Telecommunications Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Telecommunications Policy

URL: www.elsevier.com/locate/telpol

Structural changes and growth factors of the ICT industry in Korea: 1995–2009

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ARTICLE INFO

Keywords:
ICT industry
Structural changes
Growth factors
I–O SDA
Korea

ABSTRACT

This study performs an Input–Output Structural Decomposition Analysis on the ICT industry in Korea between 1995 and 2009 to examine its structural changes and growth factors. According to the results of the structural change analysis, the ICT manufacturing field exhibited a deepening of the so-called jobless growth phenomenon. Although the output of the ICT manufacturing field grew dramatically, employment consistently decreased. In contrast, the ICT service field began to show a problem with reduced labor productivity. Although the ICT service field's output experienced a slowdown in growth, employment experienced an exponential increase. According to the results of the growth factor analysis, the ICT industry's growth was fueled by export expansion, followed by consumption expansion, technological change, inventory expansion and investment expansion. However, import substitution of intermediate goods and end goods had negative effects on the ICT industry's growth in Korea. In the industrial sector, the electronic component sector and broadcasting and telecommunication equipment sector experienced marked growth, and the electronic component sector scored the greatest contribution. Furthermore, in spite of the rapid growth in other ICT manufacturing sectors, the information equipment sector sank into stagnation, and the contribution of the ICT service sector was constantly decreasing.

1. Introduction

Pushing for export-oriented industrialization through six successive 5-year economic development plans implemented between 1962 and 1996, Korea achieved expeditious economic growth and advanced industrialization. Korea's GDP, which was a mere 352 billion won (current prices) in 1962, increased over 1300 times in one-third of a century. GNI, $87 (current prices) in 1962, grew by over 140 times during the same period. However, although the Korean economy continued to thrive, it experienced negative growth (–5.7%) in 1998 in the wake of the foreign exchange crises that occurred at the end of 1997. Furthermore, the economy is currently encountering a critical situation because of the global financial crisis that began in the latter half of 2008. In response, the Korean government has committed to establishing policies that make the information and communication technology (ICT) industry a driving force to overcome the economic crisis. Moreover, the

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http://dx.doi.org/10.1016/j.telpol.2015.08.001
0308-5961/

government cares deeply about inter-industrial convergence to ensure that the ICT industry is positioned to lead national economic growth (Shin et al., 2012).

Korea has proven that it is the strongest ICT leader in the world, ranking 1st on the ICT development index for the past 4 years (ITU, 2011, 2013); the index is a comprehensive assessment based on ICT readiness, ICT intensity and ICT capability. However, Korea's position is not as positive in the IT industry competitive index, which is based on a comprehensive analysis of the R&D environment, the business environment, the support of the resources for the ICT industry's development, the ICT infrastructure, human resources and legal resources; it took a nosedive to the 19th position 5 years after it was ranked 3rd in 2007 (BSA, 2011). It is naturally difficult to accept this deteriorated ranking in the IT industry competitive index as a genuine competitive devaluation of the ICT industry in Korea. However, this drastic decrease can be interpreted as a wake-up call that the ICT industry needs to implement an overhaul. In this regard, it is necessary to examine the structural changes and growth factors in the ICT industry in an effort to create new growth engines for the ICT industry.

To understand changes in the socioeconomic structure, it is essential to analyze their impetus or sources. Input–Output Structural Decomposition Analysis (I–O SDA hereinafter), a method of analyzing structural changes through the comparative static transformation of various socioeconomic factors, has been widely used to assess the effects of economic growth and how changes in sectors and technologies affect socioeconomic factors within a nation or among nations (Hoekstra & van den Bergh, 2003). Initially, such studies primarily concentrated on changes in the economic structure at the national level. Representative studies include those conducted by Feldman, McLain, and Palmer (1987), who examined changes in the economic structure in the U.S., and by Skolka (1989), Dewhurst (1993) and Liu and Saal (2001), who performed structural decomposition analyses on the economies in Austria, Scotland and South Africa. Thereafter, researchers began focusing on structural transformation at an industrial level.

Representative studies of the latter include those conducted by Barker (1990) who analyzed the causes behind the service industry's structural changes in the U.K., Lee and Schluter (1993) who delved into the structural changes in the food and textile industries in the U.S., and Hayashi (2005) who examined the changes in the industries and trade structure in Indonesia. Studies on changes in the industries and in the trade structure among nations were also conducted by researchers such as Oosterhaven and van der Linden (1997), who conducted a comparative analysis on changes in the economic structure in eight nations in the EC, and Fujikawa and Milana (2002) who compared and analyzed the comparative level of price differences by industrial sector in Japan and China.

In recent years, a growing number of people have developed an interest in the structural changes of socioeconomic factors in various social sectors including employment, the environment and energy. Representative studies on changes in the employment structure were conducted by Han (1995), who examined factors and aspects of the changing employment structure in Japan; Koller and Stehrer (2010) who examined the changing employment structure according to integrated trade and transformed outsourcing patterns in Austria; and Pei, Oosterhaven and Dietzenbacher (2012) who analyzed the effects of exports of advanced electronic products on increased income in China. Representative studies in the environment and energy sectors have been conducted by Rose and Chen (1991) who analyzed changes in the energy consumption structure in the U.S.; Wier (1998) who examined changes in the exhaust gas emission structure in Denmark; Jacobsen (2000) who delved into relations between trading patterns in the manufacturing industry and energy consumption in Denmark; Kagawa and Inamura (2004) who conducted a comparative analysis on embodied energy demand in Japan and China; Yamakawa and Peters (2011) who conducted research on changes in energy consumption and CO_2 and green-house gas emissions in Norway; and Su and Ang (2012) who explored changes in energy consumption and the emission structure of exhaust gas.

In the I–O SDA model, the results of an analysis can vary dramatically depending on the weight, and it is thus necessary to be cautious when determining the weight method. Previously, a simple viewpoint method or combination method was widely used. However, alternatives such as the average contribution rate method, the mid-point weight method, the Mongomery method and the Sato-Vartia method, which can generate theoretically ideal results, have recently been suggested. These methods consider the determination of viewpoint to be arbitrary, and the contribution is dramatically changed by factor according to the time applied. The average contribution rate was applied in studies by Holland and Cooke (1992) and Wang, Sun, and Chou (1992), whereas the mid-point weight method was applied in research by Wyckoff and Sakurai (1992), Dietzenbacher and Los (1998), Hitomi, Okuyama, Hewings, and Sonis (2000) and Miller and Blair (2009). Dietzenbacher and Los (1998) suggested the mid-point weight method, which can be conveniently calculated with two factorizing formulae based on the result of an empirical analysis based on 24 factorizing formulae through the use of 4 factorizing variables. Additionally, de Boer (2008) concluded that it is possible to obtain a value closer to the average values of all factorizing formulae if the Mongomery method, which could be indicated in a single formula, is applied. In addition, de Boer (2009) presented the Sato-Varia method, according to which it is possible to obtain a value closer to the average values of all factorizing formulae and to be indicated in a single formula at the same time.

This study's objective is to perform an Input–Output Structural Decomposition Analysis on the ICT industry in Korea to examine its structural changes and its growth factors. Thus, this is an extension of research performed by Barker (1990), Lee and Schluter (1993) and Hayashi (2005), who analyzed the structural changes in specific industries in a particular nation. The empirical data include the Input–Output table for 2009 at 2005 constant prices, which was recently announced by the Bank of Korea; linked Input–Output tables for 1995, 2000, and 2005 at 2005 constant prices; and the employment index attached to the annual Input–Output table. In this research, the structural changes are classified into the output aspect and the employment aspect. Additionally, the growth factors are analyzed through the Input–Output Structural Decomposition Analysis model.

The characteristics of this study are as follows. First, this study fragments final demand into consumption, investment and inventory to examine seven growth factors in the ICT industry. Since Syrquin (1976), most studies have focused on a structural decomposition of the economy and industries based on the following five factors: final domestic demand, export, import substitution of intermediate goods, import substitution of end goods and technological change. However, to more closely analyze the ICT industry's growth factors, this study further departmentalized the final demand into three factors: consumption, investment and inventory.

Second, the study applies a mid-point weight to minimize possible errors in the calculation process. It should be noted that the weight is less arbitrarily designated because it is placed in the middle, based on complete factorization. In addition, the effects on changes in the output based on the combination of two factors were equally divided. According to Choi and Lee (2010), if there are two factors, the average contribution rate method and the mid-point weight method will generate the same result. However, if there are three or more factors, the result may be changed. Through an empirical analysis, the researchers established that the more factors involved, the much more logical and simplified the mid-point weight method can be.

Third, the analysis period is divided into three rounds including the periods from 1995 to 2000, 2000 to 2005, and 2005 to 2009. This allows the examination of structural changes to be focused on the ICT industry's growth in the late 1990s when Korea experienced the foreign exchange crises, in the early 2000s when the dot-com bubble burst, and in the late 2000s when the global economy endured the financial crises.

This paper is structured as follows. Section 2 classifies the I–O SDA model applied to this study as well as the ICT industry while suggesting their scope. Section 3 examines the changes in the output structure and the employment structure of the ICT industry through the Input–Output table. Section 4 analyzes the growth factors of the ICT industry in Korea based on the I–O SDA. Finally, Section 5 provides a summary and suggestions.

2. Method and range of the ICT industry

2.1. Method

In the Input–Output table, the aggregate supply is the sum of domestic output (X) and import (M), and aggregate demand is the sum of intermediate demand (W) and final demand (F). Because the final demand (F) can be subdivided into domestic final demand (D) and export demand (E), the supply-demand balanced equation of the entire economy can be represented by formula (1), where the aggregate demand corresponds to the aggregate supply.

$$X = D + W + E - M \tag{1}$$

If the unit input for the output in industry i is assumed to be a_{ij}, the input coefficient can be indicated as $a_{ij} = W_{ij}/X_j$. If a_{ij} is indicated as the determinant A, it can be indicated as $W = AX$. If the import is divided into imports for the production of intermediate goods ($\widehat{M^w}$) and import for the production of end goods ($\widehat{M^f}$) to ensure that they can be applied to formula (1), this can be indicated as formula (2) under the assumption that it is possible to use complete import determinant data with regard to the intermediate demand and the final demand:

$$X = \left(I - \widehat{M^w}\right)AX + \left(I - \widehat{M^f}\right)D + E \tag{2}$$

Here, $(I - \widehat{M^w})$ indicates the rate of domestic intermediate input against the aggregate input, and $(I - \widehat{M^f})$ represents the rate of domestic intermediate input against the final demand. If formula (2) is summarized against X, it can lead to formula (3):

$$X = \left[I - \left(I - \widehat{M^w}\right)A\right]^{-1}\left[\left(I - \widehat{M^f}\right)D + E\right] \tag{3}$$

If $[I - (I - \widehat{M^w})A]^{-1}$ is replaced with R^d, and if $[(I - \widehat{M^f})D + E]$ is replaced with G^d to indicate changes in the aggregate domestic output (ΔX) of the standard year ($t = 0$) and the compared year ($t = 1$), it can lead to formula (4):

$$\Delta X = X_1 - X_0 = R_1^d G_1^d - R_0^d G_0^d \tag{4}$$

If R_1^d and G_1^d are replaced with $R_0^d + \Delta R^d$ and $G_0^d + \Delta G^d$, respectively, through the weight of the standard year (Laspeyres Index) in formula (4), it can be indicated as formula (5). Additionally, if R_0^d and G_0^d are replaced with $R_1^d - \Delta R^d$ and $G_1^d - \Delta G^d$, respectively, through the weight of the compared year (Paasche Index) in formula (4), it can be indicated as formula (6):

$$\Delta X_L = \left(R_0^d + \Delta R^d\right)\left(G_0^d + \Delta G^d\right) - R_0^d G_0^d = \Delta R^d G_0^d + R_0^d \Delta G^d + \Delta R^d \Delta G^d \tag{5}$$

$$\Delta X_P = R_1^d G_1^d - \left(R_1^d - \Delta R^d\right)\left(G_1^d - \Delta G^d\right) = \Delta R^d G_1^d + R_1^d \Delta G^d - \Delta R^d \Delta G^d \tag{6}$$

In formulas (5) and (6), $\Delta R^d \Delta G^d$ is combined with $\Delta R^d G_0^d$ and $\Delta R^d G_1^d$, respectively, to be indicated as $\Delta R^d(G_0^d + \Delta G^d)$ and $\Delta R^d(G_1^d - G^d)$. Accordingly, formulas (5) and (6) can be indicated as $\Delta X_L = R_0^d + \Delta G^d + \Delta R^d G_1^d$ and $\Delta X_P = R_1^d \Delta G^d + \Delta R^d G_0^d$, respectively. If these are factorized, it can lead to formulas (7) and (8):

$$\Delta X_L = R_0^d\left(\widehat{M_0^f}-\widehat{M_1^f}\right)D_0 + R_0^d\left(I-\widehat{M_0^f}\right)\Delta D + R_0^d\Delta E + R_0^d\left(\widehat{M_0^w}-\widehat{M_1^w}\right)A_1X_1 + R_0^d\left(I-\widehat{M_0^w}\right)\Delta AX_1 \tag{7}$$

$$\Delta X_P = R_1^d\left(\widehat{M_0^f}-\widehat{M_1^f}\right)D_1 + R_1^d\left(I-\widehat{M_1^f}\right)\Delta D + R_1^d\Delta E + R_1^d\left(\widehat{M_0^w}-\widehat{M_1^w}\right)A_0X_0 + R_1^d\left(I-\widehat{M_1^w}\right)\Delta AX_0 \tag{8}$$

If the mid-point weight method is applied through the use of formulas (7) and (8), formula (9), which is the final model of this study, can be generated

$$\begin{aligned}\Delta X_M = {} & \left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left(\widehat{M_0^f}-\widehat{M_1^f}\right)\left(\frac{1}{2}D_0+\frac{1}{2}D_1\right)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left[\frac{1}{2}\left(I-\widehat{C_0^m}\right)+\frac{1}{2}\left(I-\widehat{C_1^m}\right)\right]\left(C_1^f-C_0^f\right)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left[\frac{1}{2}\left(I-\widehat{V_0^m}\right)+\frac{1}{2}\left(I-\widehat{V_1^m}\right)\right]\left(V_1^f-V_0^f\right)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left[\frac{1}{2}\left(I-\widehat{S_0^m}\right)+\frac{1}{2}\left(I-\widehat{S_1^m}\right)\right]\left(S_1^f-S_0^f\right)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)(E_1-E_0)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left(\widehat{M_0^w}-\widehat{M_1^w}\right)\left(\frac{1}{2}A_0+\frac{1}{2}A_1\right)\left(\frac{1}{2}X_0+\frac{1}{2}X_1\right)\\ & +\left(\frac{1}{2}R_0^d+\frac{1}{2}R_1^d\right)\left[\frac{1}{2}\left(I-\widehat{M_0^w}\right)+\frac{1}{2}\left(I-\widehat{M_1^w}\right)\right](A_1-A_0)\left(\frac{1}{2}X_0+\frac{1}{2}X_1\right)\end{aligned} \tag{9}$$

where $\hat{C}^m$, $\hat{V}^m$, and $\hat{S}^m$ mean a diagonal matrix of coefficients of import consumption demand, import investment demand, and import inventory demand, respectively. Additionally, C^f, V^f, and S^f denote a coefficient matrix of domestic consumption demand, domestic investment demand, and domestic inventory demand, respectively.

The first term on the right of formula (9) indicates the import substitution effect of end goods and the direct or indirect effects of changes in the import structure of end goods. In the I–O table, the final demand consists of the consumption demand, the investment demand and the inventory demand. As previously noted, this study fragments the final demand into consumption, investment and inventory to examine the structural changes and their contribution. The second term denotes the consumption expansion effect in a certain import structure, the third term represents the investment expansion effect, and the fourth term indicates the inventory expansion effect. The fifth term indicates the export expansion effect, and the sixth term denotes the import substitution effect of intermediate goods and the direct or indirect effects of the import structure of intermediate goods. The seventh term represents the technological change effect, the direct or indirect effects caused by the transformation of the aggregate input coefficient. At that time, the changes in the aggregate input coefficient do not measure modified productivity; however, they reflect the depth of industrial correlations caused by transformed input relations among intermediate goods. Therefore, the changes can be considered a technological changes effect when viewed from the demand perspective.

2.2. Range of the ICT industry

Because the classification and integration of the subject industries determine the size of a related multiplier in I–O SDA, it is necessary to practice care when making a decision; this is because the effect can vary depending on a researcher's individual arbitrary standard. This study designates the scope of the ICT industry by correlating the integrated subdivision system of the Input–Output table with the Korea Standard Industrial Classification (KSIC), to enhance its credibility. The KSIC was established in 1964 based on the International Standard Industrial Classification (ISIC) announced by the UN to secure the accuracy and comparability of statistical data. Since then, the classification has been regularly revised to reflect amendments made to the ISIC by the UN and to reflect changes in the domestic industrial structure and technology (KOSTAT, 2008).

Furthermore, it should be noted that because the industrial classification system in the Input–Output table established and announced by the Bank of Korea is not generated based on the Korean Standard Industrial Classification (KSIC) but is based on a separate classification system to connect it to the System of National Accounts, there are differences between them. Accordingly, this study first aligned the integrated sub-classification system of the 1995–2000–2005 linked Input–Output Tables at 2005 constant prices with the integrated sub-classification system of the 2009 Input–Output Table at 2005 constant prices, reorganized these into 164 sectors, and then extracted 10 sectors that can be considered as the ICT industry in accordance with the KSIC; this was done to reorganize the ICT industry as shown in Table 1 (BOK, 2008, 2011).

Table 1
Range of the ICT industry corresponding to the Korea Standard Industrial Classification.

Industry	Field	Sector	Sub-sector
ICT	ICT manufacturing	Electronic component	Electronic display device
			Semiconductor
			Other electronic component
		Broadcasting and telecommunication equipment	Electronic video and audio device
			Telecommunication and broadcasting device
		Information equipment	Computers and peripheral device
			Office electronic device
	ICT service	ICT service	Telecommunication service
			Broadcasting service
			Computer-related service

3. Structural changes in the ICT industry

3.1. Output structure

Fig. 1 shows changes in the output structure of the ICT industry. The ICT's output and output share as a percentage of the entire national industrial sector, which were posted as 39.5 trillion won and 3.32% in 1995, continuously grew to 312.8 trillion won and 13.01% in 2009, an 8-fold and 4-fold increase, respectively. In the same period, the compound annual growth rate (CAGR[1]) of the ICT industry was 15.93%, which was 3 times higher than the CAGR of 5.15%, of the entire national industrial sector, indicating that the ICT industry led Korea's economic growth (refer to Table 2).

In terms of sectoral changes in the output structure of the ICT industry, the ICT service sector consistently registered the largest output until 2000, as shown in Table 2. The electronic component sector overtook the ICT service sector in 2005, and the output of the electronic component sector represented 45% or more of the ICT industry's output in 2009. In addition, as time progressed, the growth of the ICT service sector and the broadcasting and telecommunication equipment sector gradually slowed. Additionally, the information equipment sector, which had sunk into a swamp of stagnation in 2000, failed to show any sign of recovery. Conversely, the electronic component sector experienced accelerated growth and is expected to serve as a growth engine in the ICT industry in the future.

3.2. Employment structure

Fig. 2 indicates changes in the employment structure of the ICT industry. The ICT's employment and employment proportion as a percentage of the entire national industrial sector have gradually increased, from 610,000 and 5.41% in 1995 to 775,000 and 6.26% in 2005 before decreasing to approximately 751,000 and 5.29% in 2009. Both the quantities and the share of the output were on the rise over the entire period; in addition, although the number of employees increased, the employment proportion as a percentage of the entire economy decreased. Moreover, in contrast to the average annual growth rate of the output, which was more than three times that of the entire national industrial sector, the employment's CAGR fell short during the entire period, which was a distinctively different result from the output (refer to Table 3).

In terms of sectoral changes in the employment structure of the ICT industry, the number of employees in the ICT manufacturing field, which encompasses the electronic component sector, broadcasting and telecommunication equipment sector and information equipment sector, was reduced by approximately 10% in 2009 compared with 1995. In comparison, employment in the ICT service field increased by approximately 100% between 1995 and 2009, as shown in Table 3. In particular, the ICT service sector represented approximately 50% of the total employment of the entire ICT industry in 2009, and this is expected to offer a key to solving the problem caused by jobless growth.

Table 4 shows the changes in labor productivity of the ICT industry. The labor productivity refers to the average production generated by one unit of labor input that was input in the process, and it is a suitable indicator for identifying the efficiency of production. The labor productivity of the electronic component, broadcasting and telecommunication equipment, and the information equipment sectors, all of which are ICT manufacturing, show higher growth compared with the average labor productivity of the ICT industry. However, the labor productivity of the ICT service sector recorded its highest figure in 1995 but afterwards began to show slow growth, remaining at approximately 55% of the average level of the ICT industry in 2009.

[1] CAGR is an index for calculating annual growth rate such as compound interest.

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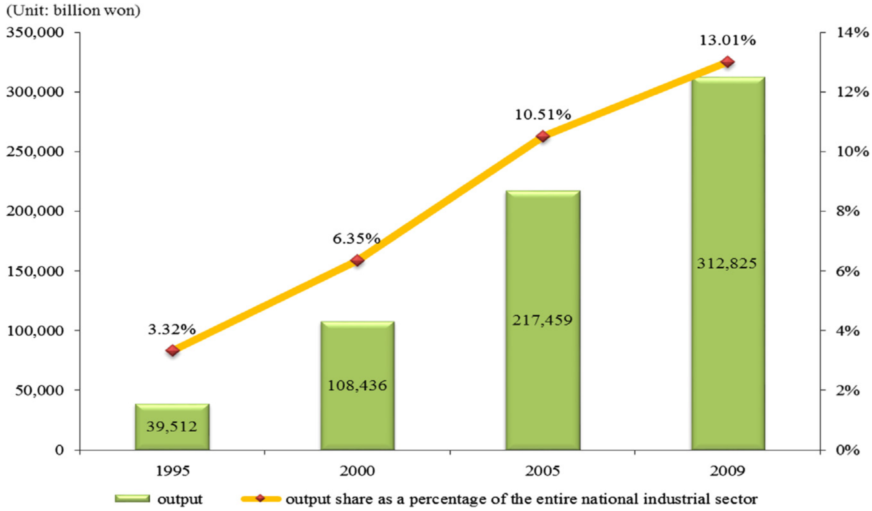

Fig. 1. Changes in the output structure of the ICT industry.
Source: Bank of Korea (2008, 2011).

Table 2
Periodical changes in the output structure of the ICT industry (billion won, %).
Source: BOK (2008, 2011).

	1995		2000		2005		2009		CAGR (%)
	Output	Share	Output	Share	Output	Share	Output	Share	
Electronic component	11,018	0.93	32,712	2.09	84,569	4.09	145,721	6.06	20.25
Broadcasting and telecommunication equipment	10,383	0.87	20,663	1.32	51,518	2.49	72,481	3.01	14.89
Information equipment	3310	0.28	11,816	0.76	10,906	0.53	11,033	0.46	8.98
ICT service	14,801	1.24	43,244	2.76	70,466	3.41	83,590	3.48	13.16
ICT industry	39,512	3.32	108,436	6.35	217,459	10.51	312,825	13.01	15.93

Note: The share means each sector's output ratio as a percentage of the entire national industrial sector.

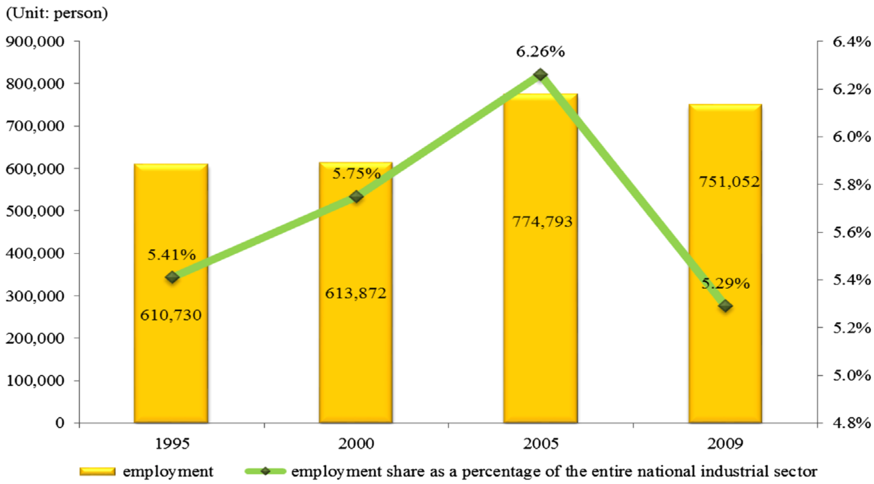

Fig. 2. Changes in the employment structure of the ICT industry.
Source: Bank of Korea (2008, 2011).

Table 3
Periodical changes in the employment structure of the ICT industry (person, %).
Source: BOK (2008, 2011).

	1995		2000		2005		2009		CAGR (%)
	Employees	Share	Employees	Share	Employees	Share	Employees	Share	
Electronic component	187,743	1.66	180,947	1.70	261,252	2.11	241,330	1.70	1.81
Broadcasting and telecommunication equipment	142,805	1.27	155,037	1.45	131,269	1.06	122,584	0.86	−1.08
Information equipment	96,276	0.85	51,184	0.48	31,203	0.25	21,936	0.16	−10.03
ICT service	183,906	1.63	226,704	2.12	351,069	2.84	365,202	2.57	5.02
ICT industry	610,730	5.41	613,872	5.75	774,793	6.26	751,052	5.29	1.49

Note: The share means each sector's employment ratio as a percentage of the entire national industrial sector.

Table 4
Periodical changes in the labor productivity of the ICT industry (billion won/person).
Source: BOK (2008, 2011).

	1995	2000	2005	2009	CAGR (%)
Electronic component	0.059	0.181	0.324	0.604	18.1
Broadcasting and telecommunication equipment	0.073	0.133	0.392	0.591	16.1
Information equipment	0.034	0.231	0.350	0.503	21.1
ICT service	0.080	0.191	0.201	0.229	7.8
ICT industry	0.065	0.177	0.281	0.417	14.2

Table 5
Sources of the ICT industry's growth in Korea 1995–2009 (%).

	Import substitution		Final demand expansion			Export expansion	Technological change	Total
	End goods	Intermediate goods	Consumption	Investment	Inventory			
Electronic component	−2.03	−2.12	1.04	0.36	4.32	46.09	5.69	53.35
Electronic display device	−1.84	0.44	0.40	0.16	3.59	22.89	2.03	27.66
Semiconductor	−0.06	−2.21	0.22	0.05	0.81	19.49	4.06	22.37
Other electronic component	−0.13	−0.35	0.42	0.15	−0.08	3.71	−0.40	3.32
Broadcasting and telecommunication equipment	0.18	−0.12	4.28	1.46	0.22	17.10	1.62	24.74
Electronic video and audio device	−0.12	−0.03	1.29	0.57	−0.07	−0.07	0.18	1.75
Telecommunication and broadcasting device	0.30	−0.09	2.99	0.89	0.29	17.18	1.43	22.99
Information equipment	−0.12	−0.42	0.66	0.49	−0.02	2.14	0.89	3.61
Computers and peripheral Device	−0.17	−0.43	0.61	0.43	−0.25	1.87	0.96	3.02
Office electronic device	0.05	0.01	0.05	0.06	0.23	0.27	−0.07	0.59
ICT service	−0.34	−0.43	11.42	0.41	0.15	3.70	3.40	18.30
Telecommunication service	−0.16	0.15	9.21	0.21	0.13	1.91	4.32	15.77
Broadcasting service	−0.05	−0.13	1.14	0.05	0.01	0.48	0.47	1.98
Computer-related service	−0.13	−0.46	1.07	0.15	0.01	1.31	−1.40	0.55
ICT industry	−2.31	−3.09	17.39	2.71	4.67	69.03	11.59	100.0

4. Growth factors of the ICT industry

4.1. Sources of the ICT industry's growth

Table 5 denotes growth factors of the ICT industry in Korea from 1995 to 2009. According to the results, the ICT industry's growth in Korea was led by export expansion, followed by consumption expansion, technological change, inventory expansion and investment expansion. However, the import substitution of intermediate goods and end goods had a negative effect on the ICT industry's growth. In particular, the export expansion of the electronic display device sub-sector, the semiconductor sub-sector and the communication and broadcasting device sub-sector registered approximately 60% contribution to the growth of

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Table 6
Periodical contribution of export expansion effect (%).

	1995–2000	2000–2005	2005–2009
Electronic component	31.63	49.82	53.55
Electronic display device	7.41	24.48	30.92
Semiconductor	19.49	20.56	19.79
Other electronic component	4.73	4.78	2.84
Broadcasting and telecommunication equipment	8.27	24.22	13.92
Electronic video and audio device	0.42	0.65	−1.32
Telecommunication and broadcasting device	7.85	23.57	15.24
Information equipment	8.17	−1.36	2.31
Computers and peripheral device	7.82	−1.58	2.07
Office electronic device	0.35	0.22	0.24
ICT service	4.66	3.24	3.08
Telecommunication service	2.23	1.98	2.05
Broadcasting service	0.58	0.45	0.49
Computer-related service	1.85	0.81	0.54
ICT industry	52.72	75.92	72.86

Table 7
Periodical contribution of final demand expansion effect (%).

	Consumption demand			Investment demand			Inventory demand		
	1995–2000	2000–2005	2005–2009	1995–2000	2000–2005	2005–2009	1995–2000	2000–2005	2005–2009
Electronic component	1.35	1.18	1.09	1.26	0.20	0.17	−0.14	0.23	4.86
Electronic display device	0.35	0.35	0.54	0.38	0.03	0.08	0.11	−0.02	3.51
Semiconductor	0.29	0.32	0.21	0.22	0.04	0.03	0.00	0.01	2.02
Other electronic component	0.71	0.51	0.34	0.66	0.13	0.06	−0.25	0.24	−0.67
Broadcasting and telecommunication equipment	3.18	4.35	5.06	6.47	−0.79	0.67	0.21	−0.29	0.71
Electronic video and audio device	−0.73	1.88	1.65	0.10	1.06	0.22	0.07	−0.17	−0.08
Telecommunication and broadcast-ting device	3.91	2.47	3.41	6.37	−1.85	0.45	0.14	−0.12	0.79
Information equipment	3.06	−0.06	0.25	2.66	−0.25	0.28	0.06	−0.01	0.26
Computers and peripheral device	3.04	−0.11	0.22	2.37	−0.13	0.19	0.06	−0.01	−0.39
Office electronic device	0.02	0.05	0.03	0.29	−0.12	0.09	0.00	0.00	0.65
ICT service	20.54	13.41	5.05	0.23	0.73	0.40	−0.18	0.12	−0.16
Telecommunication service	17.89	11.29	3.27	0.15	0.41	0.27	−0.1	0.09	−0.12
Broadcasting service	1.31	1.12	1.19	0.00	0.11	0.05	−0.02	0.01	−0.02
Computer-related service	1.34	1.00	0.59	0.08	0.21	0.08	−0.06	0.02	−0.02
ICT industry	28.13	18.88	11.45	10.62	−0.11	1.52	−0.05	0.05	5.67

the ICT industry, further promoting the ICT industry's growth in Korea. In addition, the consumption expansion of the telecommunication service sub-sector made a high contribution to the growth of the ICT industry.

By sectoral contribution, the electronic component sector made the greatest contribution, followed by the broadcasting and telecommunication equipment sector, the ICT service sector and the information equipment sector. The electronic component sector represented 50% or more of the ICT industry's growth. Within the sector, the electronic display device sub-sector (27.66%) and the semiconductor sub-sector (22.37%) performance showed that the electronic component sector had the greatest contribution. The broadcasting and telecommunication equipment sector contributed approximately 25% to the growth of the ICT industry; this was caused by the enlargement of the telecommunication and broadcasting device sub-sector. Furthermore, the information equipment sector contributed less than 0.04% to the growth of the ICT industry, a very different result from the electronic component sector and the broadcasting and telecommunication equipment sector, which made great strides. The ICT service sector represented 20% of the growth of the ICT industry, and this is believed to be because of the growing telecommunication service sub-sector.

4.2. Periodical changes in the growth factors

4.2.1. Export expansion

Export expansion made the greatest contribution to the growth of the ICT industry and recorded as high as a 53–76% contribution level. As shown in Table 6, export expansion had generally increased before recently reaching a plateau.

By sector, the electronic component sector's export expansion represented more than 60% of the export expansion in the ICT industry, and its contribution trend continues to rise (refer to Table 6). The electronic display device, which experienced the fastest growth of all sub-sectors, registered a contribution to growth of 30% or more between 2005 and 2009, and the semiconductor sub-sector steadily posted contributions of approximately 20% over the entire period. Following the electronic component sector, the broadcasting and telecommunication equipment sector was ranked 2nd in contribution level. The broadcasting and telecommunication equipment sector's export expansion primarily occurred in the telecommunication and broadcasting device sub-sector, which proved to be one of the three major sub-sectors leading export expansion in the ICT industry, in addition to the electronic display device sub-sector and semiconductor sub-sector.

However, the information equipment sector's export expansion became very small, despite an outstanding increase in exports in the ICT manufacturing field. Between 1995 and 2000, the export expansion of the information equipment sector and the broadcasting and telecommunication device sector were similar. However, following that period, the information equipment sector took a nosedive, recording negative growth, in contrast to the broadcasting and telecommunication equipment sector, whose contribution dramatically increased between 2000 and 2005. Thereafter, the sector rebounded to post positive growth. However, the information equipment sector's export expansion remained smaller than that of the ICT service sector.

4.2.2. Final demand expansion

Following export expansion, final demand expansion was ranked 2nd regarding its contributive level to the ICT industry's growth. This study divides final demand into consumption, investment and inventory categories to closely examine their impact on the growth in the ICT industry. As shown in Table 7, consumption expansion was the most prominent over the entire period, followed by the investment expansion or the inventory expansion, depending on the period.

In the initial stages, the contributive level of investment expansion was much greater than that of inventory expansion; however, recently, the contribution of inventory expansion has been greater. It is assumed that consumption expansion in the ICT industry primarily stemmed from the expanded consumption in the telecommunication service sub-sector. Additionally, it was heavily influenced by the popularization of mobile communication services, caused by the adoption of commercial CDMA technology in the mid-1990s.[2]

However, the telecommunication and broadcasting device sub-sector's consumption expansion overtook that of the telecommunication service sub-sector between 2005 and 2009. This appears to be caused by telecommunication service operators working to secure subscribers by inducing customers to change their telecommunication devices based on subsidies because the mobile communication service market was saturated.

Following consumption expansion, investment expansion was ranked 2nd before taking a nosedive to register the lowest contribution with regard to final demand. The dramatic reduction in the investment expansion was caused by a decline in investment in the telecommunication and broadcasting device sub-sector and the computer and peripheral device sub-sector. This appears to be because of the bursting of the dot-com bubble, which shrunk investments in the telecommunication and broadcasting equipment sub-sector and the computer and peripheral device sub-sector in the early 2000s. This occurred despite the fact that the advanced integration of semiconductor technology led to accelerated investments in these sub-sectors in the late 1990s.

In the early days, the contribution of inventory expansion was infinitesimal; however, it has recently soared. The rapid increase of inventory expansion was primarily caused by the growing inventory in the electronic display device sub-sector, the semiconductor sub-sector and the telecommunication and broadcasting device sub-sector, which appears to have occurred because of the popularization of mobile devices in the late 2000s.

4.2.3. Technological change

Table 8 depicts the technological change effect of the ICT industry. This refers to changes in the technological coefficients of the entire national industrial sector that contribute to the growth of output in the ICT industry. The effect was scored as 5.3% between 2000 and 2005, and increased to 14.2% from 2005 to 2009. Between 1995 and 2000, the technological change effect of the ICT service sector is highly apparent as the highest contributor, followed by the electronic component sector. It is assumed that the effect in this period primarily stemmed from technological innovations in the telecommunications service sub-sector, which appear to be the result of R&D in the technological commoditization of CDMA in the late 1990s. Between 2000 and 2005, the technological change effect of the information equipment sector was the highest. A notable point in this period is that the effect of the computer and peripheral device sub-sector was the most prominent. It is assumed that this is related to the influence of the venture capital fever that swept the nation in the early 2000s. Between 2005 and 2009, the technological change effect of the electronic component sector had the highest ranking. This was caused by a sudden increase in the electronic display device sub-sector's technological change effect, which had registered as the lowest in the previous period. It is assumed that this change is closely linked to the rapid spread of smart devices in the late 2000s.

[2] Since the successful commercialization of CDMA in 1996, the mobile telecommunication service market in KOREA has achieved remarkable growth. Although mobile telecommunication subscribers were a mere 3.2 million people in 1996, the subscribers soared to 14.0 million people in 1998 and 26.8 million people in 2000 (KOSTAT, 2014).

Table 8
Periodical contribution of technological change effect (%).

	1995–2000	2000–2005	2005–2009
Electronic component	4.38	−2.83	9.12
Electronic display device	−0.68	−2.69	8.44
Semiconductor	4.04	1.20	2.38
Other electronic component	1.02	−1.34	−1.70
Broadcasting and telecommunication equipment	0.42	1.87	3.31
Electronic video and audio device	−0.24	0.60	0.14
Telecommunication and broadcasting device	0.66	1.27	3.17
Information equipment	−0.20	3.40	−0.58
Computers and peripheral device	0.07	3.30	−0.52
Office electronic device	−0.27	0.10	−0.06
ICT service	6.67	2.88	2.36
Telecommunication service	9.32	1.53	2.66
Broadcasting service	0.63	1.52	−0.20
Computer-related service	−3.28	−0.17	−0.10
ICT industry	11.26	5.32	14.22

Table 9
Periodical contribution of import substitution of end goods and intermediate goods effects (%).

	End goods			Intermediate goods		
	1995–2000	2000–2005	2005–2009	1995–2000	2000–2005	2005–2009
Electronic component	−0.25	0.04	1.40	−2.63	0.79	−3.17
Electronic display device	−0.22	0.09	1.49	−1.13	3.38	−1.34
Semiconductor	−0.02	0.03	−0.03	−1.26	−2.35	−1.44
Other electronic component	−0.01	−0.08	−0.06	−0.24	−0.24	−0.39
Broadcasting and telecommunication equipment	−0.31	1.10	−0.18	−0.19	0.09	−0.23
Electronic video and audio device	−0.55	0.24	0.05	−0.02	−0.12	0.10
Telecommunication and broadcasting device	0.24	0.86	−0.23	−0.17	0.21	−0.33
Information equipment	0.45	−0.72	−0.31	0.10	−0.85	−0.74
Computers and peripheral device	0.11	−0.68	−0.26	0.07	−0.85	−0.73
Office electronic device	0.34	−0.04	−0.05	0.03	0.00	−0.01
ICT service	0.02	−0.27	−1.27	0.12	−0.27	−1.22
Telecommunication service	0.20	−0.19	−0.92	0.54	0.17	−0.27
Broadcasting service	−0.04	−0.03	−0.14	−0.03	−0.09	−0.35
Computer-related service	−0.14	−0.05	−0.21	−0.39	−0.35	−0.60
ICT industry	−0.09	0.15	−0.36	−2.60	−0.24	−5.36

4.2.4. Import substitution of end goods and intermediate goods

As shown in Table 9, import substitutions generally show a negative contribution to the growth of the ICT industry. The import substitution of end goods was infinitesimal over the whole period, but that of intermediate goods significantly deteriorated between 2005 and 2009. However, although the negative effect of import substitutions differed between end goods and intermediate goods in terms of degree, they occurred over all sectors in the ICT industry. In the early stages, the import substitution's negative effect of end goods was primarily concentrated in the ICT manufacturing field. However, this phenomenon has recently shifted to the ICT service field. Furthermore, the import substitution's negative effect of intermediate goods became concentrated on the electronic component sector over the entire period.

The fact that the negative effect of import substitution of end goods has shifted from the ICT manufacturing field to the ICT service field offers circumstantial evidence that the strategies for development of the ICT industry in Korea were slanted toward the manufacturing field. Additionally, because the negative effect of import substitution of intermediate goods mainly occurred in the electronic display device sub-sector and the semiconductor sub-sector, which made the greatest contribution to the ICT industry's growth, it is assumed that there are structural limitations in the Korean ICT industry in which raw materials and intermediate goods are commonly imported to be processed before exportation.

5. Conclusions

This study performed an I-O SDA on the ICT industry in Korea between 1995 and 2009 to examine its structural changes and its growth factors. Based on this research, the policy implications can be derived as follows.

First, the outstanding growth of the ICT manufacturing field and the slowdown in growth in the ICT service field should be noted. It is undisputed that the ICT industry has played a leading role in developing the Korean economy. In particular, the ICT manufacturing field, which encompasses the electronic component sector, the broadcasting and telecommunication equipment sector and the information equipment sector, experienced dramatic growth in output during the analysis period. In recent years, the growth has significantly slowed in the broadcasting and the telecommunication equipment sector and in the information equipment sector. Nevertheless, the ICT manufacturing field is expected to continue growing, propelled by the expansion of the electronic component sector, to take the largest portion of the ICT industry. In contrast to the ICT manufacturing field, the ICT service field has shown an increase in output but fell short of the ICT industry's average growth rate. Considering that increases in output have dramatically slowed in recent years, it is urgent to take measures to invigorate the ICT service field. To achieve sustainable growth in the ICT service fields, new ICT service demand based on cutting edge ICT such as Cloud, Big data analysis and the Internet of Things needs to be created through bold R&D investment.

Second, this study investigated the jobless growth phenomenon in the ICT manufacturing field and the reduction in labor productivity in the ICT service field. Despite outstanding growth in output of the ICT manufacturing field, employment has moderately decreased. In particular, the number of employees decreased the most between 2005 and 2009, when the ICT manufacturing sector grew the most, emphasizing the phenomenon of jobless growth in the field. Conversely, although growth slowed in the output of the ICT service field, employment has greatly increased, exposing problems with labor productivity. The jobless growth of the ICT manufacturing field and the reduced labor productivity in the ICT service field may be directly linked not only to reduced industrial competitiveness in the ICT industry but also to decreasing national competitiveness. Considering that Korea has the highest ICT infrastructure in the world, it is expected that the convergence of ICT and other industries will lead each industry to expand its investment in ICT, improve labor productivity, establish a virtuous cycle of 'increased production' and 'increased employment', and eventually contribute to an enhancement of Korea's national competitiveness.

Third, it is undeniable that export expansion made the greatest contribution to the industrial growth of Korea. However, given that Korean conglomerates were rapidly increasing overseas production and that innovation in the ICT industry has led to a greater contribution in terms of technological change, it is difficult to expect that export expansion could be improved in the future. In addition, the negative effect of intermediate goods' import substitution was the most apparent in the electronic component sector, which made the greatest contribution to export expansion. This appears to be because there are structural limitations to the ICT industry in Korea in which raw materials and intermediate goods are usually imported for processing before exportation. Accordingly, it is judged that emphasis needs to be placed on establishing policies to promote exports for the sustainable development of the ICT industry, and the strategic technical development of intermediate goods through selection and concentration should also be conducted at the same time.

Fourth, the electronic display device sub-sector and the telecommunication and broadcasting equipment sub-sector showed outstanding growth during the analysis period, and the semiconductor sub-sector registered a high contribution over the entire period. In particular, the technological change in the ICT manufacturing field was concentrated on the electronic display device, the telecommunication and broadcasting device and the semiconductor sub-sectors between 2005 and 2009. This technological innovation is assumed to have led the Korean ICT industry to specialize in mobile devices. Conversely, the information equipment sector began to have difficulties exiting economic stagnation, in spite of the outstanding growth of the ICT manufacturing field. It is believed that the lackluster performance of the information equipment sector was caused by a lack of trigger factors that could increase demand after the dot-com bubble burst in the early 2000s.

Because the I–O SDA method adopted by the study involves certain characteristics of the Input–Output table, it has several limitations. There are various restrictions on the analysis of rapid changes in domestic and foreign economic conditions because of the time lag between the subject year of establishment and the year of announcement. An extended table is being established; however, it does not include observation data and thus cannot be used as time series analysis data. In addition, the I–O SDA explains the ex-post Input–Output results solely; therefore, it cannot describe structural decomposition based on causal relations. This study needs to be theoretically and empirically supplemented to realize I–O SDA and to identify the cause of changes in the socioeconomic structure.

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Please cite this article as: Hong, J. P., et al. Structural changes and growth factors of the ICT industry in Korea: 1995–2009. *Telecommunications Policy* (2015), http://dx.doi.org/10.1016/j.telpol.2015.08.001

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Please cite this article as: Hong, J. P., et al. Structural changes and growth factors of the ICT industry in Korea: 1995–2009. *Telecommunications Policy* (2015), http://dx.doi.org/10.1016/j.telpol.2015.08.001