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국가정보화가 국가경제 성장에 미치는 영향분석
– 패널데이터 분석을 중심으로 –

진 상 기*, 조 정 문**

요 약 본 연구는 국가 경제발전에 있어 이론적으로 중요시되고 있는 국가 정보화 요소가 실제로(Empirically) 국가경제 발전에 영향을 미치는 지를 통계적 검정을 통해 밝히고자 '수요공급균형모형' 에 따라 IT 공급 변수, IT 수요 변수, IT 정책(투자) 변수로 연구 모형을 구성하였다. 더 나아가 경제적, 사회적으로 강조되고 있는 국가 발전 중요 요인들을 조절변수로 설정하여 국가정보화 변수의 종속변수에 대한 조절효과의 여부 및 그 의미를 교차분석을 통해 보여 주었다. 이를 통해 본 연구에서는 정치적 사회적으로 국가발전에 중요한 요인으로 강조되었던 국가 투명성과 소비자물가 변화, 국가교육지수가 국가정보화 변수가 국가경제발전에 미치는 효과를 조절하고 있음을 알 수 있었다. 즉 독립변수인 국가정보화가 국가경제력 발전에 긍정적이고 효과적인 기여를 할 수 있도록 하기 위해서는 국가투명성을 제고하고, 소비자물가를 적정한 수준에서 관리할 필요가 있음을 분석 결과 알 수 있었고 국가 경제력발전에 있어 정보화 교육이 지식정보사회에 있어 매우 중요함을 통계적으로 밝힐 수 있었다. 마지막으로 향후 지식정보사회에서 개별국가들이 국가경제발전을 도모하기 위한 국가정보화정책을 수립함에 있어 참고해야 할 정책적 시사점을 도출해 봄으로서 연구를 마무리하였다.

주제어: 패널데이터 분석, 국가정보화, 국가경제발전, 국가 투명성

An Analysis of the Impact of National ICT Development on Economic Growth

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Abstract This paper attempts to empirically verify the theoretical assumption that ICT factors actually affect national economic development. To this end, this study uses a research model, 'balance model of supply-demand', which consists of IT supply, IT demand and IT policy dimensions. Also, this paper employs several socio-economic factors such as 'size of population', 'consumer price increase', 'national transparency', and 'education' as the moderating variables. The result through the panel data analysis finds it statistically relevant to relate the ICT capacity to each country's economic growth. Also, the study finds that moderating variables were highlighted as important elements of national development: these variables actually moderate the ICT capacity's effects on each surveyed nation's economic growth. Finally, this paper suggests policy implications that nations should consider when developing national informatization policies to drive national economic growth.

Keywords: panel data analysis, national ICT capacity, national economic development, national transparency

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I. Introduction

Northrop, et al.(2000:3) indicates that the information revolution[1] is recorded as one of the most fundamental changes after the industrial revolution that has swept throughout human history. Pool(1983) explains the impact and importance of the information evolution by comparing it with the discovery of printing technology(Hudson, 1997: 17). The effects of information evolution reach a whole range of our life, bringing changes in the role and scope that the government, enterprises and individuals play(Jin, 2008). There is a mixed view of optimism and pessimism regarding the IT-led paradigm shift in human history. Thus, this issue has been subject to intensive controversies in multiple areas since 2000. Some papers made a negative pitch on information divide and Internet abuse or misuse (Haywood, 1998; Schiller, 1966; Loader, 1998; Wresch, 1996; Perelman, 1998), whereas other papers shed a positive light on IT-initiated national economic growth, and its subsequent improvement in the quality of individual lives(Kim, 2009; Naisbitt, 1982; Kraemer, et al., 1999; Negroponte, 1995; Toffler, 1990).

IT has been perceived from the development economist and industry-economist point of view as a new production value system that can drive national economic growth. Under this circumstance, IT has become a subject of discussion on how IT influences a nation's economy. These circumstances attest to the need for conducting empirical studies on the effectiveness of IT revolution that has expanded throughout the world since the 1980s. Although there were some previous studies about this topic, it is necessary to have an in-depth study on this issue since it has been nearly 30 years since ICT began to impact human history.[2]

It has become necessary to design a research model that considers time variable(Moshe, 2010; Parsons, 1976), in particular when state policies are studied.

When we consider the unique nature of state policies that includes social context(Lasswell, 1971; Huh, 1998), no analysis can produce accurate and complete findings without a comprehensive coverage that includes not only IT polices but also non-IT policies such as socio-economic aspects(Lasswell, 1971; Huh, 1998). In this vein, this paper attempts to assess the impact of ICT capacity on national economic growth. To this end, statistical and empirical verification of the IT sector, which

1) It may refer to knowledge revolution following neolith revolution, ancient agricultural revolution and industrialization revolution from the civilization history perspectives(Kwon, 2000: 30-38). Information evolution refers to the process of rapidly lowering prices for information process and information exchanging price as a result of the accelerated technological progress in computer, communications, softwares, etc.(Kamarck, et al., 1999: 200).

2) The theological arguments over the information divide have been conducted by scholars who have positive versus negative perspectives on the information society. Those who have positive view on the information society-Negroponte, Naisbitt, Toffler, Wurman, Godfly, etc.-assert theories on reducing the information divide. These scholars tend to have technology-centered perspectives. In contrast, those who have negative view on the information society-Schiller(1996), Loader(1998), Wresch(1996), Perelman(1998), Haywood(1998)-assert that the more advanced the information society is, the more inequal the society will become in using information media(Kim, 2009: 14-16).

is considered important factors in the national economy, is performed. Also, it uses a panel data analysis method-which can analyze both longitudinal and cross-sectional effect at the same time-and examines the issue with time variable on the vertical axis. This paper adopts a simultaneous analysis of 128 countries for the cross-sectional effect, which may go beyond the single-case analysis and thus strengthen the generalization of the research results. Through this method, this paper focuses on the analysis of impact of IT on national economic growth.

Ⅱ. Literature Review and Theoretical Context

1. Analysis of Literature Review

The literature review finds that it takes one of two research methods to examine how the ICT development affects national competitiveness and national economic growth. One method is to take a longitudinal approach for time series analysis. This method considers chronological time flow in examining how one variable is correlated to another. The other method is to take a cross-sectional approach that involves multiple countries; the major purpose of this method is to target multiple countries and to find a cross-country structure in which ICT progress affects national competitiveness or national economic growth.

Meanwhile, the longitudinal approach chooses one single country as a case to examine how the ICT development is related to national economic growth during a particular period of time. In this approach, the analysis method is usually the statistic time series analysis and descriptive case study as illustrated by the cases as follows.

Cisco(2003) uses time series analysis to explain that investment in the IT sector has positively affected the economic growth of England(1992-2000). The positive impact of the IT investment was found to be particularly evident in the job market, which was achieved through human capital restructuring. Similarly, Chu(2005) finds that profit generated by New Zealand's IT service sector is positively correlated to GDP growth during 1987 through 2001.

Pohjola(2001) regresses GDP growth rates on a number of independent variables to find that three knowledge-related variables-education, openness to trade, and the availability of communications infrastructure-are positively correlated to GDP growth. Likewise, analysis result by Bruinshoodf, et al.(1998) with OLS suggests a positive correlation between a sector's R&D intensity and the wage premium that white-collar workers have over blue-collar workers. Similarly, Morissette, et al.(1998) finds via OLS estimation that IT application users tend to generate more income than non-users.

The literature review finds that most of the preceding papers use one single country as a case to illustrate. Therefore, these previous studies are usually found to be too shallow to support the generalization of their findings.

Therefore, this paper broadens a horizon by involving 129 countries worldwide in order to overcome the limitation of preceding papers that resulted from their limited coverage of a single country as their study subject.

The other method is a cross-sectional approach to find relationship between ICT progress and national competitiveness(including economic growth). The major purpose of the cross-sectional approach is to support the generalization of its findings on mutual relationship between these two variables. Therefore, the analysis involves multiple nations to examine how ICT development is mutually related to national economic growth. Most of these studies use statistic analysis such as analysis of mutual relationship.

To conduct comparative studies on national ICT level across countries, Northrop, et al.(2000) examines relationship across elements of economy, social infrastructure, and information infrastructure(Garson, 2000a: 256-280). These studies have a limitation in that their coverage is confined to computer penetration and they do not take a comprehensive conceptual approach.[3)]

However, these studies present the 'path model' : They use multiple regression analysis and path analysis in studying factors that affect cross-country differences in terms of computer penetration. This way, they can identify the path over how these factors are related to each other. The analysis result finds the information infrastructure to be the biggest impact on each country's computer penetration, whereas it also finds GDP and social infrastructure to be the largest impact on information infrastructure.

One paper after another has studied how a nation's economy can benefit from ICT progress. First, NIA(2011) suggests that there is a positive mutual relationship between ICT and national competitiveness through its study on how ITU's cross-country ICT status is correlated to WEF(2010)'s indicator of national competitiveness. Second, OECD(2008) conducts a study of 19 countries over how broadband penetration in these 19 countries is related to their real-term GDP growth. In doing this, labor productivity is designated as mediator variable to study and find that these two variables are positively related. Third, GITR(2010) conducts a regression analysis on how GDP growth is related to broadband penetration. The analysis finds that a 10% increase in broadband penetration results in GDP growth of 1.20% to 1.40% each year. Besides these statistic studies, ITU(2010) defines ICT capacity as an efficiency parameter of technology change that leads to the revolution of production & logistics process and decision-making process. This way, ITU stresses the importance of ICT as a key factor to improve national productivity and to strengthen the national economy. Finally, Japan's Ministry

3) Huntington(1996) regards computer ownership as the most important factor for modernizing country. Northrop, et al.(2000) gets an idea from Huntington and conducts a research whose coverage is limited to the number of computers owned.

of Internal Affairs and Communication(2009) supports the positive relationship between ICT investment and national economic growth when it considers the positive impact of each country's ICT investment on their industry for example, the improved efficiency and competitiveness (see 〈Table 1〉).

However, these studies have a limitation in that their approach narrowly focuses on relationship between GDP and IT infrastructure (e.g. broadband penetration and IT hardware penetration). Previous studies are also found to lack depth as they take a time-flat approach without taking into account time-lag factor. In fact, it is easy to overlook a time-lag factor in conducting researches for the purpose of policy-making. When a particular factor is brought into consideration at a particular time(t), it takes time before this input becomes an output as a dependent variable.

Against this backdrop, this paper is meaningful in three aspects. First, this paper attempts to analyze what are the characteristics and problems of the analytic methods that preceding papers have used. Second, this analysis on preceding papers is a basis for taking a next step to overcome such a limitation that its preceding papers show. To do so, the paper chooses to use a cross-country analysis that involves 182 countries that belong to ITU. Third, this paper diverges itself from preceding papers in terms of its time factor; it takes into the time-lag as one of the major factors by using panel data that have been stored up during a 28-year period of 1980 through 2007.

〈Table 1〉 Summary of Literature Review

Methodology	Author	Outcome
longitudinal study	Cisco(2003)	positive
	Chu, Nancy(2005)	positive
	Solow(1987)	none
	Carr(2003)	none
cross-sectional study	Pohjola(2001)	positive
	Bruinshoodf, et al.(1998)	positive
	Morissette, et al.(1998)	positive
	NIA(2011)	positive
	OECD(2008)	positive
	GITR(2010)	positive
	Parsoms, et al.(1990)	negative
comparative study	Northrop, et al.(2000)	positive
	ITU(2010)	positive
	Japan's Ministry of Internal Affairs and Communication(2009)	positive
	OH(2010)	positive

2. Theoretical Review

1) Theory on National Competitiveness and National Economic Growth

National competitiveness has been defined from multiple perspectives by various institutions. They include ECD, EU(Competitiveness Advisory Group), U.S.A.(U.S.Competitiveness), U.K.(Competitiveness White Paper), IMD(The World Competitiveness Yearbook), WEF(The Global Competitiveness Report), UNDP(Human Development Index), and Japan Center for Economic Research. In this regard, the following chart also shows us how variously national competitiveness can be defined. These definitions can be summed up into two basic elements: One is the nation's totalistic competence from the econo-industrial perspective, and the other is the national competence that drives a country's mental, institutional and technological convergence and communication(Tyson, 1992).

National competitiveness as defined from multiple perspectives can be quantified and expressed in numerical value. So can it be mutually compared. Besides, many studies use it as a conceptual basis that involves an intrinsic concept of evolutionary direction. The following chart shows that each definition of national competitiveness draws out its respective set of measurement factors to be quantified and described. Although many controversies arise about the measurement variables, GDP is used as a major measurement variable that represents a nation's total productivity in assessing a nation's competitiveness.[4)]

Reflecting this position, Porter(1990: 543-573) explains the development process of national competitiveness by dividing the process into four stages. First, there is a factor-driven stage where factor input makes productivity improve. At this stage, most countries are shown to start economic growth. The second stage is an investment-driven stage where countries or enterprises are classified into different categories depending on their willingness and ability to invest aggressively. At this stage, countries or enterprises are classified into different categories according to whether countries are actually capable of embracing foreign technology to use. The third stage is an innovation-driven stage where enterprises reach a certain level of being capable of creating on their own as they move beyond the level of introducing advanced technology. At this stage, the government intervention decreases, whereas the private-sector drive increases to revolutionize society.[5)] Finally, there is a wealth-driven stage that engages

4) Economic growth factor is the most important measurement factor of national competitiveness. Besides this, the national competence is also stressed as another important factor that leads mental, institutional and technological communication and convergence. To explain it, national transparency, education, price increase are used in common as measurement variables by OECD, EU, U.S.A., U.K., IMD, WEF, UNDP, Japan Center for Economic Research. Therefore, this research uses them as moderating variables for its research model to examine mutual relationship between ICT progress and national economic growth. It will later be explained again in the next part of moderating variables.

5) It explains that Italy or Japan completed the third stage in the 1970s.

nation to distribute and consume the amassed wealth. At this stage, a country or enterprise reduces willingness to take risk or lessens awareness about competition, resulting in a drop in national competitiveness. At this stage, the major purpose of investment changes from capital accumulation to capital preservation.[6] To sum it up, the core message from the development strategies of national competitiveness by Porter(1990) lies in the development process of societal cohesion that comes true by undergoing three stages: National economy grows, investment is made to support the growth, and wealth is redistributed to preserve capital. Reflecting similar position, various papers made theoretical assertions

〈Table 2〉 Concept of national competitiveness as defined by major institutions

Institutions & Sources	Conceptualization of national competitiveness	Features
OECD	Each country's level of increasing their people's real income by making it possible to produce goods & services as required by world market in a free, fair market conditions.	Concept of national competitiveness from a long-term perspective
EU *(Competitiveness Advisory Group)*	Indicates the element of productivity, efficiency and profitability that serve as a source of power to enhance quality of people's life and social welfare.	To improve productivity at the national level
U.S.A *(U. S. Competitiveness)*	A nation's capacity to increase real income for all Americans by producing high value-added products and services as required by the world market.	To increase national innovative capacity
U.K *(Competitiveness White Paper)*	The capability to support enterprises and stimulate their innovation, the collaboration through which enterprises gain a competitive edge, and the competition to be promoted, etc.	To emphasize the government's new role
IMD *(The World Competitiveness Yearbook)*	A nation's capacity to provide an environment in which enterprises active within its territory can remain competitive both at home and in the world market.	To highlight a nation's ability to support enterprises
WEF *(The Global Competitiveness Report)*	A nation's capacity to sustain high level of per capita GDP growth rate, and also a set of nation's institution and economic policy that supports mid-term economic growth rates.	To value survey data on institutions & policies
UNDP *(Human Development Index)*	An individual nation's capacity to grant a decent quality of life that its people can lead substantially.	To enlighten quality of life away from traditional focus on economy-only growth
Japan Center for Economic Research	Potential economic power is not seen as the result of economic growth but as future economic potentials. Thus, it means whether a nation has capacity to nurture its future competitiveness.	Only hard data are used to assess competitiveness

Source: SERI(2001: 5)

6) England was at this stage in the 1980s.

that national economic growth is a driver behind national competitiveness on the ground that a nation's economic growth is seen as a core element of enhancing a nation's competitiveness (see 〈Table 2〉).

Antonio, et al.(2009) have shown statistically verified factors that play major roles in a nation's economic growth. In the research, they identified the key elements of economic growth: education, population growth, natural resources, size of government, openness to trade, market access, inflation, age structure, war and conflict, and size of the economy. This approach is a departure from the traditional model that focuses on economic factors to explain economic growth. The traditional model assumes economic growth as production function, Y=F(L,K.T). This theory outlines disciplined labor, capital investment and technology progress to be the key drivers of national economic growth(Hicks, et al., 1977; Kaldor, 1956; Pasinetti, 1977; Samuelson, 1978).

Meanwhile, there is an alternative economic growth theory that includes socio-economic factors(e.g. regulation, corruption,[7] education, ethics, etc.) as new factors to influence the growth($Y=F(L,K,T,S)$). This alternative model offers "S" as socio-economic factor and asserts that it needs to add non-economic factors like socio-economic variable onto the traditional model's economic factors in order to better explain economic growth(Jalilian, et al., 2007: 1-5; Nicoletti, et al., 2003: 1). In this model, corruption is singled out as a major obstacle to economic growth, and corruption-caused hindering factors have been statistically verified(Pak, 2002; Stiglitz, 2000). Zdenek, et al.(2002) assert in their paper that national transparency is a major factor that impacts inbound foreign investment and such FDI(Foreign Direct Investment) will in turn again impact the economic growth. In this regard, Keefer, et al.(1997) stresses that national economic growth is affected by government efficiency and corruption.

2) Relationship between ICT and National Competitiveness

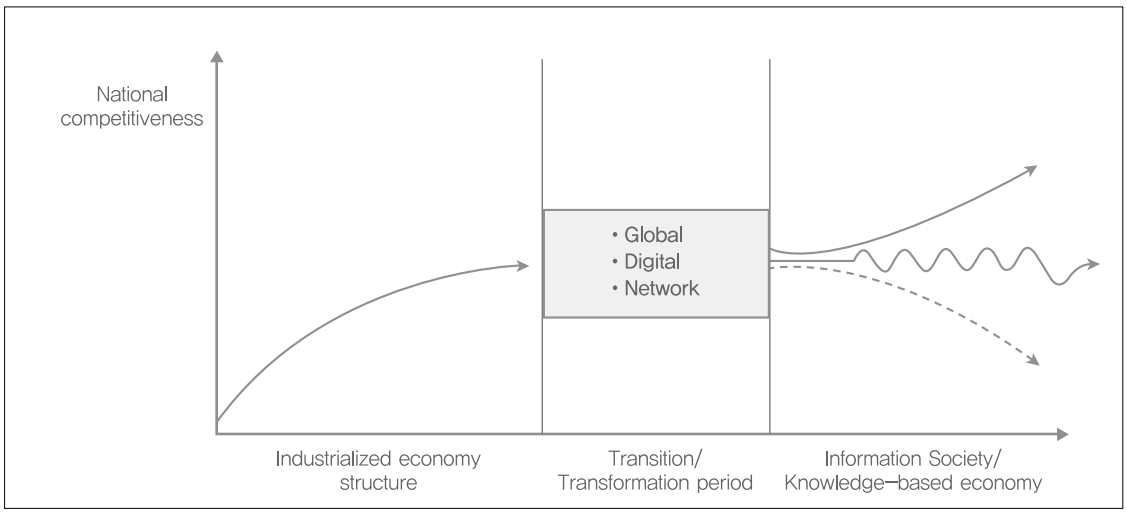
There are assertions of 'the paradox of productivity' (Solow, 1987; Parsons, et al., 1990; Carr, 2003) that, despite a rise in investment in ICT capacity, the productivity of an enterprise, an industry or a nation does not increase in proportion to the rise in ICT investment, or it could even drop. On the other hand, however, there are assertions from multiple sources that ICT investment positively affects national economic growth and national competitiveness by improving labor productivity or organizational efficiency. These theories about how ICT is related to national economic growth can be classified into two groups: One group of theories from

7) Klitgaard(1998) defines the corruption as deviation from official duty or violation of rules in order to gain monetary and status income. Transparency International (TI) defines the corruption as the abuse of entrusted power for private gain.

the national perspective and the other from the individual perspective. First, the assertions that have been made from the national perspective can be summed up that ICT progress is a driver to trigger a paradigm shift of a nation's production structure by enhancing the nation's overall productivity and competitiveness. This position is showcased by 'the four-step theory of national development' as asserted by Porter(1990: 543-573).

In the 〈Picture 1〉, the 'accumulated relationship between ICT investment and economic growth' is used to explain how national competitiveness reacts to knowledge-based economic environment. In this position, attention is paid on whether ICT investment leads to an increase in productivity and new technology adoption, whether ICT investment leads to a rise in employment and consumers' efficiency, and whether ICT investment has improved corporate management performance. This position is represented by Johnson(1992) that bases technology evolution as a determinant of economic growth and national competitiveness. Based on this, Johnson regarded mutual reaction among individual subjects as a force to achieve national development and determine national competitiveness through technology revolution. Kraemer, et al.(1999) also shares the same view through nation-to-nation studies that there is a virtuous relation or accumulated relation between ICT investment and economic growth. Such a virtuous circle can also be explained by static/dynamic economies of scale, as introduced by 'descriptive economics'.

SERI(2008) asserts that ICT investment leads to improve productivity through 'static economies of scale (e.g. the 'informatization' of industries),' and 'dynamic economies of



Source: SERI(2001: 3) data edited

〈Picture 1〉 Direction of national competitiveness to pursue in information age

scale[8] (e.g. industrialization of information).' The 'static economies of scale' refers to the economic effects to benefit each industry and each enterprise in the form of reduced cost and increased flexibility to produce high-quality products as a result of spreading ICT across industry and enterprises. The ICT use enables each industry and each company to more efficiently use production facilities and input factors than before so that they can reduce unit cost. Reflecting this position, NIA(2011) regards ICT development as a significant technology change that leads to an efficiency rise in capital element and labor element, both of which are input elements of productivity. He stresses that as these input elements are positively related to an increase in efficiency, these elements eventually cause the overall productivity to rise for the overall national economy.

Meanwhile, the 'dynamic scale of economies' refers to the improved productivity to benefit enterprise and industry, which appears as a result of increased social labor division and know-how accumulation. This position is reflected by ITU(2010) that mentions ICT development as a major factor to increase each industry's productivity by simplifying and improving efficiency for decision-making and production & logistics process. The theories on both 'static scale of economy' and 'dynamic scale of economy' are used to logically explain how a country's ICT development is positively related to a rise in national economic power and national competitiveness through its positive impact on the country's overall productivity level(Hall, 1999).

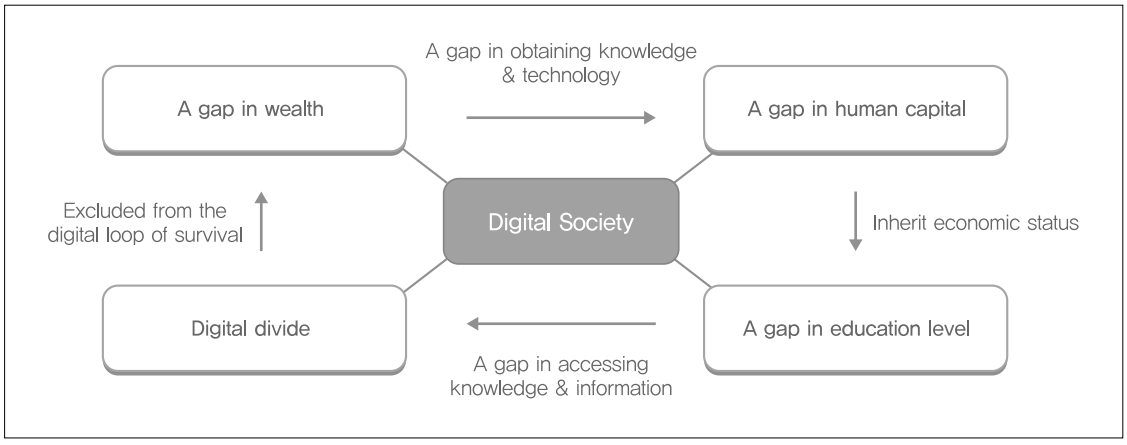
Another approach taken from the individual perspective in explaining how the ICT development affects national economic growth is 'income determinant theory'. The theory of human capital, which represents the income determinant theory, asserts that inequality in labor income depends on differences in investment in human capital; each individual's marginal production ability depends on the human capital investment(Kim, 1992) The theory is summed up to single out the differences in the human capital investment as the reason for triggering differences in labor productivity, which will, in turn, cause income differences. Therefore, it explains why access to and use of information is a major factor that causes income differences in the digital economy, for the information access is critical to building human capital.

In the digital economy, information and knowledge are viewed as a fundamental source of the wealth distribution. The result is a more polarized society where those who have more information become wealthier and those who have less information become poorer. Therefore, such information gap goes beyond the issue of being inconvenient or

8) A form of increasing returns to scale in which average cost declines over time as producers accumulate experience, so that average product rises with total output of the firm or industry accumulated over time. it related to R&D, marketing and training.

physical gap but makes it highly probable to bring another 'social barrier' that separates one group even more widely apart from the other. Besides, even if people access information, they would still be left behind in profiting from the digital economy if they lack the ability to use the information as valuable knowledge(Teresko, 1999). Even worse, the information gap not only affects immediate access to economic wealth and activities but it will likely pass down to their off-springs through transmission of human capital. Trapped in a cause-effect chain, off-springs of those who are on the disadvantageous end of the digital economy will find themselves even farther away from those who are on the advantageous end. The subsequent gap increase would become a hindering factor of societal cohesion(SERI, 2000: 381). In the digital economy, the choice of income and job depends on whether they have particular technology and knowledge. Therefore, those who have particular human capital will have an easier access to the self-generated information and knowledge than those who don't; they will become major recipients in the subsequent process of wealth reproduction. On the other hand, it raises a serious social issue for those who are isolated from information and knowledge as they will find themselves excluded from the digital environment, which is vital for their future survival. This discussion is depicted in a diagram, 〈Picture 2〉.;

However, these theories are yet to be verified clearly in terms of the circular relationship. It requires further study in details by taking into account varying time flow factors that also involve multiple countries. Started with awareness of limitations that preceding studies show, the study is accordingly designed to find answers in the face of such shortfalls. For this reason, it chose to use an empirical survey as its analytic framework.



Source: a second quote from SERI(2000)

〈Picture 2〉 Virtuous circle of digital society

Ⅲ. Research Design

1. Research scope

In examining the effects of IT development on subject country, this paper limits its scope to the impact of IT progress to a country's economic growth. Therefore, the nation's GDP is set as the dependent variable. This study seeks to increase explanatory power of its findings to generalize circumstances that can be universally applicable to most countries worldwide. This method differs from previous methods that conducted a case study to explain a particular situation that applies to a particular country. To this end, the subject countries of this study are 128 countries that belong to ITU. Considering UN member countries are 193 nations, the sample size of this paper is substantially large enough to reflect all different types of countries.

Finally, this paper uses the data that have been accumulated for a time span of 28 years(from 1980 to 2007). What this paper attempts to explain is each nation's level of economic growth. Therefore, the unit of analysis is a national-level characteristic, and thus, outcome of this research should be applied when explaining national-level development not individuals' development within a particular country to avoid 'ecological fallacy'.[9] The analytic tool for this paper is the panel data analysis of STATA 10.1.

2. Analysis framework

IT progress is highlighted as a core element of the major technology development in all countries that move into the knowledge & information society in the 21st century(Hicks, et al., 1977; Kaldor, 1956; Pasinetti, 1977; Samuelson, 1978). The rise of IT progress as a core element of technology evolution is natural from the economist point of view that stresses technology development for national development. However, opinions diverge on which factors drive IT development.[10] Otherwise, Northrop, et al.(2000) and Huntington(1996) have highlighted the importance of technology-driven national advancement through the laying out of national information infrastructure. Meanwhile, other papers have also suggested non-technological and socially-driven national development such as the role of information policies and importance of information users(Kim, 2009).

In this point, the 'supply-demand balance model' is suggested as the theoretical framework for explaining ICT development.

Kim(2009) introduced the 'supply-demand balance model', which integrates the technology

9) An ecological fallacy(or ecological inference fallacy) is an error in the interpretation of statistical data in an ecological study, whereby inferences about the nature of specific individuals are based solely upon aggregate statistics collected for the group to which those individuals belong. This fallacy assumes that individual members of a group have the average characteristics of the group at large. Stereotypes are one form of ecological fallacy, which assumes that groups are homogeneous(McGaw, et al., 1976: 134).

10) In Korea's case, government-initiated policy support for the developing nation's ICT capacity composed by IT infrastructure, IT competence and IT productivity is considered a major factor that positively impacted the nation's rise as an advanced information society(NIA, 2011).

deterministic approach of Northrop, et al.(2000) and Huntington(1996), which emphasized the supply side of IT, and the socio-economic approach of Masuda(1980), Naisbitt(1982) and Wilhoit(1981), which emphasized the demand side of IT. Furthermore, he added the policy coordination factor, which seeks a balance between supply and demand. His main focus lies in the balance of supply and demand, and therefore, his model is called 'supply-demand balance model' (see 〈Table 3〉).

In designing the research model, this paper adopts the aforementioned 'balance model of supply and demand' as the theoretical framework to explain ICT development as the driver of the national development.[11]

From this perspective, this paper uses IT infrastructure and IT capacity as important elements in explaining each nation's IT development. First, IT infrastructure represents the supply dimension of the 'supply and demand balance model'. This factor is the technology-centered supply side of this model. Fixed-line network is employed as a major measurement element for IT infrastructure in this paper. Moreover, the paper adds the PC adoption rate as another measurement indicator. Northrop, et al.(2000) have stressed the PC adoption rate as a key benchmark for ICT development. Finally, mobile phone subscription rate[12] is used as another indicator to measure the recent growth of wireless network in the light of the worldwide commoditization of mobile network as well as the growth of mobile network as a main stream national network in developing countries.

IT capacity is the demand side of the 'balance model of supply and demand'. Therefore, this factor centers on users, and is a socially-driven aspect of this model. This paper measures each nation's IT demand through the Internet adoption rate and ICT human capital. Also, the substantiality to be

〈Table 3〉 Supply-demand balance model

Dimension	Supply	Policy	Demand
Theoretical background	Technology determinism Technology expansion theory	Policy science	Socio-economic constructionism
Advocators	Northrop et al.(2000), Huntington(1996)	Kim(2009)	Masuda(1980), Naisbitt(1982), Wilhoit(1981)
Main focus	Development of technology and product, Infrastructure development	Support of R&D Development of experts Coordination between supply and demand	User's capacity Cost to use or purchase

source: Kim(2009: 4-9)

11) However, the policy factor that Kim(2009) suggested in his stress on the 'balance model of supply and demand' is not directly reflected into this study's research model. As the study covers the 128 countries into its research model, it is unable to go into depth of covering each country's policy cases. In other words, this study designs a model that gives priority in generalizing explanatory power of 128 countries instead of going into detail with each country's case study.

12) ITU(2005) suggests mobile network as a cost-efficient and time-saving alternative to the existing fixed-line network for developing countries.

supported by reinvesting in IT service is seen as an important element that shapes up each country's IT demand. Therefore, this paper adopts the telecom service sector's annual profit as another indicator to measure IT demand. One of the most important activities through IT is to use the Internet; thus Internet usage rate is adopted as an important indicator to measure IT demand and capacity(Jin, et al., 2011).

In the previous studies on the economic aspect of the ICT industry, emphasis was placed on the importance of investment in the ICT sector.[13)]

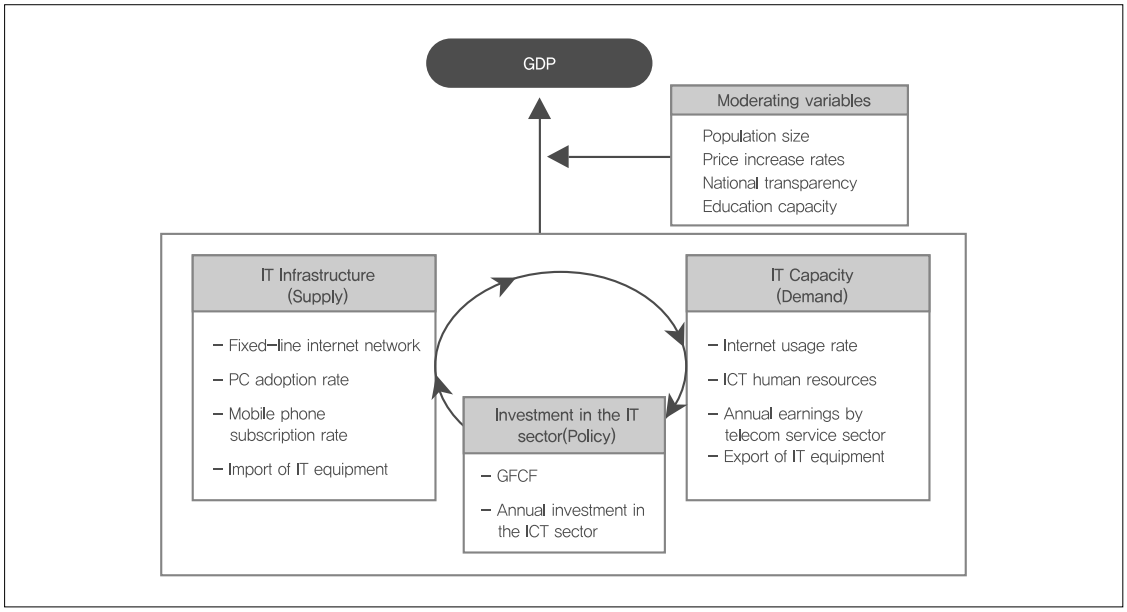
Therefore, the investment in the IT sector is included in this paper under the assumption that individual governments' effort for IT progress will eventually lead to financial investment in the IT sector, which is also aligned with the 'balance model of supply and demand' emphasizing the policy factor in IT development. Thus, Gross Fixed Capital Formation(GFCF) and annual investment in the IT sector are used as two indicators to measure IT investment. Moreover, contemporary society is characterized by the rapidity of knowledge information evolution and globalization. Furthermore, new ICT technology is rapidly spread across the world in the wave of globalization. Therefore, the paper designs a research model that uses the export status of ICT equipment as an external demand, and the import status of ICT equipment as an external supply factor to measure the effect of each country's ICT progress on national development.

Finally, this paper employs moderating variables. These variables have an indirect effect on interaction between ICT development and national economic growth. Population size, consumer price increase, national transparency, education capacity and time factor are adopted as mediators to control the variables.

User literacy is an important element that influences the usage & use of ICT information(NIA, 2011). Users' ability to read letters is seen as an useful index for measuring the information literacy(UNDP, 2002). Also, education index, which UNDP measures and discloses, is relevant to show an individual country's education capacity, and therefore, it is used as a control variable. Another indicator to measure education capacity is adult literacy; thus, UNESCO's adult literacy rate is also used in this paper. Secondly, in studying national development, each country's corruption issue is seen as a major obstacle against their economic growth, and therefore corruption[14)] has been a popular topic to statistically examine it as a hindering factor of national growth(Pak, 2002; Stiglitz, 2000). Particularly notable is an assertion from

13) Cisco(2003) invites a particular attention to both investment to IT and investment to non-IT when it studies IT influence on national economy, and thereby suggests a research model that considers both variables.

14) Klitgaard(1998) defines corruption as a deviation from public duties or violation of the rules with aims to earn private financial profits or a privileged position. TI(Transparency International) defines it as abuse of entrusted power for private gain.



〈Picture 3〉 Research framework to study ICT progress and national economic growth

Zdenek, et al.(2002) that showed a path of how greatly national transparency influences a flow of FDI(Foreign Direct Investment) into a country, and how greatly the FDI affects the nation's economic growth. Finally, population size and consumer prices, which have been traditionally mentioned as factors to explain national economic growth, are also used as mediating variables to examine how ICT development influences national economic growth. The research framework can be shown in the 〈Picture 3〉.

3. Operational definitions of variables and data sources

Traditional economic model(Hicks, et al., 1977; Kaldor, 1956; Pasinetti, 1977; Samuelson, 1978), alternative economic growth theory (Jalilian, et al., 2007; Nicoletti, et al., 2003) and Cobb-Douglas Model have introduced GDP as an important output of nation's economic growth. Thus, statistical analysis model of this research adopts GDP as a dependent variable, while adopting supply, demand, policy and moderating factors as explanatory variables.

Analysis model:

$$(GDP)_{i,t} = \beta 0 + \beta 1(Supply)_{i,t-1} + \beta 2(Demand)_{i,t-1} + \beta 3(Policy)_{i,t-1} + \beta 4(moderating\ variables)_{i,t-1} + Z_{i,t}r + \alpha i + \delta t + \varepsilon_{i,t}$$

i=128, t=1980-2007

In the formula, a country's Gross Domestic Product(GDP) in a given year is used as a dependent variable(GNIi, t) and data source

for GDP is the World Bank. Independent variables(t-1) consist of IT infrastructure, IT capacity, investment to IT, and IT trade size.

First, the supply aspect(IT infrastructure) is designed as a variable "(Supply)i.t-1", to assess the level of each country's IT infrastructure that has been established(t-1). To measure IT infrastructure, the research uses three indicators: the number of fixed-line Internet subscribers per 100 persons(fixed-line Internet network), PC owners per 100 persons(PC adoption rate), and mobile phone subscribers per 100 persons(mobile phone subscription rate). These IT infrastructure variables are analyzed by using data from ITU (International telecommunication Union). Import of IT equipment is a reference the influx of IT infrastructure(including technologies and devices) from abroad, so it was included as an indicator to measure the supply side of IT development.

Three indicators are employed to measure IT capacity "(Demand)i, t-1": Internet usage rate (that means rate of those who have used the Internet during the recent 12 months) and the number of ICT workers on pay-roll exclusively for IT work(the number of IT employees in public and private sectors) were used. In addition, this study uses the telecom sector's annual earnings(in US$) as posted by public-and private-sector telecom service providers in both fixed-line and wireless networks as another indicator for indirectly assessing IT capacity. All of these data are measured from the 'World Telecommunication Data' surveyed and disclosed by ITU. Lastly, export of IT equipment reflects a nation's capacity to sell its own technology or product to overseas countries, so it was included as an indicator to measure the demand side of IT development.

To measure IT investment and moderating capacity "(Policy)i, t-1", this study uses two variables: Gross Fixed Capital Formation (GFCF)[15] and total annual investment in the telecommunication sector(in US$) and these two data are surveyed and disclosed by ITU. To analyze the effects trade size has on economic growth "(Trade size)i, t-1", this study uses two indicators under this variable: import and export size of IT equipment in US$.

In addition, a set of mediators, moderating

15) Enterprises replace aging equipment with new ones or build factories and buy machines to maintain their production capacity and secure competitiveness. These activities are aimed at securing a future source of revenue generation on a long term. These resources that are used over multiple fiscal years are called the capital goods, and the purchase of capital good by the production subject is called the total fixed capital formation. The total fixed capital formation refers to expenses incurred when industry, government service producers and private non-profit service producers add fixed asset. Therefore, purchases of land or second-hand goods are excluded from this capital formation, whereas incremental cost like installment cost or acquisition tax or registration tax, which accompany with these purchases, are included into this capital formation. The analysis of Korea's fixed capital formation by economic activity finds that service sector represents a higher share of this formation than manufacturing sector. Total Fixed Capital Formation is one of the macroeconomic aggregates, and is one of component that comprises total capital formation. TFCF consists of physical capital formation and human resources capital formation(TFCF=Physical Capital Formation+HR Capital Formation). The Physical Capital Formation is classified into total fixed capital formation and increase in stocks. The total fixed capital formation consists of the elements as follows:
*Total fixed capital formation = Constructive behaviors + Purchasing finished capital goods
*Constructive activities = Residential constructions + Non-residential constructions + Social Overhead Capital Constructions
*Purchasing finished capital good = Transportation capital goods + Machineries

variables, are included in the analysis model to strengthen the explanatory power of the analysis model. This research employs population size, consumer price increase(PI), corruption perceptions index(CPI) and education capacity are additional variables that can control the effect of independent variables on the dependent variables.

〈Table 4〉 Definition of Variable & Data Sources

Category	Variable Name	Definition	Data Source
Dependent variable(t)	(GDP)i,t	Individual country's GDP(Gross Domestic Product)	World Bank
Independent variable (t-1)	(Supply)i,t-1	Fixed-line internet network: Number of the fixed-line broadband subscribers per 100 persons	ITU
		PC adoption rate: Number of PC owners per 100 persons	
		Mobile phone subscription rate: Mobile phone subscribers per 100 persons	
		Imports-telecommunication equipment(US$)	
	(Demand)i, t-1	Internet use rate: Rate of Internet users for the past one year vs total population	ITU
		ICT workers: Number of the ICT full-timers in public-and private sectors	
		Annual earning in telecom service sector: Annual earning as posted by mobile and fixed-line telecom service providers in public and private sectors	
		Exports-telecommunication equipment(US$)	
	(Policy)i,t-1	GFCF: Gross Fixed Capital Formation	ITU
		Total annual investment to telecommunication sector(US$)	
Moderating Variables	(Population size)i,t-1	Population as officially surveyed and disclosed by each government	World Bank
	(PI)i,t-1	Price increase(2000 year=100): Marking each year's price rise with the year 2000's price as 100	UNDP
	(CPI)i,t-1	Each year's level of corruption perception index(CPI) as surveyed and announced by Transparency International(TI)	TI
	(Education Capacity)i, t-1	Literacy rates for adults above 15	UNESCO
		Education index is a composite measure reflecting both each nation's illiteracy rate and school(both elementary and secondary) enrollment	UNDP
Zi,t		Vector of other controlling variables	
αi		Role to control unobserved individual effects	
δt		T-1 number of time dummy variable to control the unobserved time series effects	
$\varepsilon i,t$		Error item that follows I.i.d[16] distribution whose mean is 0 and dispersion is σ^2 towards every I and t	
$\beta j(j=0,1,2,12,3)$, r		Each estimated coefficient value and vector of coefficient value	

*STAT10.1 is used to conduct the panel analysis on the above data

16) i.i.d(Independently and Identically Distributed): In case of two or more variables to consider, these variables are independently and identically distributed(McGaw, et al., 1976).

Population size "(Population size)i, t-1" is the official population of each country as surveyed and disclosed by each government. This paper took these numbers from the World Bank. Consumer prices(PI)[17] are indicated as Price Increase as variable "(PI)i,t-1". Corruption Perceptions Index "(CPI)i, t-1" is used as control variable, and it is surveyed and disclosed by Transparency International(TI) to assess each country's level of transparency.[18] Finally, the UNDP education index[19] and the UNESCO's adult literacy rate are adapted to measure the education capacity(EDUi, t-1) and these two variables are sourced from Human Development Report. In addition, a vector of other moderating variables(Zi, t), t-1 numbers of dummy variable(δt), and the error term(εi,t) are included in the formula. Detailed definitions of all variables are shown in the 〈Table 4〉.

In conducting the analysis, this research conducts two types of analysis; with and without moderating variables. Comparison of these two research models will improve the validity and confidence of the analysis to detect the relationship between IT development and national economic growth.

Ⅳ. Analysis of Relationship between ICT and National Economic Growth

1. Analysis of relationship between ICT factor and national economic growth

1) Fit Model Analysis

To avoid some limitations of ordinary least squares(OLS)[20] method and get "unbiased and consistent estimates", this paper used panel data analysis which can control the cross-sectional properties such as cultural characters and attributes of individual countries. Panel data analysis requires the selection of best fit model between fixed and random effects models.[21] Selection of the

17) A consumer price index (PI: Conventional acronym is CPI, however, in order to avoid confusion with Corruption Perceptions Index(CPI), PI will be used in this paper) measures changes in the price level of consumer goods and services purchased by households. The PI is defined by the United States Bureau of Labor Statistics as "a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services." A PI can be used to index(i.e. adjust for the effect of inflation) the real value of wages, salaries, pensions, for regulating prices and for deflating monetary magnitudes to show changes in real values(Bureau of Labor Statistics).

18) Since 1995, the Transparency International(TI) has published the Corruption Perceptions Index(CPI) every year. It orders countries according to "the degree to which corruption is perceived to exist among public officials and politicians". The organization defines corruption as "the abuse of entrusted power for private gain". The 2003 poll covered 133 countries; the 2007 survey, 180. A higher score means less(perceived) corruption(TI, 2007).

19) The Education Index is measured by adult literacy rate(with two-thirds weighting) and combined primary, secondary, and tertiary gross enrollment ratio(with one-third weighting). Education is a major component of well-being and is used in the measure of economic development and quality of life, which is a key factor determining whether a country is a developed, developing, or underdeveloped country(UNDP, 2009).

20) The ordinary least squares(OLS) is a method for estimating the unknown parameters in a linear regression model. This method minimizes the sum of squared distances between the observed responses in the dataset and the responses predicted by the linear approximation. The resulting estimator can be expressed by a simple formula(Greene 2002; Hayashi, 2000).

21) Fixed effects model is a statistical model that represents the observed quantities in terms of explanatory variables that are all treated as if those quantities were non-random. This is in contrast to random effects models in which either all or some of the explanatory variables are treated as if they arise from the random causes. Often the same structure of model, which is usually a linear regression model, can be treated as any of the three types depending on the analyst's viewpoint, although there may be a natural choice in any given situation(Christensen, 2002).

best fit model was carried out by Hausman specification test.[22)]

The result of the Hausman specification test enables us to decide whether or not to reject the null hypothesis(Ho: difference in coefficients is not systematic(Allerano, et al., 1991). In other words, fixed effects model does not improve the explanatory power). The test

〈Table 5〉 The analysis of ICT's impact on national economy (1980-2007)

Model		M1	M2	M3
VARIABLES		FE (Fixed Effect)	RE (Random Effect)	FEAR (Fixed Effect with Autocorrelation)
		GDP	GDP	GDP
Environment	Population size	0.314*	0.364***	0.888***
		(0.167)	(0.037)	(0.041)
IT Policy	Investment in the ICT sector	0.004	0.013	0.022*
		(0.011)	(0.012)	(0.013)
	GFCF	0.113***	0.125***	0.046***
		(0.012)	(0.013)	(0.016)
IT demand	Annual earnings by telecom service	0.391***	0.484***	0.439***
		(0.026)	(0.028)	(0.029)
	Number of ICT workers	-0.072*	0.085***	-0.074*
		(0.031)	(0.030)	(0.041)
	Internet usage rate	0.000	0.002*	0.004***
		(0.001)	(0.001)	(0.001)
	Export value of ICT equipment	0.000***	0.000	0.000
		(0.000)	(0.000)	(0.000)
IT supply	Mobile network subscription rate	0.003***	0.001***	0.003***
		(0.000)	(0.001)	(0.001)
	PC adoption rate	0.181***	0.114***	0.108***
		(0.022)	(0.024)	(0.033)
	Fixed-line network subscription rate	-0.060***	-0.070***	-0.023
		(0.009)	(0.010)	(0.021)
	Import value of ICT equipment	-0.000**	0.000	-0.000
		(0.000)	(0.000)	(0.000)
Constant		9.727*	5.000***	-0.060*
		(2.631)	(0.449)	(0.034)
R-Sq(overall)		0.8512	0.8473	0.7246
Observations		621	621	502
Number of id		119	119	105

Standard errors in parentheses, *** p<0.01, **0.05, * p<0.1

22) The Hausman test or Hausman specification test is suggested by Jerry A. Hausman, it tests by comparing relevance of fixed effects model with random effects model that it may monitor the set errors(Hausman, 1978).

result shows that p value is smaller than 0.0001. The study, thus, rejects the null hypothesis within the 1% significant level (Prob>chi2=0.0000). So we can statistically confirm that the fixed effects model would improve the explanatory power and fit the study more than the random effects model.[23)]

Another issue arising in conducting panel data analysis with time series data is autocorrelation. Autocorrelation refers to the correlation of a time series with its own past and future values. It is sometimes called "serial correlation", which refers to the correlation between members of a series of numbers arranged in time. Alternative terms are "lagged correlation", and "persistence." Autocorrelation can also complicate the identification of significant covariance or correlation between time series. Therefore, statistical analysis of time series data requires to test whether autocorrelation exists or not. If autocorrelation is detected, certain measure to rectify autocorrelation should be applied(Patrick, 2005).

In order to test the existence of autocorrelation, the Wooldridge test[24)] was conducted. The test result shows that the p value is smaller than 0.001 and we reject the null hypothesis(there is no first order autocorrelation) within the 1% significant level. Therefore, the third model(M3), a fixed effects model with autocorrelation was chosen as the best fit model in this research (see <Table 5>).

2) Analysis of ICT factors on national economic growth(Model M3)

The analysis result finds the M3 model as the fittest to explain the relationship between ICT level and national economic growth. The M3 model shows that national economic growth is influenced by IT infrastructure, IT capacity, and IT investment but not by IT trade size. R-Sq value of this analysis model is found 0.8246, proving the significant explanatory power of this model. The followings are outlines of the findings of this model about the impact of ICT development on economic growth in the surveyed 128 countries from 1980 to 2007.

Among three indicators under the IT supply, PC adoption rate and mobile network adoption rate are found to have positive effects on the national economic growth at 99% significance level. However, the fixed-line network adoption rate is not statistically found to affect the relationship between ICT and economic growth. Furthermore, its relationship with economic growth is

23) Analysis result summary of the Hausman test

```
Test: Ho: difference in coefficients not systematic
      chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
      = 249.88Prob>chi2 = 0.0000
```

24) Analysis result summary of Wooldridge test

```
H0: no first-order autocorrelation
    F(1, 15) = 41.446Prob>F = 0.0000
```

negative. The analyzed result shows that there is a shift in mainstream Internet infrastructure from fixed-line network to mobile network in affecting economic growth.

Secondly, IT demand is also found to be a statistically significant contributor to a nation's economic growth. Internet usage rate and the telecom sector's annual profit rate show strong effect on economic growth at 99% significance level. However, the number of ICT workers, which represents human capital size of the IT sector, shows a relatively modest impact on the relationship between ICT and economic growth. Furthermore, the ICT workers points to a negative effect on national economic growth. The reason for this may be found in that as ICT progresses, the industry structure moves toward more technology-driven and less labor-intensive one. In other words, the analysis result shows that the number of employees on payroll exclusively for ICT jobs shrinks with the growth of the ICT sector and economy in each country.

Finally, the analysis result of M3 model shows that the impact of IT investment size(Policy dimension) on national economic growth is found to be statistically significant. The GFCF, which represents a comprehensive national investment made at the national level, is found to have very strong positive effects on a country's economic growth at 99% of statistical significance. It also finds statistical significance at 90% for the effect of ICT investment on national economic growth.

In summary, the above statistical analysis shows that both of the supply and demand of IT development have a positive impact on a nation's economic growth as hypothesized by 'supply-demand balance model'. In addition, IT policy measured by IT investment has also significant impact on a nation's economic growth.

2. Analysis of ICT and national economic growth with addition of moderating variables

For the analysis of ICT's effects on each country's economic growth, this paper included a set of moderating variables,[25)]

which are assumed to have a close relationship with national economic growth. This paper assumes that certain variables (e. g. education capacity, national transparency, consumer price index, population size) that have been emphasized from the economists' and sociologists' points of view, may control or intermediate the relationship between ICT progress and national economic growth. Therefore, this paper diverges from previous studies that only used ICT factors to explain the relationship between ICT factors and national economic growth. Data for national transparency index and education index began to be measured from 1999; therefore

25) As a kind of independent variable to systematically change relation between independent variables and dependent variables, moderating variables can adjust cause-and-effect relationship between independent variable and dependent variables.

data on these variables do not exist for the period from 1980 to 1998. The following analysis with the addition of moderating variables has a shorter time span(9 years) compared with the previous model with only ICT factors(28 years from 1980 to 2007).

1) Fit Model Analysis

As conducted in the previous model, this model also needs fit model analysis. Panel data analysis requires the selection of best fit model between fixed and random effect models. And the selection of the best fit model was carried out by Hausman specification test. The result of the Hausman specification test enables us to decide whether or not to reject the null hypothesis(Ho: difference in coefficients is not systematic. In other words, the fixed effects model does not improve the explanatory power). The test result shows that p value is smaller than 0.0001. The study, thus, rejects the null hypothesis within the 1% significant level(Prob>chi2=0.0000). So we can statistically confirm that the fixed effects model would improve the explanatory power and fit the study more than the random effects model.

Next, in order to test the existence of autocorrelation, the Wooldridge test was conducted. The test result shows that p value is smaller than 0.001(Prob>F=0.0000) and we reject the null hypothesis(there is no first order autocorrelation) within the 1% significant level. Therefore, the third mode(T3), a fixed effects model with autocorrelation was chosen as the best fit model in this research.

2) Analysis of ICT factors and moderating variables on national economic growth(Model T3)

This study includes various moderating variables whose impact on national development and economic growth had been verified by previous studies. The analysis result of the new model(T3) that includes these variables is found to be partially different from that of the previous model(M3) that does not include moderating variables in analyzing the effects of ICT variables on economic growth. The analysis result is outlined in 〈table 6〉.

The effects of ICT development on national economic growth remain almost same even adding moderating variables, resulting three ICT factors(e.g. IT supply variable and IT demand variable, and IT policy) are related to national economic growth. First, among the three indicators under the IT supply dimension, only mobile network adoption rate is found to have strongly significant effect on a country's economic growth. The reason can be traced to the rapid shift of mainstream broadband access from fixed-line to mobile network that has taken place since 2000. It can, thus, be inferred that a more intensive and wider mobile network in a country can have a more positive effect on the country's economic growth. However, the analysis of model T3 did not find statistically significant effect of PC adoption rate on national economic growth whereas model M3 highlighted statistic relevance for PC adoption rate's effect on national economic growth. The reason can be inferred

〈Table 6〉 The analysis of ICT's impact on national economy with moderating variables(1999-2007)

Model		T1	T2	T3
VARIABLES		FE (Fixed Effect)	RE (Random Effect)	FEAR (Fixed Effect with Autocorrelation)
		GDP	GDP	GDP
Moderating variables	Education index	-0.194	0.038	0.242
		(-0.235)	(0.130)	(0.300)
	Adult literacy rate	0.007	0.013	0.014
		(-0.022)	(0.023)	(0.020)
	National transparency	0.071	-0.005	0.344**
		(-0.090)	(0.093)	(0.146)
	PI(Consumer price index)	0.703***	-0.388	1.215***
		(-0.303)	(0.274)	(0.395)
Environment	Population size	0.340	0.202***	0.151
		(-0.315)	(0.047)	(0.130)
IT Policy	Investment amount into ICT sector	-0.001	0.008	-0.009
		(-0.015)	(0.016)	(0.019)
	GFCF	0.389***	0.581***	0.600***
		(-0.052)	(0.044)	(0.070)
IT demand	Annual earnings by telecom service	0.193***	0.207***	0.151*
		(-0.053)	(0.051)	(0.083)
	Number of ICT workers	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
	Internet usage rate	-1.160***	-0.495	1.945***
		(-0.523)	(0.475)	(0.567)
	Export of ICT equipment	0.000*	0.000	0.000
		(0.000)	(0.000)	(0.000)
IT supply	Mobile network adoption rate	0.004**	0.002*	0.004**
		(-0.001)	(0.001)	(0.002)
	PC adoption rate	0.004	0.025	0.004
		(-0.033)	(0.032)	(0.041)
	Fixed-line network subscription rate	0.000	-0.000	0.000
		(0.000)	(0.000)	(0.000)
	Import of ICT equipment	0.000	0.000	-0.000
		(0.000)	(0.000)	(0.000)
Interaction terms	Crosprice(Int_PI) (Internet usage rate vs Price increase rate)	0.263**	0.104	-0.487***
		(-0.113)	(0.101)	(0.121)
	Croscpi(Int_CPI)(Internet usage rate vs Corruption Perception Index)	-0.052	0.013	0.217***
		(-0.040)	(0.037)	(0.062)
	Crosedu(Int_Edu) (Internet usage rate vs education index)	0.040	-0.009	0.153*
		(-0.044)	(0.043)	(0.105)
Constant		8.973***	4.945***	-0.392***
		(-4.981)	(1.432)	(0.061)
R-Sq(overall)		0.8716	0.8812	0.7716
Observations		183	183	128
Number of id		75	75	67

Standard errors in parentheses, *** p<0.01, **0.05, * p<0.1

from the fact that a variety of multiple Internet interfaces have been made available as alternatives to PCs that used to be the main Internet interface in the 1980s and 1990s. Therefore, it is logically induced that it is not the simple PC adoption rate but the adoption rate of multiple Internet-interfacing devices that have a positive influence on national economic growth.

Next, the analysis result of the T3 model on IT demand dimension is similar as that of the model M3, indicating that the Internet usage rate and profit from the telecom sector are found to be statistically significant for national economic growth. However, the analysis did not find statistic relevance for the effect that ICT workers has towards each country's economic growth as found in model M3.

The analysis of how IT policy dimension (investment) is related to national economic growth shows strong statistical relevance for the positive effect of GFCF on individual countries' economic growth. Although analysis of the model M3 indicates that the effect of IT investment is statistically supported, analysis of the model T3 finds that the effect of IT investment is not statistically supported. Finally, the analysis result of T3 and M3 are the same in that IT trade size is statistically unrelated to national economic growth.

Next part is the analysis of the effects of moderating variables on economic growth. It shows that human capacity-related moderating variables do not have any statistically significant direct relationship with national economic growth. It can be, thus, inferred from this that the use of technology that fits the information age has a greater impact on national economic growth than just education or literacy capacity. The panel analysis indicates that Internet usage rate has more meaningful influence on national economic growth than education index or adult literacy rate.

Next moderating variables are national transparency and consumer price index; both are shown to affect national economic growth positively, as both indicators are statistically significant at 95% and 99% respectively. The positive effect of the CPI (corruption perception index) on economic growth is consistent with the assertions that emphasize good governance as a critical factor for economic growth. However, price increase should not be regarded as a real cause of economic growth. Instead, GDP calculated every year reflects the price level of that particular year, and therefore, GDP is highly correlated with price increase.[26)]

3) Analysis of interaction effect of ICT factors and moderating variables on national economic growth

This section reviews the interaction effects

26) This statistical result could be used to show the existence of relationship between GDP and PI rather than interpreting that PI has a real positive impact to national development. In other words, we can say that a rise in consumer price leads to the increase in volume of national production, which cause GDP to increase.

of ICT factors and moderating variables on a nation's economic growth. Among all ICT variables.[27] The interaction effect analysis of model T3 could be used to explain whether the moderating variables moderate the effect of ICT development on a country's economic growth. In other words, it allows the statistical verification about whether control indicators(e. g. PI, CPI, national education index) negatively or positively moderate the Internet usage rate's impact on national economic growth.

First, the analysis of T3 panel model shows that both consumer price index(PI) and Internet usage rate affect positively each country's economic growth at 99% statistical significance. And the analysis of 'crosprice' terms shows that interaction effect of consumer price increase(PI) and Internet usage rate is negative(−), meaning that a rise in consumer prices tends to diminish the Internet usage rate's net marginal effects on national economic growth. Second, this study employs the 'croscpi' term to examine the interaction effect of the CPI (corruption perception index) and Internet usage rate on economic growth. National transparency is often stressed as a source of national competitiveness(Pak, 2002; Stiglitz, 2000). The previous analysis of direct effects indicated that both Internet usage rate and corruption perception index(CPI) are found to be statistically significant for the economic growth of individual countries. The positive coefficient of the interaction between national transparency and Internet usage rate is shown in the analysis result of the 'croscpi' effect. This attests to the fact that the transparency level of a country and its Internet usage rate have a reinforcing effect on the country's economic growth. Two variables–national transparency and Internet adoption rates–have a mutually-boosting effect on one variable's effects on a dependent variable. It can be, thus, inferred that high national transparency tends to lead to an increase in net marginal effects of Internet usage rate on national economic growth, whereas a high Internet usage rate tends to lead to an increase in net marginal effects of national transparency on national economic growth.

Finally, this study examines whether the national education index moderates the Internet usage rate's effects on economic growth. To do this, it uses the 'crosedue' term. Contrary to the previous finding of no direct effect of national education index on economic growth, interaction term analysis shows that national education index has a positive interaction effect with Internet usage rate on national economic growth. This result indicates that a rise in a country's education index tends to increase the net marginal effect of Internet use on the country's economic growth. This attests to

27) Internet use rate is most often used as representative indicator by international organizations like OECD, World Bank, UNDP, etc. in measuring the level of a country's information advance. The reason behind this assertion is that ultimate goal of ICT development is the use of ICT(Internet), therefore, IT infrastructure or investment should lead to an increase in the number of Internet users.

the fact that the national education index has a mediating effect rather than direct influence on economic growth through the impact of the Internet usage rate on economic growth. This analysis result underscores the importance of indirect effect that ICT capacity has towards national economic growth.

Ⅴ. Conclusion

Traditional economists emphasized the importance of human capital, capital, and technology as vital elements of national economic growth. Since the advent of the information society after industrialization, ICT and knowledge have been stressed as major factors for national economic growth. Therefore, ICT factors have been theoretically highlighted as drivers behind national economic growth. This study seeks to statistically prove whether ICT components actually affect national economic growth.

For this purpose, this paper adopts "balance model of supply and demand", and used four components(IT investment, IT trade, IT capacity, and IT infrastructure), which reflect various aspects of ICT development. Furthermore, some socio-economic factors such as human capital, national transparency, and price increase are also included as control variables to reveal intermediating effects of these variables in the causal relationship between the ICT factors and economic growth. Another merit of this paper is to conduct the analysis of time series data from 1980 to 2007, not cross-sectional data or case study of one or two nations.

The followings are the results derived by the data analysis. First, IT demand, IT supply, and IT policy among three components of ICT development turn out to have a positive causal effect on national economic growth. The effect of these variables remains strong even after controlling the socio-economic factors such as human capital, national transparency, and consumer price increase.

Second, analysis of moderating variables shows that national transparency and consumer price increase have a direct relationship with nation's economic growth. Furthermore, national transparency, and price increase have interaction effect with ICT development on the nation's economic development. Thus, it could be said that these two moderating variables have a reinforcing effect with ICT development on national economic growth.

Third, a nation's human capital, one of key moderating variables, turned out not to have significant relationship with the nation's economic growth. However, nation's human capital has an interaction effect with ICT development on economic development. Thus, we can say that a nation's human capital does not have a causal effect on national economic growth by itself, but it may have significant causal effect when it comes with the co-progress of ICT development.

Overall, this paper has proved that ICT development is a key significant factor for a

nation's economic growth, and additional analysis of the effects of moderating variables also shows that increase of national transparency, management of consumer price, and a tanation's human capital have direct or indirect effects on national development. Policy suggestion derived by this analysis is that planning of ICT development as a catalyst for a nation's economic growth requires not only to consider ICT factor itself but also to take socio-economic factors together. Finally, this research may deserve appreciation by the fact that it has proven that 'balance model of supply and demand' is a suitable model in analysing the impact of IT development on a nation's economic growth.

However, despite the above contribution, authors are admitting the necessity of a further qualitative case study to see and explore the internal policy dynamics which are mediating IT development and economic growth. Particularly, policy factor(one of key components of 'supply and demand balance model') can not be easily detected by quantitative studies like this research. Therefore, a further qualitative study revealing the policy dynamics of IT development and economic growth is strongly recommended.

Further, this paper has to more carefully manage the spurious regression problem of variables, in spite of research modeling from academic theories. So, further researches have to carefully control the spurious regression problem among the variables.

■ References

Allerano, M. & S. Bond (1991). "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." *Review of Economic Studies,* 58: 277-297.

Antonio, Ciccone & Marek, Jarocinski (2009). *"Determinants of economic development-will data tell?."* Working Paper Series 852, Frankfurt: European Central Bank.

Baltagi, B. (2008). *Economic Analysis of Panel Data.* New York: John Wiley & Sons.

Bruinshoodf, A. & Weel, B. T. (1998). *Skill-biased Technical Change: On Technology and Wages in the Netherlands,* Research Center for Education and the Labour Market and Department of Economics, Maastricht University, the Netherlands.

Bureau of Labor Statistics (2010). "Consumer Price Index-Frequently Asked Questions (FAQs)." http://www.bls.gov/cpi/cpifaq.htm. (Retrieved on September 10, 2010).

Carr, Nicholas G. (2003). "IT Doesn't Matter." *Harvard Business Review,* May 2003: 41-49.

Chenery, H. B. & A. Strout (1966). "Foreign Assistance and Economic Development." *American Economic Review,* 56(September) : 679-733.

Christensen, Ronald (2002). *Plane Answers to Complex Questions: The Theory of Linear Models(3rd ed.).* New York: Springer.

Chu, Nancy (2005). "ICT And Causality In The NEW ZEALAND Economy." Proceedings of the 2005 International Conference on Simulation and Modelling.

Cisco (2003). "ICT and GDP Growth in the United Kingdom: A Sectoral Analysis." A Report to Cisco Systems by London Economics.

Damiaan, P. L. & Joakim, W. (2008). "Error-correction-based cointegration tests for panel data." *The Stata Journal,* 8(2): 232-241.

Fisman, Raymond & Miguel, Edward (2008). *Economic Gangsters: Corruption, Violence, and the Poverty of Nations.* Princeton: Princeton University Press.

Garson, D. (2000a). *Handbook of Public Information Systems.* New York: Marcel Dekker, Inc.

Garson, D. (2000b). *Social Dimensions of Information Technology: Issues for the New Millennium.* Pennsylvania: Idea Group Publishing.

Greene, William H. (2002). *Econometric analysis (5th ed.).* New Jersey: Prentice Hall.

Hall, R. & Jones, C. (1999). "Why Do Some Countries Product So Much More Output Per Worker than Others?" *Quarterly Journal of Economics*, 114(1): 83-116.

Hausman, J. A. (1978). "Specification Tests in Econometrics." *Econometrica*, 46(6): 1251-1271.

Hayashi, Fumio (2000). *Econometrics.* Princeton: Princeton University Press.

Haywood, Trevor (1998). "Global networks and the myth of equality: Trickle down and trickle away?" In Loader, B. D.(ed.), *Cyberspace Divide: Equality, Agency and Policy in the Information Society*, 19-34. London & New York: Routledge.

Hicks, John & Hollander, Samuel (1977). "Mr. Ricardo and the Moderns." *Quarterly Journal of Economics*, 91(3): 351-369.

Huh, Bum (1998). "Searching the New Public Administration Way." Proceedings of KAPA the 1st global conference, The Korea Association for Policy Studies.

Huntington, S. P. (1996). "The West: unique, not universal." *Foreign Affairs*, 75(6): 28-46.

ITU (2010). *Measuring the Information Society.* Geneva: ITU.

Jalilian, H. & Kirkpatrick, C. & Parker, D. (2007). "The Impact of Regulation on Economic Growth in Developing Countries: A Cross-Country Analysis." *World Development*, 35(1): 87-113.

Japan Ministry of Internal Affairs and Communication (2009). *White paper: Information and Communications in Japan 2009.* Tokyo: Japan MIC.

Jin, Sangki (2008). "A study on the Policy network of bridging the global digital divide." doctoral dissertation, Sungkyunkwan university in Seoul.

Jin, Sangki & Hyun, Joonho (2011). "An Analysis of Panel Data on the Web-accessibly Policy in Korea Local Government." *Informatization Policy*, 18(4): 42-58.

Johnson, Gerry (1992). "Managing Strategic Change Strategy, Culture and Action." *Long Range Planning*, 25(1): 28-36.

Kaldor, Nicholas (1956). "Alternative Theories of Distribution." *Review of Economic Studies*, 23: 83-100.

Kamarck, Elaine Ciulla & Nye, Jaseph S. (1999). *democracy.com?: Governance in a Networked World.* New Hampshire: Hollis, NH.

Keefer, Philip & Knack, Stephen (1997). "Why don't Poor Countries Catch Up? A Cross-National Test of an Institutional Explanation." *Economic Inquiry*, 35(3): 590-602.

Kim, Sungtae (1992). *Management Information System in Public Sector.* Seoul: Bumnoonsa.

Kim, Sungtae (2009). *New E-government: theories and practices.* Seoul: Bumnoonsa.

Klitgaard, Robert (1998). "International Cooperation Against Corruption." *Finance & Development*, March 1998: 1-25.

Kraemer, Kenneth L. & Paul, Tallon (1999). *The Information Technology and Economic Development: Ireland's Coming Age with Lessons for Developing Countries.* Irvine: Center for Research on IT and Organizations, University of California.

Kwon, ki hun (2000). *The Logic of Policy science.* Seoul: Bumnoonsa.

Lasswell, H. D. (1971). *A Pre-View of Policy Sciences.* New York: Elsevier.

Loader, Brian D. (1998). *Cyberspace Divide: Equality, Agency and Policy in the Information Society*. London & New York: Routledge.

Masuda, Y. (1980). *The Information Society as Post-Industrial Society*. Maryland: World Future Society.

McGaw, Dickinson & Watson, George (1976). *Political and Social Inquiry*. New York: John Wiley & Sons.

Morissette, R. & Drolet, M. (1993). "Computer, Fax Machines and Wages in Canada: What Really Matters? Business and Labour Market Analysis." Statistics Canada Working Paper No. 126.

Moshe, Mira (2010). "It's about time: policy time." *Policy Studies*, 31(3): 319-330.

Naisbitt, John (1982). *Megatrend: Ten New Directions Transforming Our Lives*. New York: Warner Books.

Negroponte, N. (1995). *Being Digital*. New York: Knopf.

NIA (2011). *SMART SOCIETY : IT issues and strategies to realize the smart society*. Seoul: NIA.

Nicoletti, G. & Scarpetta, S. (2003). Regulation, productivity and growth: OECD evidence, *OECD Economics Department Working Paper*, No.347.

Northrop, Alana & Kraemer, Kenneth L. (2000). "The Information Age: Which Nations Will Benefit?." *I.T. in Business*, 1-19.

OH, jy (2010). *IT, Growth and national renewal strategy trough IT: case of Japan*. IT policy study(10). Seoul: NIA.

Pak, Hung Mo (2002). "Corruption and Economic Growth." *Journal of Comparative Economics*, 29(1): 66-79.

Parsons, D. & Gotlieb, C. C. & Denny, M. (1990). "Productivity and Computers in Canadian banking." University of Toronto, Dept. of Economics Working Paper.

Pasinetti, Luigi L. (1977). *Lectures on the Theory of Production*. Columbia: Columbia University Press.

Patrick F. Dunn (2005). *Measurement and Data Analysis for Engineering and Science*. New York: McGraw-Hill.

Perelman, Michael (1998). *Class Warfare in the Information Age*. Oxford: Macmillan.

Pohjola, M. (2001). "Cross-country Diffusion of the Internet." WIDER Discussion Paper No. 153.

Porter, Michael (1990). *The Competitive Advantage of Nations*. New York: The Free Press.

Samuelson, Paul A. (1978). "The Canonical Classical Model of Political Economy." *Journal of Economic Literature*, 16: 1415-1434.

Schiller, Daniel (2000). *Digital Capitalism: Networking the Global Market System*. Massachusetts: The MIT Press.

Schiller, Herbert I. (1996). *Information Inequality : The Deepening Social Crisis in America*. New York: Routledge.

SERI (2000). *Digital Shock and Selection of Korea Economy*. Seoul: SERI.

SERI (2001). *Reality and Direction of National Competitiveness*. Seoul: SERI.

SERI (2008). "truth and falsity on the National competitiveness." CEO Information Vol. 682.

Solow, R. M. (1987). "We'd Better Watch Out." The New York Times Book Review section, July 12, 36.

Stiglitz, Joseph E. (2000). "Capital Market Liberalization, Economic Growth, and Instability." *World Development*, 28(6): 1075-1086.

Teresko, John (1999). "Information rich, knowledge poor?." Industry Week, 19-24.

TI (2007). *Corruption Perception Report*. Berlin: TI.

Toffler, A. (1990). *Power shift: Knowledge, Wealth, and Violence at the Edge of the 21st Century*. New York : Bantam Books.

UN (1994). *Telecommunication and Economic Development*. Baltimore: The Johns Hopkins University Press.

UNDP (2009). *Human Development Report 2009*. New York: UNDP.

Wilhoit, G. (1981). "Foreign news coverage in two U.S. wire Service." *Journal of Communication*, 31(2): 55-63.

Wooldridge, J. M. (2002). *Economic Analysis of Cross Section and Panel Data*. Massachusetts: MIT Press.

World Economic Forum (2010). *The Global Competitiveness Report*. Geneva: WEF.

Wresch, W. C. (1996). *Disconnected: Haves and Have-Nots in the Information Age*. New Jersey: Rutgers University Press.

Zdenek, Drabek & Warren, Payne (2002). "The Impact of Transparency on Foreign Direct Investment." *Journal of Economic Integration*, 17(4): 777-810.