An Analysis of the Economic Effect Resulting from New Technology Convergence

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Chapter 1. Introduction

Recently, the global economy has entered a period of low growth—the so-called "New Normal" era—not only for the advanced economies, but also for the developing nations, the latter having previously achieved rapid growth.

Under the circumstances, many countries, including Korea, have been paying close attention to the trends toward convergence and fusion within the field of information and communications technology (ICT). In many previous studies, ICT has been defined as a general-purpose technology; indeed, numerous examples of empirical research have shown that ICT influences productivity in other industries and fuels innovation. In view of this, ICT convergence may be said to represent a strategy for generating added value in a wide range of industrial areas.

As a foundation for the creative economy, ICT has an influence that spans all areas of industry, with effects on the national econo-

my that follow three specific channels. First, rapid developments in ICT have led to total factor productivity rising at a faster rate in ICT manufacturing than in other industries; this, in turn, has helped power productivity growth for the economy as a whole. Second, falling prices of ICT products have led to an increase in ICT investment; while ICT capital goods, which exemplify advances in technology, have come to substitute for other production input factors. In other words, inputs of ICT equipment, which is somewhat more efficient than existing non-ICT capital goods and human labor, have led to an increase in production efficiency in a phenomenon known as "ICT capital deepening." Third, ICT has long been fused with other industries as a general-purpose technology, resulting in greater efficiency in the production process and helping to promote innovation in other industries.

This study seeks to analyze ICT convergence from a different perspective. First, it considers the characteristics specific to ICT convergence and comparatively analyzes its aspects vis-à-vis those of other examples of technology convergence, including nano- and biotechnology. A conceptual framework along these lines is also presented at the end of the report.

Another aim is to gauge the impact of ICT convergence on economic development in Korea and offer a quantitative analysis of its anticipated future effects. Specifically, growth accounting methods are applied to analyze the extent to which ICT has helped boost economic development and productivity. (Growth accounting is an approach that is widely used to analyze the influence on productivity of different factors input during the production process.) These findings are then used to develop a computational general equi-

librium model to forecast the future economic impact of ICT convergence and conduct a preliminary analysis of hypothetical policy approach scenarios. It is hoped that the model developed here can eventually be refined to permit a range of policy experiments.

Chapter 2. ICT Convergence Policy and Previous Research

The ICT convergence phenomenon is expected to have a significant impact not only on product innovations in the industrial environment, but also on process innovations such as "smart processes." In anticipation of this, governments around the world have been striving to develop policy approaches focused on the use of ICT convergence to overcome low growth. The United States has consistently issued recommendations to individuals, educators, the government, and private enterprise supporting the development of convergence technology, and has allocated significant convergence technology–related funding at the federal government level in its research and development budget. Japan has attempted to use knowledge convergence among SMEs specializing in different business areas to promote the exploration of new areas. More specifically, it has regarded such convergence as a means of adapting to a new economic environment and creating added value. The countries of Europe have adopted a broad definition of convergence technology that encompasses human society, with a focus on the social and cultural effects of technology convergence (Kim Sang-hoon, 2013). China has adopted a convergence strategy as a way of overcoming its lag in technology competitiveness and nurturing new growth industries, with a focus on advancing its

industries and improving public welfare.

In Korea, policy support has been provided on a consistent basis; the government's third Science and Technology Framework Plan, formulated in 2013, identifies the creation of new IT convergence industries as a key element of its strategy. Related ICT convergence policies have been implemented in a range of areas, beginning with the "New IT Strategy" near the end of the first decade of the twenty-first century and continuing with the Framework Plan for National Convergence Technologies (2009–2013), the first Framework Plan for Industry Convergence Development (2013–2017), the IT Convergence Expansion Strategy (2013–2017), the Information Communications Promotion and Convergence Encouragement Framework Plan (2014–2016), and the fifth National Master Plan for Informatization Promotion (2013–2017). Despite some trivial differences in support areas and methods, these policy approaches are essentially indistinguishable from one another. Analysis of three forms of support policy for which detailed budget execution data were available showed that budgets, due to the nature of ICT convergence, had generally been formulated to promote the spread of ICT across all industries rather than focusing on one particular industry. Even so, a particularly high percentage of support had been allocated for ICT convergence in manufacturing, education, and research and development.

Meanwhile, the social and economic ripple effects of ICT convergence have been the subject of a lively academic debate. Analyses have focused on a broad range of products, technologies, and industry levels, and have employed a diverse range of methodologies. To date, however, no clear definition of "convergence" has

been established, and clear limitations exist with the available data.

Technology categorization approaches such as International Patent Classification and Korean Standard Industrial Classification are ill suited to precise quantification of the growing ICT convergence phenomenon. The root cause of the issues that arise with most current research lies in the difficulty of precisely defining convergence and assessing its characteristics. For this reason, the current study applies a multidimensional scaling approach in analyzing the characteristics of ICT convergence, which are then used to attempt a definition of the concept.

Chapter 3. Analysis of ICT Convergence Characteristics

The term, convergence, is generally defined as the phenomenon of two or more elements concentrating on a single element or in a single direction. At the outset, the technologies involved are confined to specific industries or independent technological areas. In combination, however, these disparate technologies produce converging technology, which has recently been identified as a new form of technology providing a basic framework for guiding technological innovations in the twenty-first century.

The category of ICT convergence encompasses cases of convergence among new technologies (e.g., nanotechnology, biotechnology, and ICT) to overcome the limitations of the individual technologies in isolation, as well as ICT convergence industries based on the combination of ICT with manufacturing (e.g., ICT + some mainstay industry such as automobiles, shipbuilding, machinery, fibers, defense, or healthcare). Accordingly, ICT convergence may

be defined as the combination of ICT with some other technology or industry or service.

On this perceptual map, certain arrows can be drawn to show major convergence characteristics for different areas depending on the distances between stimulus points. To focus on ICT convergence, the chief concern of the current analysis, ICT-based convergence can be represented as having the most varied characteristics in terms of convergence focus, while the mainstream consists less of technology-centered convergence than of convergence among products, industries, and services. Moreover, it may be concluded that the focus of ICT-based convergence is more on supplementing existing technologies or expanding existing markets than on creat-

Figure 1. Perceptual Map Showing Similarities in Convergence Characteristics for Different Business Areas

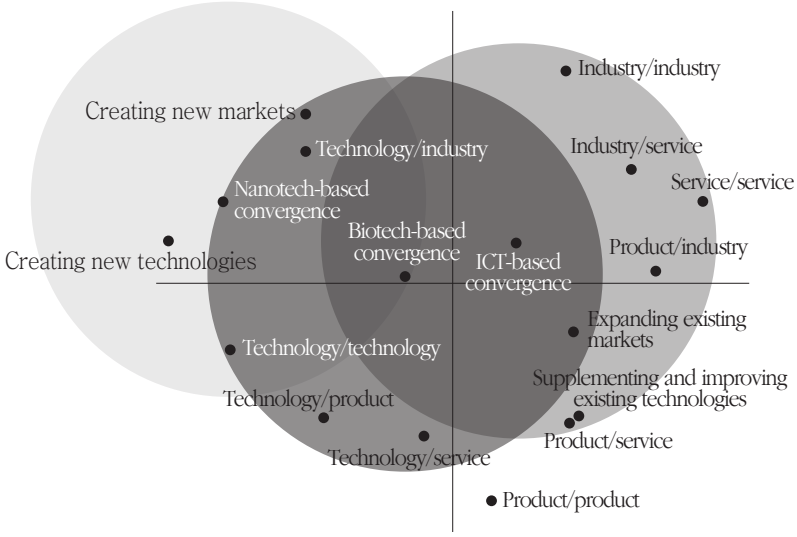


Table 1. Targets and Effects of ICT-, Biotech-, and Nanotech-Based Convergence

	ICT-Based	Biotech-Based	Nanotech-Based
Convergence targets	Industry/service Product/industry Industry/industry Product/service Service/service	Technology/industry Technology/product Technology/service Technology/technology	Technology/industry Technology/technology
Convergence effects	Supplementing and expanding existing technology Expanding existing market	Supplementing and expanding existing markets Creating new markets	Creating new technologies Creating new markets
Other areas with similar Characteristics	BT-based convergence	ICT-based convergence, BT-based convergence	BT-based convergence

Note : * Listing of criteria in overlapping circles on perceptual map.

ing new technologies or markets in anticipation of biotechnology or nanotechnology convergence.

Taken together, the findings show differences in the targets and levels of convergence according to different patterns.

This implies that a different methodological approach to ripple effect analysis should take those characteristics of convergence into consideration when measuring the economic effects of corresponding convergence types. Specifically, the relatively strong characteristics of inter-industry and product/service convergence suggest that attempts to measure ripple effects from ICT-based convergence, which are of concern in this study, should focus on those types rather than on simple convergence between technologies per the traditional approach.

Chapter 4. ICT Convergence and Industrial Development

In this chapter, growth accounting analysis is used to measure the ICT industry's influence on Korea's economic growth since the 1970s. As noted in the introduction, ICT contributions to the national economy occur through three main channels. First, because of rapid developments in ICT, related industries have shown a much higher rate of productivity growth than other industries, which has helped drive an increase in total factor productivity across the national economy. As the aforementioned results show, the average annual rates of increase in labor and total factor productivity for ICT manufacturing and ICT services during the 1990s and the first decade of the twenty-first century were notably different from the corresponding figures for non-ICT industries. Moreover, the importance of total factor productivity has grown since the 1990s, and ICT-related industries have made a very large contribution to the increase in total factor productivity for the country as a whole.

Second, ICT development and the resulting decline in ICT product prices have increased ICT investment, and a phenomenon of ICT capital deepening has arisen in which ICT capital goods are replacing other production goods. This phenomenon can be observed in the fact that the rate of increase for ICT tangible and intangible capital in Korea has far outpaced that for non-ICT forms of capital.

Finally, as it is incorporated across industries over time as general-purpose technology, ICT contributes to greater efficiency in production processes and plays a role in generating innovation in other industries. This can be observed in the large role that ICT

tangible and intangible capital plays among factors increasing labor productivity in other industries. Even in terms of factors promoting labor productivity across all industries, the ITC industry accounted for around 40 percent during the '90s and over 20 percent during the first decade of the twenty-first century. From this, it can be concluded that ICT has represented a key national industry driving Korea's economic growth to date.

Chapter 5. ICT Convergence and Policy Assessment Modeling

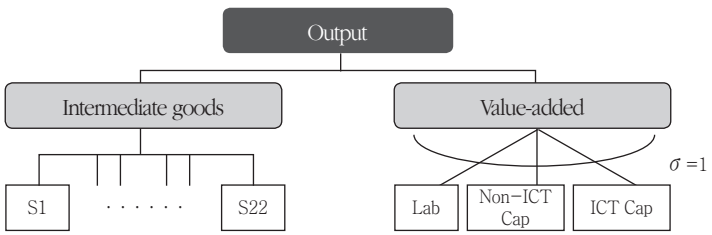
In this chapter, a social accounting matrix is developed and used as a basis for constructing a computable general equilibrium model. Prior to constructing that model, it must first be decided which policies to apply to the simulation. The aim of this study is to provide a quantitative assessment of the effects of ICT investment and ICT convergence in other industries on Korea's future economy. In terms of that goal, a dynamic (rather than static) model is needed to analyze a given point in time. For this study, a recursive dynamic computable general model was used, with an equilibrium point found for each year. For the time period, 2013 was set as the base year for a simulation extending to 2030. During that period, the productive population (i.e., those aged 15 to 64) is expected to undergo continued change, which will lead in turn to changes to the labor supply. The risk of not reflecting a changing population structure in a long-term predictive model covering a period of ten years or more is that it will generate unrealistic predictions. In order to incorporate workforce changes into the model,

future population trend data from Statistics Korea were used.

Investment goods were broadly classified into two types: those related to the ICT industry and those related to non-ICT industries. In other words, the use of goods produced by ICT manufacturing or services (ICT-related equipment, parts, and/or software) as investment goods increases the ICT capital stock, while the use of goods produced by other industries as investment goods increases the non-ICT capital stock.

One important difference between the ICT and non-ICT capital stocks is their differing price curves when qualitative product differences are considered as a reflection of technological development. Because qualitative change is so much faster for ICT products than for the products of other industries, failure to adjust prices results in underestimation of actual ICT capital stock. In the United States, the hedonic pricing approach is used to adjust prices so as to reflect developments in ICT. Previous studies by Schreyer (2000) and Jung et al. (2013), among others, have used a harmonized ICT deflator approach to correct prices for qualitative ICT difference, using the U.S. ratio of ICT to non-ICT capital prices to adjust the prices of ICT capital goods in other countries.

Figure 2. Industry Production Structure

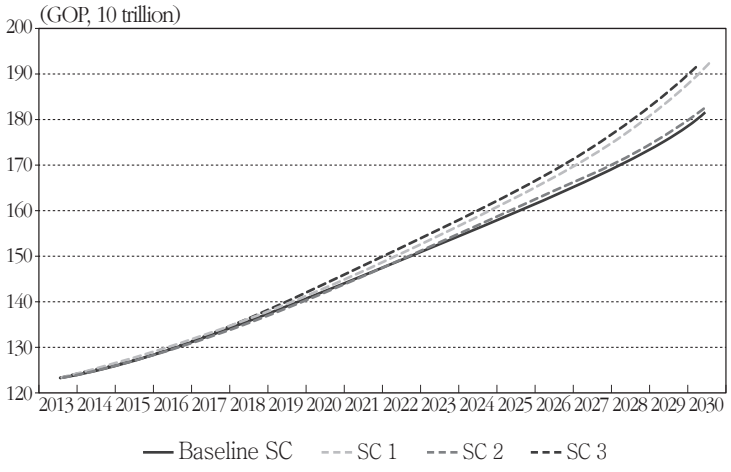


Chapter 6. Empirical Analysis of ICT Convergence Policy

In this chapter, the computable general equilibrium model discussed in the last chapter is used to perform experiments with specific policy types. Two scenarios were hypothesized: one in which the current situation continues without any implementation of policy measures, and another in which investment in capital goods is increased. Simulations showed the scenario of increased ICT capital goods investment to be more helpful in terms of economic growth. Because the decline in prices due to technology development is greater for ICT capital goods than for general investment goods, even the same level of investment is more helpful in boosting economic growth and productivity.

One fact that should be taken into account is that the limited nature of investment resources necessitates decisions on distribution

Figure 3. GDP Trends for Four Scenarios



priorities. Moreover, deciding these priorities requires an understanding of the characteristics of Korean industries and a carefully crafted strategy. As an example, this chapter juxtaposed cases in which uniform increases in ICT investment slightly raised the percentage of investment in leading manufacturing industries against other cases in which it did not. Because leading industries typically have higher total factor productivity than other industries, and larger ripple effects on the national economy, it was determined that investment in these industries is more helpful in terms of economic growth. From this, it can be seen that investment priorities are just as important as amounts invested.

Chapter 7. Policy Implications

(1) The Role of ICT Convergence in Sustainable Economic Growth

□ ICT Convergence as a Next-Generation Growth Engine

Internally, Korea has lost growth engines amid the global economic downturn; at the same time, externally, it is contending with hot pursuit by China and other developing economies. Under the circumstances, ICT convergence may be viewed as a new driver of economic growth for Korea. In particular, it should be noted that ICT has permeated the full range of industries as general-purpose technology, and that it is becoming more difficult to exclude in terms of advancing industrial structure and generating added value. In other words, ICT can be said to represent the form of indus-

try/technology convergence with the farthest-ranging effects across industries. At the same time, there are limits to the potential of ITC to stimulate growth based on technological advances alone. It is therefore necessary to apply cutting-edge ICT to other industrial areas to create new high-value-added fields.

□ Promoting Industry Productivity through ICT Convergence

The use of ICT hardware and software offers a means for manufacturers to increase productivity and reduce energy consumption, while at the same time providing consumers with services that did not previously exist. During past phases of the nation's industrial development, productivity increased as a result of the replacement of human workers with machinery in what may be described as "capital deepening." As the growth accounting analysis in this study showed, ICT equipment has recently increased labor productivity by again replacing human workers in a process that may be called "ICT capital deepening." The true strength of ICT thus lies in the way in which it propagates positive external effects by promoting productivity and encouraging innovation across all industries.

□ Solving Future Societal Problems through ICT Convergence

ICT convergence also has the potential to help societies address costly social problems. For example, smart grids—developed through convergence between ICT and the electric power industry—have been posited as a method of curbing energy consumption. Problems related to urbanization may be solved through

convergence between ICT and existing urban infrastructure, as exemplified by smart cities and intelligent transportation systems. The rising societal costs of an aging population may be mitigated somewhat through remote diagnosis and smart healthcare services. While the decline in the productive population poses a potentially fatal drag on national economic growth, this may be overcome through production efficiency improvements and automation in the form of smart factories.

(2) Strategic ICT Convergence Policies

□ Priorities in ICT Convergence Investment

National finances are limited, and the state's role in directing industrial development is more constrained than in the past. Accordingly, priorities must be decided for ICT convergence investment. Policies that are created mostly for show, with sweeping increases in ICT convergence across all industries, are not only lacking in efficacy but also unhelpful for industry and the national economy. At the present time, policy efficiency is equal to company efficiency as a matter of paramount importance.

□ Creating Continued Demand through ICT Convergence

One of the key roles of a government is to assist in hastening the commercialization of the products developed by companies through the creation of ongoing public demand and test beds, among other measures. Examples can already be found of unprec-

edented achievements thanks to the introduction of the Internet of Things, big data, artificial intelligence, and cloud services to the public sector. One of the most important contributions that the government can make is to invite continued investment in ICT capital goods by creating public demand for ICT-based cutting-edge industries.

□ Fostering SMEs and Startups

The spread of ICT convergence has led to a change in the industry paradigm. Shifts are predicted from the current manufacturing focus to a service focus, from a product focus to a software focus, and from a limited-item mass production structure to one of small-scale production of more varied items. One of the most important roles in this process belongs to creative ideas from SMEs and startups. These types of companies will need to emerge as centers of industry for the ICT convergence era. The most crucial role for the government, in turn, is to establish support policies in financial and institutional terms so that creative ideas can be immediately commercialized. Additionally, it should work to supplement its national innovation system to create an ecosystem where innovations can spread easily across the country. While developing economies may imitate existing technologies, they are less likely to be able to imitate national innovation systems within a short time.

□ Improving Regulations and Coordinating Duties across Agencies

ICT convergence is destructive to established industries and

technology borders. This is one reason that it creates added value. Yet the compartmentalized distribution of institutions and presiding agencies for different industries poses a substantial risk of impeding the spread of ICT convergence. Moreover, it is also necessary to adopt a negative-list system in applying regulations related to ICT convergence and establish effective systems of cooperation to minimize conflict between areas where agency duties overlap. In terms of legislation and enforcement, a flexible response is needed, with sufficient consideration given to opinions not only from experts but also from industry participants themselves.