....., different types of learning capacity, social valorisation of the use of science, universities linked to the productive system (and) non-bureaucratized educational and training system linked to the productive system ....."(Cooke *et al.* 1997. pp.488). Accordingly, I recognize the importance of social connections and cultural aspects in the innovation process. Concept of national system of innovation is extended by many scholars to the concepts of "social system of production"(Hollingworth and Boyer 1997) implying not only the structure of the state and its policies and the elements in the concepts of national innovation system, but also the conceptions of fairness and justice held by capital and labor; and especially a society's idiosyncratic customs and traditions as well as norms, moral principles, and rules for action. Because the social processes are quite historically specific, resulting social system of productions are necessarily national-specific. They classify the social systems of production into the "social system of mass standardized production" and four

[4] Schumpeter distinguished five types of innovations: (a) introduction of a new product or a qualitative change in an existing product; (b) process innovation new to an industry; (c) the opening of new market (d) development of new sources of supply for raw materials or other inputs; and (e) changes in industrial organization. The last type represents the nontechnological innovation.

possible successors to it like "system of customized production, of diversified quality mass production, of flexible diversified quality mass production and of adaptive production"[5], according to a certain level of technological capacities, flexibilities, institutional arrangements and sociocultural specificities which facilitate cooperation among competitors and stable relationships with high levels of communication and trust among suppliers and customers(Piore and Sabel 1984; Hollingworth and Boyer 1997). The last four systems are named the "social system of flexible production".

They focus more on the social relationships and cultural aspects, while the theory of technology gap tends to pay attention to the technological capacity and the concept of national innovation system highlights the institutional aspect. Although the three systems can be investigated separately, they should be understood from a 'holistic' point of view[6]. The different variables included in three evolutionary concepts are all together interconnected and interactive within a social production system. Noting the sociocultural determination on innovation, I try to reconstruct the concept of the 'social system of innovation', comprising three evolutionary concepts of the technological gap, the national innovation system and the social system of production as surveyed above. This concept may somewhat go beyond the Schumpeter's view that neglects the social and cultural features. The results of three evolutionary concepts are, certainly drawing on their empirical studies, are summarized in the Table 1. Thus, I have investigated the various concepts focusing on the country-specificities. I determined the country-specificities in terms of technology gap, context conditions among institutions, social system of production others than the neo-classical views assuming homogeneous and representative agents. A social system of innovation in a country would belong to one of two systems, or at least a hybrid similar to one of five types. The national-specific social systems of innovation is the result of complex configurations of technological, institutional, social and cultural forces which are deeply rooted in the histories of each society. The in this way complexly intertwined social systems of innovation are not easily transferable from one country to another. As a result, it is unlikely that there will be such rapid convergence as neo-classical economists expect.

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[5] Depending on accumulated technological capacities, technological efforts, technological opportunities and techno-economic paradigm shifts, the social system of mass standardized production is 'evolving' to these four systems.

[6] This view is supported by Parsons(1968) who pointed out that a certain social system consists of the economic, the political, the technological and the cultural sub-system and each sub-system also comprises the economic, the political, the technological and the cultural sub-sub system, and each sub-system appears by way of reciprocal conditioning and interaction and therefore a social-economic system is build in such interactive process among the subsystems.

[Table 1] A Typology of Social System of Innovations(SSI)

Variables	SSI based on Mass standardized production	SSI based on Flexible production
Technological activities	Low	High
Technological output	Low	High
Economic performance	Relatively low	High
Industrial structure	labor- or capital-intensive	Technology-intensive
Size and nature of the market	Large homogeneous markets	More heterogeneous tastes
Technology transfer system	Separated	Interconnected
Financial system	Capital markets well developed; equities are highly liquid, frequently	Capital markets are less well developed, strong bank-firm links, extensive cross-firm ownerships of equities
Technology of the product	Stable and slow to change; not highly complex	Rapidly changing and highly complex
Work skills	Narrowly defined and very specific in nature	Well-trained, highly flexible, and broadly skilled workforce
Labor-management relations	Low trust between labor and management; poor communication but hierarchical in nature; conflictual labor-management relations	Relatively high degree of trust; High social peace between labor and management
Investment in skills by firm	Low	High
Relationship with suppliers	Highly confrontational, rather impoverished institutional environment	Highly cooperative relationships with suppliers in a very rich institutional environment
Collective action	Trade associations poorly developed and where existent are lacking in power to discipline members	Trade associations highly developed with capacity to govern industry and to discipline
Institutional training facilities	Public education emphasizing low levels of skills	Greater likelihood of strong apprenticeship programs linking vocational training and firms

Source: Hollingworth(1997)[7]

[7] To his 'institutional and sociocultural' variables I add some 'technological' variables such as technological activities, technological output, economic performance, industrial structure, size and nature of the market. According to the theoretical and empirical studies of the evolutionary economics, a certain level of the development in technological variables corresponds approximately to that of the development in institutional and sociocultural variables. See Han(2000) for specifications on a logical context among different innovative variables.

Ⅲ. COMPARISON OF GERMAN AND KOREAN SOCIAL SYSTEM OF INNOVATION

In this section I bring to the forefront the specificities of both countries in terms of the technological gap, the institutional arrangement related to technology generation and transfer, and the social system of production including industrial culture and relationships[8]. Quantitative analysis will be carried out for the technological gap in the first part, while qualitative or appreciative ones will be made for institutional arrangements and social system of production in the second part. In spite of many variables discussed above, I am forced to examine only some available variables.

1. Technological difference of both countries

The different economic performances among the countries participating in international trade are primarily caused by their different technological activities which result in building technological gaps among them or their technological capabilities. Technological activities include both the generation and the transfer of technologies. In this part, I make clear the specificities between Korea and Germany in terms of the technological activities and the resulting gap. German figures in terms of absolute amounts of R&D expenditures and research manpower are much higher than Korean ones. The absolute amounts of R&D expenditures and researchers in Korea account for 16 % and 42 % of their German counterparts. Although Korea invested virtually the same amount of R&D expenditure as GDP as Germany did, it did not support its human capital with sufficient money, which indicates that German researchers could be more intensively dedicated to their work than Korean researchers. Korean R&D expenditures per researcher were only 38% of German ones(Table 2).

[Table 2] Indicators concerning technological input

Indicators	Unit	Korea	Germany	Korea/Germany
R&D expenditures(1993)	100 million $	76.6	464.0	0.16
R&D expenditures as a percent of GDP (1993)	%	2.30	2,43	0.95
R&D expenditures as a percent of total sales(manufacturing)(1993)	%	2.06	4.29	0.48
Manpower of science & technology (researchers)(1993)	1,000 Person	98.7	229.8	0.42
Researchers per 10,000 population(1993)	Person	22.3	28.4	0.78
R&D exp. per researcher(1993)	1,000 $	77.1	201.9	0.38

Source: Ministry of Science and Technology(MOST)

[8] Several features of both countries concerning national systems of innovation have been demonstrated by Nelson and Winter(eds. 1993). This study, however, focuses more on sociocultural aspects than that of Nelson and Winter and highlights industrial relations and banking systems. Additionally, it compares both systems directly, while the latter does not attempt to.

[Table 3] Indicators concerning technological output

Indicators	Unit	Korea	Germany	Korea/ Germany
Patent applications(1995)	1,000 cases	96.6	136.6	0.71
Number of scientific and technical papers (SCI Data Base 1995)	1,000 cases	5.8	54.5	0.11

Source: MOST; STEPI

[Table 4] Economic performances of Korea and Germany(1995)

Indicators	Unit	Korea	Germany	Korea/ Germany
GDP per capita	$	10,853	29,562	0.37
Export market shares by total values	%	2.45	10.25	0.24
Productivity	$	23,933	39,794	0.59
Export market shares by tech-intensive sectors	Million $ (%)	46,945 (5.99)	67,819 (8.65)	0.692
Technological receipts	Million $	1,124	10,530	0.11
Competitiveness of knowledge base	Index	42.2	78.2	0.54

Source: National Statistical Office; Korea Productivity Center; MOST; STEPI; BMBF

The differences in variables of technology input caused those in technological outputs. Such two representative indicators concerning technological output as number of patent applications and number of scientific and technical papers in Korea were 71 % and 11% of figures in Germany. The latter indicator has been negligible compared with Germany, which reflects the lack of basic capability to improve domestic technologies(Table 3).

The differences in knowledge base led to differences in economic performance. Gross domestic products and productivity in Korea amount to 37 % and 24 %, respectively. Its international competitiveness does not surpass even one tenth of its German counterpart. Its technology balance is even more dismal. Receipts from technology exports are merely 11% of German ones. Clearly, we can see the existence of nationally different and asymmetrical "production functions". Moreover, national production function in Korea is much less technology-intensive than that in Germany, as indicated by the different shares in export markets of the technology-intensive sectors. In consideration of these factors, the STEPI estimates the indices of competitiveness of knowledge base in 1999 as 78.2 in Germany and 42.2 in Korea(Table 4). To summarize, there have been not only great differences but also asymmetrical distributions in the knowledge base in terms of technological input and performances between Korea

and Germany.

2. Different system of innovation

Many deeply interrelated factors shape the system of innovation in a given country. In addition to the technological activities and the knowledge base, specific styles of innovation concerning allocation of national R&D expenditures and societal goals and priorities as expressed in it and the interaction styles of transfer institutions constitute its specific system[9]. I will investigate varieties in terms of innovation styles and system of technology transfer.

1) Different styles of innovation

I determine here the clear difference in the innovation style as expressed in the technology developing strategy. Korea has chosen a strategy of importing foreign technologies, while Germany has focused somewhat on developing the required technologies domestically. Korea's values of technology exports amount to only 6 % as that of technology imports. They are generally small, compared with the German figure of 49 %. In 1995, public and private shares of total R&D funding were somewhat different in the two countries. German system relies more on the fund sources of government. Table 5 shows the similar features in the R&D performers. The shares of total R&D by companies are 73.2 % and 66.1 % in Korea and in Germany, respectively. Public sector in German innovation system plays a more important role than that in Korea. But the higher proportion of public shares is not always attributable to the dominant role of government. 18.9 % of German R&D activities are performed in the universities and colleges. Universities and colleges contribute considerably to the technological development of the German economy, which is not the case in Korea. Correspondingly, the share of basic research in Germany is much higher than that in Korea. German innovation system spends virtually more than two times volumes on basic research(21.0%), compared with the Korean one. The greater effort to basic research might help Germany maintain the higher ratio of receipt and payment in the technology trade, and follow an 'independent path' concerning the technological development in the future. By contrast, it might not be easy for Korea to be 'locked out of' the 'dependent path', unless it would make greater efforts at basic research.

[9] Types of innovation would play a role in different performances. The transfer system of technology is also of a crucial importance in that it helps actualize potentials of generated technologies. It is evident that characters of transfer system influence the economic performance of innovation. In this paper, however, I will limit the research to investigating only differences of innovation style and the technology transfer system, but not research their on economic performance. Moreover, it is still under discussion how a certain type of innovation affects a given country.

[Table 5] Different R&D strategies in Korea and Germany(Unit: %)

Indicators	Korea			Germany		
Receipts/Payments	0.06			0.49		
R&D exp. by source of funds	Gov't	Private	Foreign	Gov't	Private	Foreign
	22.1	77.8	0.1	37.1	61.1	1.8
R&D exp. by sectors of performance	Research institutes incl. National & pub. and Non-profit	Uni. & Colleges	Companies	Research institutes incl. National & pub. and Non-profit	Uni. & Colleges	Companies
	17.4	9.4	73.2	15.0	18.9	66.1
R&D exp. by character of work	Basic(95')	Applied	Development	Basic(91')	Applied	Development
	12.5	25.0	62.5	21.0	79.0	

Source: MOST; BMBF

[Table 6] Public R&D expenditures by socio-economic objectives(Unit: %)

Sectors	Korea	Germany
Agriculture, Forestry, Fishing	16.9	2.6
Defence	16.9	8.4
Infrastructure	15.9	1.8
Energy	13.0	3.8
Industrial development	11.3	12.7
Health	3.8	3.3
Environmental protection	2.6	4.2
Aero space	2.5	5.6
Earth & atmosphere	1.9	2.6
Knowledge improvement	0.9	52.6
Others	13.6	0.2

Source; OECD data bank(1996)

There are several important differences between the two countries in terms of how they allocate public R&D monies. In Korea, about 34% of all public R&D spending is committed to national defense and fields of agriculture, forestry and fishing and an additional 24.3 % of the total support is allocated to infrastructure and energy. Korea pays the least attention to knowledge improvement. By contrast, agriculture, forestry and fishing and defense claim only 2.6 % and 8.4 %, respectively, of total German public R&D expenditure. A special focus of German public R&D spending is on 'generic technology activities' like knowledge improvement and industrial development, which receives 52.6 % and 12.7 % of public R&D monies, respectively. About 21 % of Korean public R&D support goes toward such activities. This difference reflects a more direct engagement of German research policy in civilian and basic industrial technology (Table 6).

There are sectoral differences and also general similarities in the industrial R&D portfolios of the two countries. The distribution of the Korean industrial

R&D has been heavily concentrated in electronics, semiconductors and motor vehicles. The Korean industrial R&D enterprise has seen a low interest in the share of total industrial R&D accounted for by chemicals and chemical products(1.81%), fabricated metal products machinery and equipment(1.65%). As the empirical studies(Abramson 1997) indicate, for the past 20 years, German industrial R&D has remained concentrated in traditional manufacturing industries in which German firms have long excelled, namely the automotive, electrical and non-electrical machinery, electronic and communication and equipment, and industrial-chemicals sectors.

As indicated in the Table 7, such propensities continue to hold and electronics and precision & optical instrument have big shares also. From the end of the 1980s and the beginning of the 1990s, Germany has begun to accelerate its development in the field of aerospace. Even though based on the insufficient data, the table shows differences in aircraft, chemicals and machinery as well as the similarities in the electronics and motor vehicles(Table 7). These differences in industrial R&D activity seem to be reflected in their industrial exports.

[Table 7] The five highest R&D-intensive industries of the two countries

	1	2	3	4	5	Total
Korea (1996)	radio, television & communication euip. apparatus (5.49%)	Medical, precision, optical instruments (4.58%)	Motor vehicles (4.57%)	Office, accounting & computing machinery (3.98%)	Publishing, printing & reproduction of record media(2.39%)	2.13
Germany (1993)	Aircraft etc. (24.0%)	Electronics (6.45%)	Chemicals & chemical products (6.06%)	Motor vehicles (5.22%)	Precision & optical instruments (4.87%)	3.48

Source: MOST

Overall, the German system of innovation tends to choose the strategy oriented towards basic research and development of domestic technological base, while its Korean counterpart prefers to import foreign technologies and innovation types of applied and experimental development. The German public supports focus on civilian industries and generic technologies, as opposed to the Korean system of innovation which concentrates more on defense and specific technologies. Moreover, it is noteworthy that the universities and colleges play a crucial role in technological activities in Germany. The German system is specialized in the industries of chemicals and chemical products, machinery, precision & optical instruments and recently aircraft, while the Korean one concentrates on the electronics and semiconductors and medical, precision, optical instruments and

also reveals not a few shares in office, accounting & computing machinery. All variables concerning the types of innovation evidently indicate the differences. One might suspect those to lead to the differences in economic performance.

2) Different system of technology transfer

Technological outputs would be of less important if they were not commercialized in the industries. They must be transferred and diffused in the industrial world. To facilitate the technology transfer among research institutes and industry, Germany has developed a specific innovation system in which every member specializes functionally well, but is connected densely.

The large German Helmholtz Centers and large federal laboratories are promoted jointly by the federal government and the state government. Research using large-scale equipment and focusing on specific priority topics is the particular focus of the Helmholtz Centers, of which there are sixteen in Germany. The Helmholtz Centers contribute significantly to long-term pure research in several fields, especially in areas of public interest, through their own projects and as partners of universities and other research institutes. Institutions on "Blaue Liste", including departmental research institutes, and independent state institutes, are characterized as one of the four cornerstones of the common promotion of research of the federal government and the German states. They cover all major fields of natural and social sciences, technology and applied technological research.

The Max Planck Gesellschaft(MPG) is a sponsoring organization with seventy one research institutions, active and represented throughout Germany. The MPG is primarily involved in pure research and near-exclusive basic research in selected areas of natural sciences, social sciences as well as the arts. It promotes new, promising research topics which are not yet adequately represented at universities. The MPG co-operates with universities, for example by allowing them to use their technical equipment. Expenditure amounted to 1,708 million DM for 1995. The MPG has a staff of 11,500, including 3,015 scientists.

Although the primary mission of the MPG is maintaining German excellence in all fields of basic research, the requirement for technology transfer has recently begun to play an increasing role. The society has a special patent and licensing office that actively looks for appropriate industrial partners to exploit the society's research results. In addition, many Max Planck research projects in strategic technological areas, such as biotechnology, material sciences, and organic chemistry, are conducted in cooperation with industry.

The highly networked, semipublic German Fraunhofer institutes conduct primarily applied research and development and pursue the mission of technology transfer to industry. The research orientation is heavily demand driven. Close relationships with universities are institutionalized through the joint appointment of Fraunhofer directors as regular university professors. Thus, the FhG is a significant bridging institution between academic and industrial research which

transfers technology. Other typical channels of technology transfer from Fraunhofer institutes are on-the-job training of graduate students and an active patent policy. In recent years, Fraunhofer institutes have assumed a more active role in the establishment of spin-off companies, a highly effective yet still underutilized instrument of technology transfer in Germany like for-profit "innovation centers". The mission of the innovation centers is to develop the research results of the institutes further to industrial products, and to introduce them into the marketplace. The creation of better links between industry and the higher education sector was recognized in the 1980s by federal and state government as a task for technology policy. Most universities and, in some regions, technical and commercial colleges(Fachochschulen) now have a special office for technology transfer(Schimank 1988)[10]. Korea has no single institutional counterpart(public or semipublic) to the Fraunhofer Institutes and the "An-Institutes". Indeed, most public research institutes do not have their own commercializing functions(STEPI 1998). It is, therefore, very difficult to transfer technologies generated in universities and public research institutes to industries and commercialize them in industries. In companies' opinion, the commercialization is considerably restricted because public research institutes and universities lack the experiences on the spot(25%), are not interested in technology transfers(16%), nor active to publishment of R&D outputs(15%) and finally diffusion institutions are not organized(11%). Bottleneck in the commercialization of technologies generated by public research institutes and universities stems generally from behavioral and institutional drawbacks inherent in the transfer system, but not from the low R&D expenditures of both(Lee *et al.* 1998) and finally "poor interaction" between public R&D and private enterprises(Oh and Masser 1993).

Cooperative industrial research, whereby independent enterprises join together to conduct research projects of common interest, is an important vehicle of technology transfer in Germany. R&D consortia have a long history and a established role in Germany. There are about 100 industrial research organizations, representing 50,000 enterprises, joined under the umbrella organization of the Federation of Industrial Research Associations(Arbeitsgemeinschaft industrieller Forschungsvereinigung: AiF). The comprehensive, institutionalized character of the German AiF appears to facilitate organizational learning among participating industries and consortia. These highly networked, publicly funded R&D institutions and industry-organized R&D consortia are heavily oriented toward the incremental product and process R&D needs of a national industry base

[10] In regard to the specific system of technology transfer, it is noteworthy that in Germany, a specific institutional response to the growing demand for increased technology transfer from academia to industry are the "An-Institutes". An-Institutes are legally defined as independent entities in order to achieve more administrative flexibility than regular university institutes. As a result, they can adjust more easily to the needs of industry. Most of their industrial support takes the form of contracts, not grants.

dominated by technologically mature industries. Korean system of innovation has several similar organizations like council of contracting firms, association of different industrial firms, research association of industrial technologies and non-profit corporate. Their role is limited to the personal, societal meeting, at most the exchange of information. They do not play a role in organizing the research projects or a society for research. Even their research projects are mostly just concerned with economic or institutional subjects and have nothing to do with any projects of researching technologies(STEPI 1998). Inter-firm systems of technology transfer are not so developed in Korea like that of the German case.

Thus, the German innovation system consists of organizations and institutions that are highly differentiated by their own functions and technology area, while also being interconnected or coordinated. The integrated structure and stability of the German system has yielded enhanced communication and cross-institutional learning among organizations, as well as rapid incremental innovation and technology diffusion in several technologically mature industries. German government support of effective diffusion and use of technology by industry is very extensive[11]. By contrast, Korean publicly funded institutes do not have their own well defined, specialized role. Moreover, the Korean innovation system is not as systematically interconnected as the German one. Clearly, there are specificities between Korean and German system of innovation in terms of strategy of technology development and technology transfer.

3. The Social system of production in both countries

In the above section I have examined the existence of the technological gap, the different system of innovation and the social system of production. Based on the surveyed results, I constructed the concept of social system of innovation. In this section I finally identify the national specificity in the social system of innovation, examining the social system of production in both countries. I focus on differences in the industrial relationships and banking systems determined by a specific industrial culture.

1) Industrial relationships

A number of recent political economists have argued that the German industrial relationships based on specific industrial culture such as corporatism, education, histories of banking are key elements in the path to development.

The key to the German industrial relation system and much of the recent success of the German economy is shaped by the highly developed centralized employer and business associations as well as trade unions. Peak association

[11] In 1996, the federal ministry of education and research(BMBF) in Germany spent 190 Million DM on the technology transfer(BMBF 1998).

bargaining, mediated by the state, not only has played an important role in shaping distributional issues but also has played a role of great importance in influencing the quality and international competitiveness of German products. Employer associations and trade unions in Germany have had relatively encompassing and centralized organizational structures. Unions are responsible for collective bargaining and participation - through policies of codetermination - in corporate boardrooms, while elected work councils participate in organizing working conditions to ensure that employment protection laws are followed by employers. In the mid-1980s, among 480 of West Germany's largest companies - amounting to approximately half of the national output - workers and their representatives held approximately one half of the seats on the supervisory boards of firms(Hollingworth 1997). Collectively, these specific arrangements have been instrumental in reducing conflict between labor and management and in enhancing flexible production inside firms.

The job security enjoyed by the workforce, under codetermination policies, has encouraged firms to invest in the long-term training of their labor force. When management realized that it cannot easily dismiss workers in the event of economic downturns, this was an incentive to engage in investment in employees with skills high and broad enough to adjust to complex and rapidly changing technologies and unstable markets. And in Germany, the rigidity imposed by strongly organized industrial unionism and work councils has encouraged firms to invest in more skills and social peace than managements would have otherwise invested in under flexible external market conditions, a process which has directly contributed to a diversified quality, flexible social system of production - the key to Germany's high level of competitiveness in the world economy.

Managers of many German firms were constrained by the system of codetermination(regulated at the plant level by the Work Constitution Act of 1972 and at enterprise level by the Work Constitution Act of 1952, superseded in 1976) which resulted in a high wage system. German firms were forced to become engineering and skill intensive, with diversified and high quality producers. Almost unintentionally, German firms were pushed to develop one of the world's most skilled labor forces(Hollingworth and Streeck 1994; Streeck 1991). The 'social market system' that is organized institutionally operated rather as 'absolute advantage' in international trade.

The peak associations of employers and labor have resulted in an enterprise-based vocational training or apprenticeship program whereby young workers learn the theory behind their trade, the theoretical principle of related trades, as well as rich practical training for particular tasks. In the mid-1980s, approximately 60 % of West German teenager were engaged in such vocational training, which now tends to last three and a half years. Employer's associations and unions have jointly developed different training programs directed to young people who, upon completion of their training, go into more than 400 different occupations

Since 1984, the number of training programs has been reduced to eighteen in order to provide a broad-based and less specialized curriculum, while at same time the level of training has been substantially upgraded. Because of the rich theoretical training that is integrated into their apprenticeship, German workers have a high capacity to continue advancing their training(Hamilton 1987; Streeck 1991). In relation to the theoretical results investigated above, it is particularly noteworthy that German apprenticeship training is executed collectively with unions, business associations, schools, the state and students(Streeck 1989).

With a high level of worker training, German firms are less hierarchical than Korean firms - with workers more involved in both conceptualizing and executing projects. This, of course, has led to a strong emphasis on product quality, which has in turn increased opportunities for long-term close cooperation and trust between assemblers and suppliers in controlling quality and in product research and development[12](Hollingworth 1997). Moreover, the technologically high capability of German suppliers based on the specialized knowledge has also made the cooperation with assemblers possible. The flexible systems of production are unlikely to exist unless they are embedded in national socioeconomic structures that are democratic corporatist in nature. Adequate examples of contemporary societies with neocorporatist institutional arrangements were Germany of the 1980s[13]. Regional and local governmental authorities in Germany have also promoted both a minimization of conflict between labor and capital, cooperation among competing producers and long-term stable relations with suppliers and customers(Zeitlin 1992).

In contrast to Germany, Korea has had a long history of suppressive asymmetrical labor relations; only recently is it on the verge of - even though only to a small extent - a symmetrical relationship between labor and capital. In the long historical process of suppressive and asymmetrical relations, ever tightened by the political power, it was impossible to build the industrial culture of cooperative partnership. Participation of labor in management or codeterminism, just as in the German case, has been thoroughly excluded from discussion.

Chairmen of the 30 biggest "chaebols"[14] in Korea hold about 10% equities and own 34% equities by means of cross-equity investment between affiliated

[12] Product innovations tend to require the flow or exchange of qualitative information between economic actors, and take place in an interaction and therefore interactive learning between users and producers. The process of interactive learning sometimes involving the collective creation of complex new knowledge demands cooperation and trust. They could not benefit from interactive learning if they had behaved, in this case, according to the maximizing and calculating principles, but not to social norms like mutual respect and mutual trust(Lundvall 1993).

[13] Sweden of the 1980s is also a good example.

[14] "Chaebol" is defined as "conglomerate owned and controled by its chairman and his family"(Kang 1999). That is quite different from conglomerates or conglomerate complex which indeed consists of industrially diverse firms, but is not owned and controlled by chairman and his relatives and children. Chaebol is regarded as Korea's specific form of conglomerate.

companies. Because the equities of affiliated companies are actually controled under the chairmen's ownership, chairmen hold 44% equities. With such equity holdings chaebol chairmen actually excercise 100% control over their group-wide operations[15], acting like "emperors". Such control is based on the management style of "fleet of ships" with the assistance of cross-equity investment[16], mutual stockholding etc[17]. Moreover, chaebol owner-chairmen hand over their empires to their children[18]. Most decision making is made by the owners and their families. Professional managers hardly exercise their influence on the final decision making.

The low transparency of corporate management is characteristic of Korean firms. Currently, shareholders have no voice in setting the dates and venues for meetings and must attend them in person to vote on the firm's major policy decisions. The current business law requires shareholders to own more than 3 % of the total stake of a firm for a period of more than six months to request the firm's accounting information. Most Korean firms do not provide their corporate data in English for foreign investors. Not only workers and professionals but also small shareholders are unable to participate in the process of decision-making. Instead of codetermination and participation, Korean specific industrial culture including the family-controlled structure, the arbitrary decision and the autocratic management system prevail in Korea. Additionally, it is noteworthy that the Korean government established the anti-communism as the first national policy in the constitution. The ideology of anti-communism embedded in the Korean social system of production has considerably contributed to this specific industrial relation. The ideology of anti-communism in Korea played a similar function to that of social partnership in Germany ideology, though their contents and social-economic results are quite different.

Although it is generally accepted that a high level of education contributed to the rapid economic growth, a considerable amount of education investment is expended by private Korean households. The Korea Development Institute reports

[15] As a specific example, Samsung Group chairman Lee Kun-hee's group wide control is based on his family's 66.7 % stake in Samsung Everland and 4 % stake in Samsung Electronics. Samsung Everland controls Samsung Life Insurance, which holds equities in many major Samsung companies ranging from 4.7 % to 43 %. Of course, equities hidden under the names of company executives are not included in these amounts.

[16] The cross-equity-investment is not only characteristic of Korean system of production. In Germany as well, the share of cross-equity-investment between companies in 1996 amounted to 42 %. But German companies are different in that, according to the industrial culture of codetermination, they are controlled by banks, and managements participation of employee and audit committees.

[17] These schemes also enable chaebols to provide support to weak subsidiaries, which has resulted in a considerably inefficient allocation of national resources.

[18] Samsung Chairman Lee Kun-hee's 31 -year-old eldest son, Jae-yong, has been called heir-apparent to the Samsung throne, while the late SK group Chairman Chey Jong-hyun's eldest son, Tae-won, is delaying his ascent to the post of group chairman.

that the average annual tutoring fees for Korean elementary, middle and high school students amount to 12 to 16 % of the per-capita GDP, are about three to four times as high as those for their Japanese counterparts. This has provided disincentives for Korean firms to invest in worker training[19]. Despite the huge spending on tutoring, Korean students lack 'original thought and creative skills' which are essential for the social system of flexible production. Moreover, Korean employers are very disinterested in investing in the diversified skills of their workers[20] because the current technological system, demand structure, labor market[21] and unions in Korea have not required it.

Korean relationships between assemblers and suppliers could be regarded as somewhat stable, but the stability is maintained by dependent[22], and moreover unfair relationships. Many small and medium-sized suppliers except for only a few large ones are highly exploited by big assemblers by way of the 'unfair trade practices' like issues of long-dated bills or underpricing of supplied components. 55.7% of small and medium-sized firms were paid for sales with bills, but only 29.4% with cash. The settlement was completed after an average of 99 days. 39.2% and 40.2% of suppliers had to wait for the settlement from 90 to 119 days and more than 120 days in 1996, respectively. It must be stressed that it had taken 37 days even to receive these long-dated bills. It takes thus a total of 136 days to be paid after sales(Small & Medium Business Administration 1999). The long-lasting subcontracting system exploiting small and medium-sized firms, based on relatively "asymmetrical power relationship" (Lundvall 1993) has not weakened, but rather strengthened recently. It is extremely difficult to verify in Korea the existence of a cooperative industrial culture between assemblers and suppliers, based on the reciprocal dependence and trust

2) The banking system

German securities industries have been less developed, with the result that banks have long been more important than equities and bond market in supplying capital. Moreover, banks have also been important in exercising the

[19] According to the report by Korean association of managers(1993), 41.0% of Korean firms regard investing in vocational training as negative, while only 34.1% of them regard it as positive. Only 16.3% of firms under an obligation to enforce the vocational training actually did so.

[20] 60.0%, 92.0% and 86.7% of respondents do not perform any advanced, reorientation and reprofessional training respectively(Korean association of managers 1993).

[21] Large firms have an excessive labor force, while small and medium-sized firms suffer from the high rate of job separation. Such characters do not give the firms any incentives to carry out the labor training.

[22] In 1996, subcontracting firms provided 83.6% and 46.3% of total outputs to their assemblers and their main assembler, respectively. Volumes supplied to the 'main' assembler amounted to 55.4% of total volumes supplied to their all assemblers(Small & Medium Business Administration 1999).

stock voting rights of a substantial proportion of outstanding shares of the country's large firms. For example, the banks have played the role of checks and balances by way of cooperating firms and monitoring the business strategy and performance of companies.

Because banks have been so important in these two roles, bank officers have long served on the supervisory boards of hundreds of large companies and have even served as board chairmen of numerous firms. This type of long-term relationship between banks and firms has encouraged firms to be immune to short-term fluctuations of the price of equities and to take a long-term perspective concerning their industry needs. This capacity on the part of management has meant that German firms have had more incentives to engage in the long term development of products and have been less likely to lay off workers during a modest economic downturn, as has so often been the case with their American competitors who have been more constrained by short-run fluctuations in the financial markets. Even the argument for the "declining" importance of banks in coordinating German economy(Deeg 1992) does not recognize that holdings by very large banks of shares in major firms and the cross-share holdings among the major firms still contribute to the stability in the management of German firms and to the deterrence of the hostile takeovers in contrast to the market and volatile pattern of ownership of large American firms(Vitols 1995).

Korean banks are controlled strongly by government. Because political powers have colluded strongly with chaebols through the "political fund", Korean banks are not free from the economic interest of industrial chaebols who have connections with political power. Additionally, chaebols are strongly linked with the large banks through educational and regional relationships, which is often called "crony capitalism". Under this specific structure, banks cannot afford to manage their assets according to economic principles and autonomy, so that they have to take on huge amounts of non-performing loans[23]. They could not play a role of checks and balances against industrial capital based on the cooperative culture, like in the German case. Rather, they have been checked and controlled by government and chaebols.

The so-called "second" financial institutions like investment trust companies, stock companies etc. have been recently established. The five biggest chaebols owned 39 financial institutions in 1999. This means also the "second" financial institutions are more strongly controlled by the chaebols and have served as their own "private cashbox". The Korean financial system might not be different from German one in that they have long-term, stable relationships between large firms and banks. However, they are dissimilar to German ones because large

[23] According to OECD criteria, the volume of non-performing loans amounted to 32 trillion won in September 1997 and 8.1% of total loans. 14 banks could not fulfil the BIS condition(OECD 1998).

Korean banks and the "second" financial institutions are strongly controlled, respectively, by central government and by chaebol owners. Their long-term relationships are based not on cooperation and trust according to democratic procedures, or at least market principles, but on political collusion, the asymmetrical relations and finally the bureaucratic and arbitrary culture. These specific characters lead to corruption, irrational capital portfolio like overinvestment or doubled investments. The Korean long-term and stable relationship between industrial firms and financial sectors led to the loss of Korea's competitiveness, in a different manner from the German one.

In conclusion, the characteristics of the German social system of production include: a social configuration of a host institutional arrangements which complement one another; a workforce that is broadly and highly qualified, a codeterminating education and management system, a financial system with close ties between large firms and banks, a high degree of stable and long-term relationships between assemblers and suppliers, powerful peak associations and state which enable the social partnership, a high degree of social peace, especially based on the industrial culture such as the somewhat cooperation and trust

[Table 8] Summary of specificities of Korean and German system of innovation

	Korea	Germany
Technological activities	Middle	High
Knowledge base	Middle	High
Economic performance	Middle	High
Innovation strategy	Applied, private, specific,	Basic, public, generic
Three most R&D-intensive Industries	Electronics, semiconductor, Vehicles, Medical, precision, optical instruments	Aircraft, Electronics Vehicles,
Transfer system	Less specialized and separated	Well specialized and interconnected
Labor relationship	asymmetrical, opposing	Cooperative, trusting Social partnership
Labor skill	Semi- and rigidly skilled	Highly and broadly skilled
Management	Arbitrary, autocratic Family-controlled	Codetermination, Participating
Inter-firm relationships	Exploitative	Cooperative, stable, trusting
Banking system	Government- and Chaebol-controlled	Independent Cooperation with firms
Social system of production	Mass standard production	Diversified mass production

among economic agents. All of these institutional arrangements and cultural specificities are intertwined and together with the technological gap and the elements of national innovation system constitute the specific social system of innovation which, concerning the production mode, draws on the social system of diversified mass quality production, in any case one of various systems of flexible production. The key to the success of German industrial sectors might result from these "absolute advantages"(Dosi *et al.* 1990) specific to such social system of innovation. The Korean social system of innovation which has greatly contrasting features in terms of the aspects described above, would be similar to that based on the system of mass standardized production. I summarize the investigated results as the Table 8.

Ⅳ. TEMPORARY CONCLUSION

In this final section I will determine some theoretical and policy implications of this study. I have tried to determine the differences in the social system of innovation between Korea and Germany including the technological gap, national system of innovation and social system of production. As a result, it is evident that the systems of two countries are not homogeneous, but quite different and even asymmetrical. From the theoretical point of view, those results highlight the erroneous features of the neoclassical assumption on "internationally homogeneous production functions". Korea has had a less technology-intensive, interconnective innovation system and less cooperative social system of production than Germany. Considering those technological and institutional conditions and industrial culture, Korea still belongs to the social system of innovation based on the mass standardized production or, at best might be on the verge of the diversified mass production system. On the other hand, Germany would be at least classified into the social innovation system of diversified mass production, which certainly stems from the more technology intensive industrial structure, the more developed institutional networking and cooperative, trusting culture.

From these results we might draw some political implications. Firstly, prior to constructing a policy improving the international economic relationship between Korea and Germany, it is necessary to identify the national differences in the social system of innovation. The presumed cooperation policy with Germany must be different from that with, for instance, the United States. Generally speaking, we should make different international cooperation policies according to technological, institutional and sociocultural specificities of each country.

Although we still do not come to any significant conclusion concerning correlations between economic performance and specific institutional settings of innovation and industrial culture, this empirical study on the different experiences of partners might suggest that the specific features of social innovation system have caused the different economic performance. The institutional and cultural specificities as well as the technological excellence in the German social innova-

tion system might have a positive effect on economic performance. Therefore, secondly, we might be motivated to learn some useful lessons from the German system and adapt them specifically to the Korean system. Beyond the strategy of curtailing the labour cost, Korean social system of innovation is required to pay more attention to the strategy of making technological efforts, reforming institutional settings and constructing sociocultural atmosphere based on the cooperation and trust. This may be a method of reforming the inefficient path which led the Korean economy to the current economic crisis.

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