Analysis of the Dynamic Changes in and Effects of Service-IT Industry Convergence

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Chapter 1. Introduction

A growing number of policy measures for promoting IT convergence in industries have been proposed recently, with particular emphasis on encouraging the use of IT in the service sector, which has long lagged behind the manufacturing sector in terms of both productivity and the application of IT. Despite the rising importance of service-IT industry convergence, little quantitative and empirical research has been done to determine the extent to which IT convergence has progressed so far, as well as in what manner it has progressed and with what effects on the service sector. The policy measures and legislative drafts that have been proposed so far thus tend to be quite abstract and generic in substance (Koh et al., 2014).

While numerous attempts have been made to measure the progress of service-IT industry convergence and determine how IT

convergence has affected the performance of the Korean economy, few have approached the matter from the perspective of industries. Moreover, very few studies have examined IT convergence over certain periods of time from dynamic perspectives, with fewer still having focused on the service sector.

Motivated by the lack of research on these key questions, this study: (1) examines the dynamic changes occurring in various service industries that have adopted IT; (2) analyzes the economic effects of service-IT convergence; and (3) proposes measures for promoting further and more effective service-IT convergence.

With a view to providing basic information and identifying implications for not only the service sector as a whole but also policymaking with the aim of promoting the convergence of IT with various service industries, this study specifically focuses on the following.

First, using the input-output tables for the years 2005 through 2014, featuring a total of 101 industries, this study measures the degrees of convergence between 31 conventional service industries and four IT manufacturing and service industries, on both the supply and demand sides, and examines the dynamic changes that have been occurring in the process. The methodology formulated by Xing et al. (2011) is applied to measuring the degrees of industry convergence.

Second, using a quantitative model based on a production function, this study measures and analyzes how the diverse IT-service industry indicators on the supply and demand sides have influenced the performance of service industries, including their output and labor productivity.

Third, based on the analysis of the dynamic changes in service-IT industry convergence and the effects of such convergence on the performance of service industries, this study identifies and explains implications for the service sector as a whole and implications for increasing the effectiveness of policymaking aiming to promote service-IT industry convergence.

Chapter 2. Theoretical Background and Literature Review

1. Concept and Significance of Industry Convergence

The recent trend has been to define and explain convergence in terms of the stage of innovation in which such convergence takes place. Convergence-induced innovation takes place in three to four stages. Industry convergence refers to the final stage of this innovation, where technology and market convergence occur simultaneously. Industry convergence thus transforms the existing industrial structures and business ecosystems (Choi et al., 2013).

Korea's Industrial Convergence Promotion Act (ICPA), for example, defines industry convergence as consisting of "activities for innovating existing industries or creating new industries with societal and market values through the creative combination and convergence of industries, of technologies and industries, and of technologies." Industry convergence represents the culmination of scientific (or knowledge) convergence, technological convergence, and market convergence and is often representative of the extent to which convergence has progressed in a given society, economy, or country (Koh et al., 2014).

2. Literature Review and Significance of This Study

Previous studies on convergence, particularly those on industry convergence, employed diverse methods and techniques in analyzing their subject. However, this research is still in the early stages due to the absence of a universally accepted definition of convergence and a general consensus on what indicators or measures may be used (Hacklin and Wallin, 2013; Choi et al., 2013; Choi et al., 2014; and Koh et al., 2014). Narrowing the range of relevant studies to those focusing on industry convergence reveals a growing tendency toward quantification and the diversification of methodologies used (Choi et al., 2013, and Choi et al., 2014). Xing et al. (2011), which attempts to measure industry convergence using input-output tables, provides a particularly pertinent example.

This study borrows the methodology used by Xing et al. (2011) to measure service-IT industry convergence based on input-output tables. The distinctiveness and significance of this approach can be summarized as follows (Koh et al., 2014).

First, as the approach allows the researcher to address industry convergence at the macro level, it enables the resulting study to overcome the inability of micro-level studies to identify and analyze inter-industry convergence. Second, unlike the majority of existing studies, the conclusions of which are limited due to the use of difficult-to-access micro-level data (data on merger and acquisition (M&A) deals or joint ventures, standard industrial classification (SIC) system-based industry participation data, etc.), this study's approach relies on easily accessible input-output tables with well-established theoretical and empirical values and uses a far

more intuitive and simpler method for measuring industry convergence. Third, whereas existing studies were compelled to focus on convergence on the demand or supply side only, this study analyzes industry convergence on both sides. Fourth, the use of input-output tables spanning multiple years affords the researcher the opportunity to perform both static and dynamic analyses.

The following factors serve to further distinguish this study from the established literature.

First, using the method proposed by Xing et al. (2011), this study quantifies and measures service-IT industry convergence in Korea in a manner that conforms to the theory of convergence. It also provides analyses of the dynamic changes in convergence and its effects on the Korean economy by measuring convergence on both the supply and demand sides. Second, using input-output tables spanning a period of 10 years (2005 through 2014), modified to encompass a total of 101 industries, this study provides an analysis of the dynamics by which service-IT convergence has progressed and evolved in Korea over time. Third, this study uses a more quantitative and refined two-way error, fixed effects panel analysis model to examine how service-IT convergence, measured using the method of Xing et al. (2011), has affected the performance of the Korean economy.

Chapter 3. Dynamic Measurement of Service-IT Industry Convergence and Its Implications

1. Overview

In Chapter III, we apply the method of Xing et al. (2011) to the

input-output tables spanning 2005 through 2014, modified to encompass 101 industries, for the purpose of measuring the degrees of service-IT industry convergence. In this regard, there are four IT industries of particular concern: the electronics manufacturing, information and communication service, computer and software service, and broadcasting service industries. The convergence between these four IT industries and the rest of the 101 industries is measured on both the supply and demand sides. Using the degrees of convergence so measured, we then estimate the overall level of convergence between industries and IT in general, the level of convergence between industries and the IT manufacturing industry (electronics), and the level of convergence between industries and the three IT service industries, on both the supply and demand sides.

We then examine and analyze: (1) how these three levels of convergence have changed with respect to all industries, the manufacturing sector, and the service sector, and (2) how the three levels of convergence have changed with respect to the 31 service industries. In addition, we divide the 31 service industries into different groups depending on the extent and pace of their convergence with IT industries to identify implications for further convergence between IT industries and different service industries.

2. Method

The method used by Xing et al. (2011) measures convergence between two industries in terms of the similarity between the intermediary input ratios and between the intermediate and final

demands of the given industries, i.e., the similarity between the production technologies and/or between the demands of the two industries (Koh et al., 2014). Similarity between intermediate input ratios indicates similarity between production technologies, enabling the researcher to measure the convergence between industries on the supply side. Similarity between intermediate and final demand ratios, on the other hand, indicates similarity in terms of demand, which then supports the measurement of convergence on the demand side. Most importantly, this method measures such similarities and convergence using input-output tables, which refer to each industry or sector as a "pure sector." These pure sectors are defined as sharing the same input structure, manufacturing process, and output distribution. Using this definition of pure sectors helps clarify the boundaries between industries. In turn, this clarity of industry demarcation allows the researcher to measure and evaluate the similarities between industries on both the supply and demand sides, and therefore supports the quantification of industry convergence (Koh et al., 2014).

Applying the pure sector assumption and the method of Xing et al. (2011), we first estimate vector $\widetilde{A}_t^i$ for the direct consumption coefficient representing the ratio of intermediate input to total input and vector $\widetilde{B}_t^i$ for the demand coefficient representing the ratios of intermediate and final demands to total demand, and use them to measure industry convergence on both the supply and demand sides, respectively.

$$\widetilde{A}_t^{\,i} = \begin{pmatrix} A_{1t}^i \\ A_{2t}^i \\ \vdots \\ A_{N-1t}^i \\ A_{Nt}^i \end{pmatrix} = \begin{pmatrix} x_{1t}^i / X_t^i \\ x_{2t}^i / X_t^i \\ \vdots \\ x_{N-1t}^i / X_t^i \\ x_{Nt}^i / X_t^i \end{pmatrix}, \widetilde{B}_t^{\,i} = \begin{pmatrix} B_{1t}^i \\ B_{2t}^i \\ \vdots \\ B_{N-1t}^i \\ B_{Nt}^i \\ B_{N+1t}^i \end{pmatrix} = \begin{pmatrix} y_{1t}^i / Y_t^i \\ y_{2t}^i / Y_t^i \\ \vdots \\ y_{N-1t}^i / Y_t^i \\ y_{Nt}^i / Y_t^i \\ r_t^i / Y_t^i \end{pmatrix}$$

Industry convergence on the supply side is the result of technological convergence, and the similarity between the direct consumption coefficients of industries reflects the similarities between the production processes and technologies of those industries. Industry convergence on the demand side, however, represents the tendencies of different industries catering to the same demand or engaged in the same business. The similarity between the demand coefficients of industries thus reflects the similarity of those industries' demand for intermediate materials as well as the final demand for those industries' products (Koh et al., 2014, and Xing et al., 2011).

$$S\_Conv_{ijt} = \frac{Cov(\widetilde{A}_t^{\,i}, \widetilde{A}_t^{\,j})}{\sqrt{Var(\widetilde{A}_t^{\,i})\, Var(\widetilde{A}_t^{\,j})}},$$

$$D\_Conv_{ijt} = \frac{Cov(\widetilde{B}_t^{\,i}, \widetilde{B}_t^{\,j})}{\sqrt{Var(\widetilde{B}_t^{\,i})\, Var(\widetilde{B}_t^{\,j})}}$$

Accordingly, the larger the vectors of the given industries' direct consumption and demand coefficients and the closer the vectors are to a value of one, the more converged the industries are on the supply and demand sides.

3. Data

The input-output tables for the years 2005 through 2014 used by this study to analyze the dynamic changes in service-IT industry convergence in Korea required some modification. Furthermore, employment tables needed to be created for the relevant industries included in the modified input-output tables in order to analyze the effects of service-IT industry convergence on labor productivity per capita in the service sector.

We thus modified and reformatted the input-output tables with respect to the 101 industries and sectors that appeared on a consistent basis. The seven industries from 001 to 007 pertain to agriculture and livestock farming; the following four, 008 through 011, to mining; the next 53, 012 through 064, to manufacturing; the next six, 067 through 070, to energy, the environment, and construction; and the remaining 31, 071 through 101, to service. The IT manufacturing industry is 055 (electronics and machinery), while the IT services industries are 082 (information and communication service), 083 (computer and software service), and 084 (broadcasting service). It is these four industries that are used in our analysis of IT convergence. In addition, taking 2010 as the baseline year, we created access-invariant input-output tables, applying the 101 industries and sectors identified based on the tables for 2010 as the reference for the tables of all 10 years from 2005 to 2014. We also created the employment tables for the 101 sectors for all years from 2005 through 2014 so as to estimate labor productivity per capita in each sector (measured in terms of output per capita and value-added per capita) each year.

4. Findings

Using the input-output tables of 101 sectors for the years 2005 through 2014 and the method of Xing et al. (2011), we measured service-IT convergence on both the supply and demand sides with respect to all industries, the manufacturing sector, the service sector, and each of the 31 service industries.

The findings of our analysis can be summarized as follows.

(1) Convergence between IT Industries and the Manufacturing and Service Sectors

First, in all industries, including the service sector, IT convergence was greater on the demand side than on the supply side. Convergence of the IT manufacturing sector and the service industries was also significantly higher on the demand side than the supply side. In other words, demand was the main factor driving the increasing industry convergence with IT in Korea over the 10 years from 2005 to 2014. However, the pace of convergence with IT was faster on the supply side than on the demand side.

Second, contrary to our expectation, the service industries led other industries in terms of convergence with IT, on both the supply and demand sides. Whereas the manufacturing industries showed significant convergence with only the IT manufacturing industry, the service industries showed significant convergence with IT in general, with the exception of the IT manufacturing industry on the supply side.

Third, the indicators of industry convergence between the man-

ufacturing and service sectors varied significantly over the 10-year period. Both sectors' convergence with IT on the supply side lagged behind their convergence with IT on the demand side. However, supply-side convergence with IT was growing rapidly, while the pace of demand-side convergence with IT was slowing.

(2) Convergence between each Service Industry and IT

First, while the specifics of convergence with IT varied dramatically from industry to industry within the service sector, such convergence tended to be stronger overall on the demand side than on the supply side. However, the other business service industry showed significant convergence with information and communications, computer and software, and broadcasting services on both the supply and demand sides, while the research and development service industry was the only service industry that showed strong convergence with IT on the supply side and weaker convergence on the demand side.

Second, with only a few exceptions, most service industries showed stronger convergence with IT services and weaker convergence with the IT manufacturing industry on the demand side, while showing weaker convergence with all four IT services in general on the supply side. In other words, convergence with the IT service industries has progressed much further than convergence with the IT manufacturing industry. The computer and software service industry was the only IT industry that saw strong convergence with the service industries in general and the IT manufacturing industry on both the supply and demand sides.

Third, of the three IT service industries, the information and communications service industry showed the highest level of convergence with the service industries in general on both the supply and demand sides. The broadcasting service industry failed to show the highest level of convergence with any of the service industries. Only certain IT service industries showed strong convergence with most of the service industries on both the supply and demand sides.

Fourth, while convergence with IT increased in almost all service industries on both the supply and demand sides over the 10-year period, the pace of that increase for most service industries was more dramatic on the supply side than on the demand side. Most service industries showed increasing convergence with the IT manufacturing and service industries on the supply side and with IT service industries on the demand side. No significant change was noted in convergence with the IT manufacturing industry on the demand side.

Chapter 4. Economic Effects of Service-IT Industry Convergence

1. Overview of the Analysis Model

The two main aspects of economic performance we consider are output and productivity. Because convergence with IT can have varying effects on these two factors, we consider the total output and value-added. For simplicity of analysis, we examine labor productivity, i.e., productivity per capita, of the single-factor input, in

addition to total output per capita and value-added per capita. In other words, we assume that convergence with IT industries influences (1) total output, (2) value-added, (3) total output per capita, and (4) value-added per capita in each industry. We then apply the Cobb-Douglas production function—perhaps the most commonly used of all production functions in analyses of the effects of convergence with IT—to these four economic indicators, and also assume that convergence with IT has impacts on technology shifters and technological progress. The models we use to analyze output $Y_{i,t}$ and labor productivity $\frac{Y_{i,t}}{L_{i,t}}$ can be expressed with the following equations:

$$\ln Y_{i,t} = a_0 + \theta Conv_{i,t} + \alpha \ln L_{i,t} + \beta \ln K_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

$$\ln \frac{Y_{i,t}}{L_{i,t}} = \widetilde{a_0} + \theta Conv_{i,t} + \widetilde{\beta} \ln \frac{K_{i,t}}{L_{i,t}} + \mu_i + \lambda_t + \epsilon_{i,t}$$

Here, a_0 and $\widetilde{a_0}$ are constants, while μ_i represents the unobserved individual heterogeneity of industry i, and λ_t, the unobserved time heterogeneity at time t. $K_{i,t}$ stands for the fixed capital input, and $L_{i,t}$ stands for the labor input of industry i at time t. $\epsilon_{i,t}$ is a disturbance term. $Conv_{i,t}$ represents the diverse indicators of the convergence of industry i with IT at time t, while θ reflects how these diverse indicators of IT convergence affect the output and productivity of industry i at time t.

Our empirical analyses of IT convergence in all industries, the manufacturing sector, and the service sector involve the use of four empirical models to estimate: the (1) convergence with all IT indus-

tries on the supply and demand sides, (2) convergence with the IT manufacturing and service industries on the supply and demand sides, (3) effects of convergence with each of the four IT industries, on the supply and demand sides, on the technological shifter of the production function. The models we use involve two-way error components to account for the unobserved individual heterogeneity of each industry and the unobserved time heterogeneity at specific points in time. We then apply a panel model that assumes the fixed effects of these two types of heterogeneity.

2. Findings

The results of our analysis on the effects of service-IT industry convergence on the four indicators of economic performance can be summarized as follows.

(1) Effects on Productivity

□ Total output

First, as with most industries, convergence with IT industries served to increase the output of service industries. Unlike other industries, however, convergence with IT on the demand side had far greater impacts on the output of service industries than convergence on the supply side.

Second, service industries' supply- and demand-side convergence with the IT manufacturing industry and demand-side convergence with the IT service industries both served to increase the

total output of service industries. Supply-side convergence with the IT manufacturing industry, by far, had the greatest output-increasing effect. This contrasts with the findings in relation to convergence between other industries and IT, and suggests the need for a more refined and detailed analysis of service-IT industry convergence and its effects and implications for policymaking. It also indicates that policy measures that foster service industries' supply-side convergence with the IT manufacturing industry would be effective in increasing the total output of service industries.

Third, the patterns of convergence between service industries and specific IT industries showed significant variance from the patterns observed with respect to other industries, particularly the IT service industries on the supply side. Service industries' supply-side convergence with the electronics manufacturing and computer/software service industries and demand-side convergence with the information and communications service industry served to increase total output. However, supply-side convergence with the information and communications service industry led to a contraction of the total output of service industries. This result shows that policymakers need to tailor and refine their approach to promoting convergence with the IT industries based on careful consideration of the different effects convergence with IT can have on service industries.

□ Value-added

First, convergence with IT can have both positive and negative effects on the value-added of all industries and the manufacturing

industries. By contrast, convergence with IT on either the supply or demand side led to increases in the value-added of service industries. Convergence with IT is therefore much more effective and beneficial in respect to service industries than others.

Second, convergence with the IT manufacturing industry showed no significant effect on the value-added of service industries, whether on the supply or demand side. However, convergence with the IT service industries on both sides served to enhance the value-added of service industries. Although convergence with the IT manufacturing industry may be necessary to increase the total output of service industries, it may play a much smaller role in increasing value-added.

Third, whereas the IT service industries in general showed value-added-enhancing effects on some non-service industries, the value-added of service industries increased only as a result of supply- and demand-side convergence with the computer and software service industry. Encouraging convergence with this particular IT industry would therefore help increase the value-added of service industries in the short term.

(2) Productivity

□ Output per capita

First, unlike the cases of other industries, convergence with IT led to dramatic increases in productivity in service industries on both the supply and demand sides, while convergence on the demand side had a greater influence in terms of increasing output

per capita. Because convergence with IT industries significantly increases total output, value-added, and output per capita of service industries, policy measures designed to sustain and encourage greater service-IT industry convergence would be effective in supporting these industries.

Second, while convergence with the IT manufacturing industry on only the supply side enhanced the productivity of non-service industries, convergence with the IT manufacturing and service industries on both the supply and demand sides had the effect of increasing the productivity of service industries. In particular, demand-side convergence between service industries and IT services increased output per capita by the greatest margin.

Third, as with non-service industries, service industries also experienced some repercussions in terms of output per capita due to their convergence with certain IT industries. While service industries' supply-side convergence with the electronics and computer/software service industries and demand-side convergence with the electronics industry led to increases in productivity, their convergence with the information and communications service industry reduced output per capita.

□ Value-added per capita

First, contrary to all industries and the manufacturing industries, convergence with IT resulted in significant increases in the productivity of service industries on both the supply and demand sides. The fact that convergence with IT positively affected total output, value-added, output per capita, and value-added per capita of ser-

vice industries in general indicates that it will be important for policymakers to promote and sustain service-IT industry convergence in the coming months and years.

Second, while demand-side convergence with the IT manufacturing industry increased the productivity of all industries and the manufacturing industries, demand-side convergence with the IT service industries reduced productivity by even greater margins. In contrast, the productivity of service industries benefited greatly from convergence with the IT service industries on both the supply and demand sides, particularly with respect to value-added per capita on the demand side.

Third, certain IT industries, such as computer and software service, promoted the productivity of all industries and the manufacturing industries. Most of these industries, however, saw greater losses than gains in productivity due to their convergence with IT. Service industries, on the other hand, experienced increases in productivity following their convergence with all three IT service industries.

(3) Comparison of the Effects of Service Industries' Convergence with IT

The effects that convergence with IT exerts on service industries and their economic performances can be summarized as follows.

First, convergence with IT, whether on the supply or demand side, serves to improve all four indicators of service industries' performance. Convergence on the demand side tends to be more effective in improving these indicators than convergence on the

supply side. This is particularly evident with respect to total output and output per capita.

Second, convergence with the IT service industries tends to improve the performance of service industries in most cases, while convergence with the IT manufacturing industry improves the total output and output per capita of service industries only. Convergence with the IT service industries has an especially positive effect on the productivity of service industries.

Third, among the IT industries, only supply-side convergence with computer and software service has the effect of improving all four indicators of service industries' performance. Convergence with the other IT industries serves to improve only some of the performance indicators. In the meantime, supply-side convergence with information and communication service is the only case of service-IT industry convergence that reduces the total output and output per capita of service industries.

Chapter 5. Conclusion

This chapter summarizes the policy implications that can be drawn from the preceding analyses in relation to how service-IT industry convergence should be promoted and supported.

□ Promoting overall service-IT industry convergence

We recommend the following policy measures with respect to encouraging overall service-IT industry convergence.

First, our analyses indicate that service industries in general

should strive to maintain or even increase convergence with the IT industries.

Second, in the short term, it would be better to focus on service-IT convergence on the demand or business side. This will require relaxing the regulations that strictly compartmentalize the IT and service markets. It will also be necessary to promptly establish and provide the legal grounds necessary for introducing new convergence-based services. Finally, policymakers need to shift the entire legal system toward the negative approach in the long run.

Third, policy measures that serve to increase the extent and effectiveness of supply-side service-IT convergence in the long run are also needed. While service-IT convergence has already progressed to a considerable degree on the demand side, no such progress has yet been made on the supply side. In the long term, diverse forms of policy support will be needed to allow supply-side convergence to catch up with demand-side convergence and ensure that IT products and services are incorporated into the production of various services.

□ Promoting service-IT convergence across various industries

We propose the following policy measures to foster effective service-IT convergence in specific industries.

First, while promoting convergence between service industries and IT services should be the top priority in the short term, promoting convergence with the IT manufacturing industry will also be necessary to ensure the outward growth of service industries and their output and foster convergence with new IT services as

a means of increasing the value-added of service industries in the long term. In addition, policymakers need to relax the strict regulations separating the IT service and general service markets and devise policy plans that account for the different effects that convergence with the IT manufacturing and IT service industries will have on service industries on the supply side.

Second, policymakers need to allow the IT industries to lead the convergence with the service and manufacturing industries. While conventional industries have already achieved significant convergence with the IT service industries, comparatively little convergence with the IT manufacturing industry has occurred, particularly on the supply side. Sustained policy support will be thus needed to enhance convergence with the IT manufacturing industry in the long term. The conventional manufacturing and service industries, on the other hand, have achieved little convergence with each other through IT. Policy measures will thus be needed to promote the convergence of these two conventional industries, especially through IT and mutual learning and emulation.

Third, policy support is needed to ensure the supply-side convergence of more diverse service industries with computer and software service. This, in turn, will require more detailed analyses and fine-tuned policy measures. Moreover, policymakers need to promote innovation and competitiveness in computer and software service, so that it can be applied even more effectively to a wider range of service industries. They will also need to find out why information and communications service has no positive effects on the production and distribution processes of service industries, and devise policy measures to address and correct the problem.