Industrial Labor Productivity from IT Innovation: Korea Case 1995-2000

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Abstract

This paper analyzes the labor productivity and impact on employment in Korea as a result of innovation in IT. The information policies implemented by the Korean government, especially after the economic crisis in 1997, were intended to facilitate economic recovery. The industrial responses to the structures for the years 1995 and 2000 through VIO(Variable Input-Output) model are compared by way of labor productivity changes. This comparison is intended to determine whether IT related process innovation was effective during the period prior to the economic crisis and during the post economic crisis of IMF control. The conclusion I have reached is that the development of IT neither improves the labor productivity nor creates employment overall, according to statistical tests. However, by comparing individual industries, we can see that the principal benefits of IT innovation accrue to the manufacturing rather than to the service sector.

JEL Classification: L19, L63, J21

Key words: labor productivity, IT innovation, employment, displacement and compensatory effect

1. Introduction

The Information and Communications Technology industry(IT industry) has been cultivated as a strategic industry in Korea especially since the economic crisis in 1997. This strategy was intended to overcome the impasse of IMF control and was expected to lead to economic recovery by enhancing national competitiveness. The proportion of IT industry as a share of the Korean national economy has grown from 7.6% to 11.4% between 1995 and 2000, an increase of 3.8% over five years(Appendix A.2.).[1] This high growth rate was made possible through strategic support and investment as a measure to induce economic development under the government-led “informatization policy.”

This paper will analyze whether this rapidly growing IT industry contributes to an increase in labor productivity and employment in the Korean economy. A major concern about labor productivity in the transition to newer IT related technologies is the availability of workers with the trained skills that the work requires. Another concern is that if output is affected by the newer IT related technologies, additional employment would be created to satisfy the increased demand for commodities.

In this analysis, IT industry is adjusted according to the industrial classifications of Korea Ministry of Information and Telecommunications. IT industries are defined to include a basic communication service, broadcasting service, communication device, electric appliances, computer service and software industry. This classification comprises a relatively broader range of IT industry than is found in most international papers. The data used in this paper derives from the manufacture's price evaluation tables of Input-Output issued by the Bank of Korea(1995 and 2000[2]).

For analysis, a Variable Input-Output(VIO) model is used to trace changes in production activity of all industries resulting from a change in cost variation of a specific industry(in this paper, IT industry).

2. Factors of employment change due to technological innovation

Through technological innovation, the existing production process is substituted and the labor related to that process is decreased. This initial labor saving for productivity increase is expressed as a process innovation. The innovation of new technology enhances labor productivity and reduces production costs and commodity prices. The decrease in commodity prices will lead to an increase in demand for the commodities, which will require the additional employment for the increased demand. The process innovation from a decrease in labor is a "direct displacement effect" and an increase in employment to produce more to satisfy the increased demand is a "compensatory effect."

We cannot guarantee whether technological innovation will increase employment in these two conflicting effects. However, there are some other compensatory effects of increasing employment through technological innovation along with the aforementioned price compensatory effect (Spiezia and Vivarelli, 2002, pp. 102-105):

· Process innovations that displace workers in the user industries create jobs in the capital sectors where new machines(capital goods) are produced.
· Extra profits through the cost reduction accrued due to process innovation are

invested and so advance more production, and new jobs are created.

· The direct effect of labor saving technologies may be compensated within the labor market through wage decrease, which leads to an increase in demand for labor.

· Increased demand and higher consumption due to higher real incomes affected by price reduction leads to increase in employment.

· Product innovations through creation and commercialization of new products developing new economic branches create additional jobs.

Despite these positive factors for creations of employment, much research shows different results about the relationship between productivity and employment. The present IT related issue is about whether there is an end of Fordism where there was a positive relation of economic growth with employment increase. Presently, when the innovation of IT is prevalent, the phenomenon of jobless growth seems to be emerging. Thus, this paper will test whether the initial displacement caused by IT innovation in Korea affects industrial labor productivity and with an accompanying positive compensation effect. The positive compensation effect implies increases in employment from the production increase caused by the increase in demand for the commodities which decrease in prices.

3. Methodology

This paper deals with VIO model for the analysis of labor productivity and employment effect from IT innovation. VIO(see Appendix A.1.) can trace the change in output of all industries based on the cost variation of a specific industry. Without the change in final demand(f) in the basic equation of input-output table, the change in production activity can be found through the substitution of intermediate input use in all industries. This is possible through the connection between the input side and the output side, which cannot be found in the traditional Leontief model. As a result, changes in the intermediate input demand among industries resulting from the changes in prices of commodities can be traced. In other words, the substitution of intermediate inputs implies changes in inter-industry trade.

The scenario used in this paper assumes a reduction in the capital cost by 1% in the Korean IT industry as a technological innovation. The capital cost reduction will change the prices of all commodities and labor input use in the economy. The change in labor input use is found through employment elasticity introduced in Liew and Liew(1988). With the changed level of labor use from process innovation, the change of production activity of all industries is traced out. These changes in labor use and output will give us information for forming the rate of change in labor productivity. By comparing the rate of change in labor productivity for 1995 and 2000, we can test the IT's impact on labor productivity and employment over five years.

3.1. Industry level studies

Klein(2003) used U.S. input-output data from 1972 to 1998 for the analysis of productivity utilizing the KLEMI production function without referring to multi-equation estimation process. He found an evidence of increasing return to scale, which accounts for some of the average productivity gains seen in using trends of output per worker-hour.

Whitley and Wilson(1982) also used input-output data of the United Kingdom through simulation for 1990 with a dynamic input-output model named the "Cambridge Growth Project model". They analyzed that compensating effects reduce and outweigh initial job losses (displacement effects) due to process innovation.

Leontief and Duchin(1986) used 1978 U.S. input-output data through simulation for 1990 and 2000 and compared the results for those years. They used a dynamic input-output model with four different scenarios of paces of technological change. They found that the development of IT industry induces a labor saving trend under any pace of technological change. At the scenario of the fastest pace of technological change, the biggest aggregate gross output and lowest employment growth rate are revealed. By occupation, the demand for IT related professionals and engineers is increased while the demand for all categories of clerical workers is significantly lower under the scenario of a faster pace of IT innovation. The increasing use of IT was predicted to involve shifts not only in the occupational but also in the sectoral distribution of the work force, with the increased capital goods slowing the transfer from manufacturing to service sector employment over the period of 20 years between 1980 and 2000.

Kalmbach and Kurz(1990) used West German input-output data through simulation for 2000. They analyzed the impact of microelectronics development on employment with a dynamic input-output model close to Whitley and Wilson's. Their study revealed that the compensation effect was not strong enough to fully make up for the initial labor displacement caused by IT diffusion.

The papers using the I-O model, mentioned above, dealt with the various projections such as paces of IT technology and diffusion, capital investment, and consumption and trade in final demand.[3] However, this paper only examines the assumption of reduction of capital cost in the IT industry. The VIO model in this paper reveals change in the economic structure for production resulting from changes in primary input. With the simple scenario of capital cost reduction, we trace the technological change for production of all industries through the substitution of intermediate inputs. The change in intermediate demand implies structural change in entire industry of the economy. Whitley and Wilson(1982) admit that further research is required to explore changes in intermediate demand that may also play an important role.[4]

In this paper, we will follow a two step process in examining the data to arrive at an explanation of structural change in production activities. At the first stage, we find the initial displacement of labor affected by the reduction of capital cost of IT industry through technological innovation. The labor displacement will be sought from employment elasticity. At the second stage, we will determine the change in output (production activity) resulting from the initial labor displacement. With this information connecting labor displacement and the following output change, we will discuss the change in labor productivity and compensating effect of employment.

4. Employment elasticity[5]

Liew & Liew(1988) introduced the employment elasticities derived from VIO model. The optimal level of labor use for profit maximization of equation (3) in A.1. in Appendix can be rewritten as

$$L_{kj} = \beta_{kj}(p_j/w_{kj})x_j.$$

This equation can be rearranged as

$$w_{kj}\, L_{kj} = \beta_{kj}p_jx_j.$$

This can be expressed in a matrix form as a labor cost equation

$\hat{w}_k L_k = \hat{\beta}_k \hat{p} x$, the "^" sign means diagonal matrix of wage, labor share, and price.

The equation above can be totally differentiated after combining output equation(5) of A.1. in Appendix and labor cost equation. This yields the following results:

$$\hat{L}_k dw_k + \hat{w}_k dL_k = \left[\hat{\beta}_k (I - A)^{-1} \hat{f}\right] dp,$$

where dw_k is an n-component vector of the derivatives of w_{kj} and dL_k is an n-component vector of the derivatives of L_{kj}. After premultiplying the differentiated terms dw_k, dL_k, and dp by $\hat{w}_k(\hat{w}_k)^{-1}$, $\hat{L}_k(\hat{L}_k)^{-1}$, and $\hat{p}(\hat{p})^{-1}$, respectively, we obtain the elasticity equation using price equation(4) of the A.1. in Appendix as follows:

$$d\ln L_k = (\hat{w}_k \hat{L}_k)^{-1} \left[\hat{\beta}_k (I - A)^{-1} \hat{p}\hat{f}\right] d\ln p - d\ln w_k$$

$$= (\hat{w}_k \hat{L}_k)^{-1} \left[\hat{\beta}_k (I - A)^{-1} \hat{p}\hat{f}\right] \cdot \left[(I - A')^{-1} \sum_{j=1} \hat{\beta}_j d\ln w_j\right] - d\ln w_k .$$

When we analyze the effect of reduction in the capital cost (w_j) due to innovation of the IT industry on labor use, the first term in the above equation should be used. The second term, w_k , which indicates the wage rate of labor, can be used when we analyze the effect of a change in the wage rate in a specific industry on the labor use in all industries, including the specific industry under review.[6]

In the first term, the 24th column[7] of the ($d \ln L_k/d \ln w_j$) implies elasticities of employment with respect to capital cost change in the IT industry. From this column vector we can find a reduced use of labor resulting from IT innovation. This will be the initial displacement of labor as a labor saving device from process innovation. The reduced amount of labor is used in a price equation using primary input share, not its unit cost.

$$p = (I - A')^{-1} v .$$

The vector "v" represents a labor share for production (w_kL_k/x_j), which is the reverse of the average product of labor(x/L). The reduction of v will affect the prices of commodities of all industries. These changed prices affect the outputs of all industries by forming the substitution of intermediate inputs. As the VIO model is based on the Cobb-Douglas production function that is homogeneous of degree one, the system allows input substitution.[8] Thus the output equation with the changes of relative prices is for the production activities change through the varied technological coefficients, A.

$x = (I - \hat{p}^{-1} A\hat{p})^{-1} f$, the "^"sign indicates a diagonal matrix of price.

Through this equation we derive the changes of output of all industries resulting from the decrease in labor use, holding the final demand, f, constant. Thus, household consumption, government spending, export and import in final demand categories are not simulated in this analysis. Furthermore, the aforementioned employment compensating effects of additional investment from extra profit, consumption from real income increase, wage rate decrease, and product innovation[9] are not related to the model used in this analysis.

5. Empirical results

5.1. Overall test for the economy

A.3. and A.4.in Appendix show the employment elasticity in the 2nd column. The positive values indicate decrease in labor use when the price reduction of IT commodity occurs from producing cost reduction through technological innovation. From this cross elasticity we obtain the amount by which the labor cost ($w_k L_k$) has been reduced. For example, the number, 0.006032, which is the elasticity for the #1.Agriculture, forestry, and fisheries industry of A.3. in the Appendix gives us the change in labor use of -168.9296 million won.

$(dL_k/dw_j)/ (w_j /L_k)= 0.006032,$

$dL_k=0.006032 * (dw_j) * (L_k/w_j)= 0.006032 * (-0.01) * (2{,}800{,}445/1)= -168.9296$

This can be regarded as a decrease in cost expended on labor in monetary value and a decrease in workers because we are operating on the assumption that there is no change in wage rate (w_k). Similarly, we can follow this procedure for all 31 industries for both the years 1995 and 2000. The 3rd columns of A.3. and A.4. in the Appendix show the initial displacement effect of technological innovation in reducing the production cost of 1% in capital cost(w_j) of IT industry.

We used the numbers of decreased labor use of displacement effect as the exogenous variable for obtaining prices of all commodities in the economy. There will be a variety of changes in prices because each industry has its own typical labor share. The industries having relatively lower burden on the labor cost compared with the others will have relatively lower prices and will have competitiveness in the economic activity. Price depends on the change in the burden on the labor cost in the production process. The changes in prices will form a relative price that will constitute the substitution of intermediate inputs among industries. Through this change in production method, the outputs of all industries will change. The industries that become price competitive in the changed environment will increase production, and vice versa. The 5th columns in A.3. and A.4. in the Appendix illustrate the changes in outputs that result from process innovation in the industries.

With data for the variables of dL and dx, we can set up an equation for the rate of change in average productivity of labor(AP_L).

$AP_L=x/L$ taking natural log(ln) on both sides in this equation,

$\ln(AP_L)=\ln x - \ln L$ differentiating this equation,

$d\ln(AP_L)=d\ln x-d\ln L=dx/x-dL/L.$

This equation implies that there are two ways to increase the labor productivity through increased rate of change in output(dx/x) and increased rate of change in initial labor displacement(dL/L). The last columns in A.3. and A.4. in the Appendix illustrate the value of the rate of change in AP_L. These two columns are used for testing the contribution of IT innovation to labor productivity over five years. The Paired Observations Test is used to determine whether 31 industries have increased labor productivity overall for five years through process innovation. The differences of change rates in AP_L of 31 industries for five years are tested with the hypotheses setup based on a positive mean value: Ho: μd=0, Ha: μd>0.

Table 1. Test for $dln(AP_L)$

N	Mean	Std Dev	t Value	Pr > |t|
31	0.000287111	0.0012936	1.24	0.2262

The probability of making an error of rejecting Ho is 11.31%(=0.2262/2). Even at a significance level of 10%, we fail to reject the Ho. Thus, we must conclude that IT innovation is not sufficiently effective to contribute to an increase in the overall productivity of labor in the Korean economy over the five year period under review.

The rate of change in output(dx/x) is a factor of $dln(AP_L)$. We can use this rate for testing whether IT innovation contributes to increased employment as a compensating effect. Because the employment equation is associated with the output(x), the output change(dx) will affect employment.

$$L_{kj} = \beta_{kj}(p_j/w_{kj})x_j \dashrightarrow d L_{kj} = \beta_{kj}(p_j/w_{kj})dx_j \dashrightarrow d L_{kj}/x_j = \beta_{kj}(p_j/w_{kj})dx_j/x_j.$$

The hypotheses is set up again for the Paired Observations Test: Ho: μd=0, Ha: μd>0. As the mean value of the difference of rate of output change in 31 industries for five years is positive, the alternative hypothesis is of positive sign. This means IT innovation contributes to increases in output and the compensating effect of increased employment is positive. However, the probability of making an error of rejecting Ho is 14.59%(=0.2918/2). Even at a significance level of 10% again, we fail to reject the Ho. Thus we can conclude that IT innovation does not induce any meaningful increase in employment as a compensating effect.

Table 2. Test for dlnx

N	Mean	Std Dev	t Value	Pr > |t|
31	0.000195814	0.0010160	1.07	0.2918

In summary, the labor saving resulting from process innovation does not statistically contribute either to labor productivity or increased employment in Korea for the five years under review. Even if the rate of initial labor displacement[10] has significantly changed over five years, labor productivity cannot improve because of the weak increase in output. The only way to increase labor productivity and employment is through a significant output increase, which does not happen in our analysis.

5.2. Graphic comparison by industry

Even if the difference between two years is statistically too weak to improve the Korean economy overall, there is some room to explain the change in industry itself. Instead of an overall statistical test, we survey the results by each industry of interest for the manufacturing and service sectors. Figure 1 and 2 show the differences of the change rate of labor productivity and output between 1995 and 2000 due to process innovation. Both figures show the manufacturing and service sectors by disregarding industry #1. (Agriculture, forestry, and fisheries), #2. (Mining and quarrying), and #31. (Dummy sectors). The industries from #3 through #17 are categorized into the manufacturing sector. The remaining industries are included in the service sector, except #24 (IT industry). This is appropriate because the IT industry includes both manufacturing and service industries.

Figure 1 reveals a change in $dlnAP_L(=dAP_L/AP_L)$ for five years through use of a bar graph. We can see the differences between manufacturing and service sectors. At the difference level over 0.0001, there are 6 industries (#5, #7, #9, #10, #13, and #15) in the manufacturing sector while there is only one industry (#18) in the service sector. The change in $dln(AP_L)$ is on average larger in the manufacturing than in the service sector.

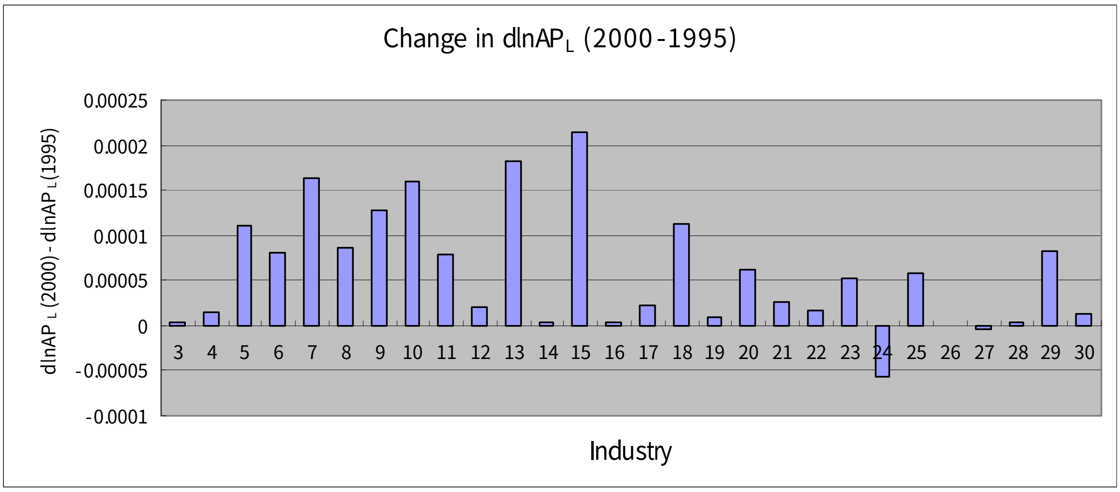

Figure 1. The difference in the change rate of AP_L

The process innovation from IT development may stimulate the labor productivity on the manufacturing side rather than on the service sector.

Figure 2 is a bar graph which shows the change in dlnx(=dx/x) over five years. We can also see the differences between the manufacturing and service sectors. At the difference of 0.00002, there are five industries (#5, #7, #8, #9, and #10) in the manufacturing sector while there is only one industry (#18) in the service sector. The change in dlnx is on average larger in the manufacturing than in the service sector as in the previous case of dln(AP_L). We can also see that the service sector shows negative production activity changes more than does the manufacturing sector.

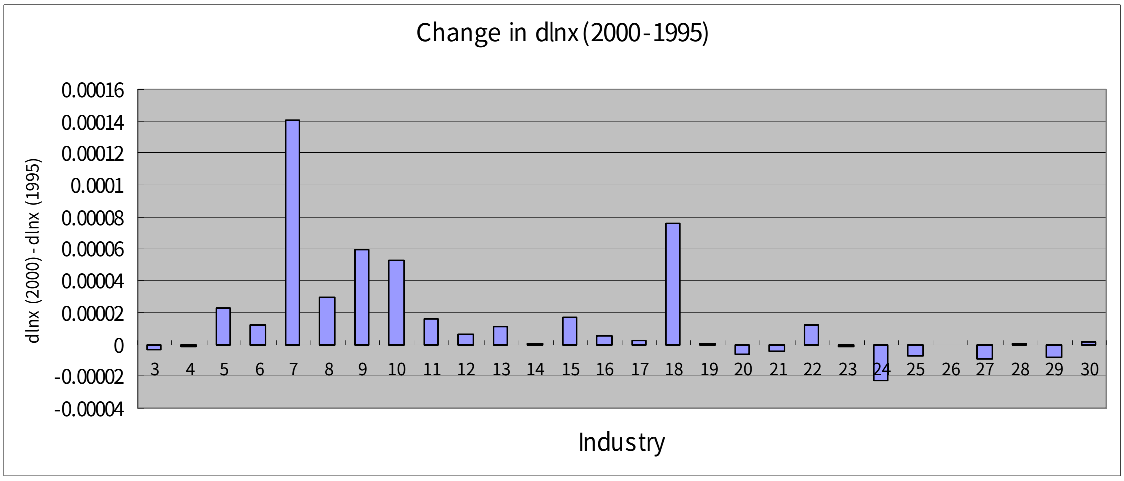

Figure 2. The difference in the change rate of output

This also implies that the process innovation might contribute to the production increase in the manufacturing sector more than in the service sector. This means that there is the possibility of employing more labor in the manufacturing sector than in the service sector. In particular, we can see little increase or decreases of production in the advanced service industries such as #22 (Transportation and warehousing), #23(Finance and insurance), and #25(Real estate and business services), respectively. This also implies that our economy is prone to the expansion of manufacturing, rather than the advanced industries of the service sector in production activity and employment increase.

In summary, IT process innovation gives our economy the chance to benefit the manufacturing sector rather than the service sector, which does not happen in the economically advanced economy. In highly advanced knowledge based societies, there is a trend toward shifting from the manufacturing sector to the service sector.

Finally, the IT industry has been growing rapidly due to strategic investment at the government level. The initial displacement effect (dL/L) for 1995 is -0.00174, while the figure for 2000 is -0.00171. The output effect (dx/x) for 1995 is 9.06519E-05, while the figure for the year 2000 is 6.84423E-05. As a result of these two elements, the change in AP_L and x diminishes over the five year period. Consequently, the bar graphs in figures 1 and 2 for #24.IT industry show negative values. Despite support from the government level for this industry, the labor productivity and compensatory effect of employment are atrophied. One possible interpretation of this data is that even if the IT industry expands due to strategic policy, it would not necessarily contribute to the labor productivity or result in increased employment in the IT industry itself.

6. Concluding remarks

Despite government-led strategy to cultivate the IT industry, this analysis reveals that it neither improves labor productivity nor creates employment overall based on statistical tests. Analysis shows that the contribution of process innovation to the Korean economy is not so strong as to affect labor productivity and cover the initial labor displacement. The positive mean values of differences in the test of labor productivity and employment increase can make us think that our economy is on the trend of improving even if the statistical value is not strong enough to be significant. The proper interpretation of this analysis should be that we have not yet reached the stage where labor productivity and employment increase have realized in five years, not that IT is unable to increase labor productivity and employment in Korea.

By viewing the graphic comparisons of industries, it can be seen that the benefit from

IT innovation is likely to occur in the manufacturing sector, which is not desirable for a knowledge based economy. We are not yet in a position where IT would be expected to slow the transfer from manufacturing to service sector employment because of capital goods production, as was found in Leontief and Duchin(1986). The example of the US, which demonstrates a slowing transfer, is different from our analysis in that our economy is prone to an expansion of the manufacturing and a contraction of the service sector.

The VIO model used for this analysis can be closely related with the compensating effect of price reduction resulting from the decrease in labor use. The work of the VIO model is to find the change in the industries' production process, and the result can be interpreted that the industrial structure for production is not yet IT friendly. In Korea, government-led "informatization policy" has concentrated on support of capital investment in hardware infra and R&D. This is not enough to improve the production system during the period of pre and post economic crisis without forming the market mechanism.

In the expectation as a measure for economic recovery, the development of IT is not effective not only in the industry-level productivity growth (Kim and Oh, 2004) but also in this labor productivity growth. From this analysis of labor, it can be argued that the lack of improvement in output change shows that IT related training is not yet grown sufficiently to cultivate manpower in the economy. The growth and quality of IT-based education and its delivery are recommended to become an item of government policy and corporate strategies. The cultivation of habitat for the IT industry to operate in the market mechanism is also recommended, the purpose of which is to foster a basis of e-commerce for inter-industry trade. The stimulation of inter-industry trade will create a change in intermediate demand that implies IT friendly structural change in entire industries of the economy.

Acknowledgement

I am very grateful to Dr. Jae Ha Jung, researcher at Korea National Assembly, and to Professor Joonmo Cho of Soongsil University for their invaluable comments that helped improve this research. In addition, especially detailed advice from Walter J. Folger, JD contributed considerably to the completion of this paper.

Appendix

A.1. VIO model

VIO model is established by transforming a Cobb Douglas' production function into log-linear type: $\ln x_j = \alpha_{oj} + \Sigma_i \alpha_{ij} \ln x_{ij} + \Sigma_k \beta_{kj} \ln L_{Kj}$ (1)
Profit equation(zero profit): $p_j x_j - \Sigma_i p_i x_{ij} - \Sigma_k w_{kj} L_{kj} = 0$ (2)

The Lagrangian Equation for profit maximization by enlarging the difference between revenue and cost subject to technical constraint.

$$\text{Max } \Pi = \Sigma_j (p_j x_j - \Sigma_i p_i x_{ij} - \Sigma_k w_{kj} L_{kj})$$

$$+ \Sigma_j \lambda (\ln x_j - \alpha_{oj} - \Sigma_i \alpha_{ij} \ln x_{ij} - \Sigma_k \beta_{kj} \ln L_{Kj})$$

x_j: output of j industry
x_{ij}: commodity (intermediate medium) of i industry purchased by j industry
L_{kj}: amount of labor or capital employed in j industry as value added.
p_j: commodity price of j industry,
p_i: commodity price of i industry,
w_j: unit price of primary production factors (labor or capital) purchased by j industry
$\Sigma_i \alpha_{ij} + \Sigma_k \beta_{kj} = 1$: condition of linear homogeneity

The optimal levels of employment of intermediate input, labor and capital obtained from the first derivative procedures are:
$x_{ij} = p_j \alpha_{ij} x_j / p_i$, $L_{kj} = p_j \beta_{kj} x_j / w_{kj}$ (3)

These optimum values of intermediate medium, labor, and capital in (3) into eq.(1) in order to obtain a following price function.
$\ln p = (I - A')^{-1} [\Sigma_k \beta_k \ln w_k]$ (4)

In the above equation(4), primary input(labor or capital) wage rate (w_k)is the only variable to affect the commodity prices(p). The cost variation in the primary input of a certain industry affects prices of all industries' commodities. These changed prices are reflected in a basic equation of IO table as follows:
$x_i = \Sigma_j x_{ij} + f_i = \Sigma_j p_j \alpha_{ij} x_j / p_i = \Sigma_j (p_j / p_i) \alpha_{ij} x_j$

The x_{ij} in equation(3) including the changed relative prices will lead to change in intermediate input use through the change in production method(α_{ij})affected by relative prices of commodity. In matrix form, we can express output equation as follows:

$$x = \hat{p}^{-1}(I - A)^{-1}\hat{p}f\ , \quad \text{the "^" sign indicates a diagonal matrix of price,} \qquad (5)$$

A.2. Industries and change in industrial share for year 1995 and 2000

	Industrial share		Difference in share
Industry	yr 1995	Yr 2000	yr2000-yr1995
1. Agriculture, forestry, and fisheries	3.80%	2.75%	-1.05%
2. Mining and quarrying	0.39%	0.19%	-0.20%
3. Food, beverages and tobacco	4.98%	4.24%	-0.74%
4. Textile and leather products	4.13%	3.36%	-0.77%
5. Wood and paper products	1.55%	1.21%	-0.34%
6. Printing and publishing	0.91%	0.71%	-0.20%
7. Petroleum and coal products	2.21%	3.82%	1.61%
8. Chemicals and allied products	6.39%	6.36%	-0.03%
9. Nonmetallic mineral products	1.89%	1.23%	-0.66%
10. Primary metal products	4.97%	4.14%	-0.83%
11 .Fabricated metal products	1.95%	1.51%	-0.44%
12. General machinery and equipments	3.55%	3.10%	-0.45%
13. Electrical machinery and equipment	1.43%	1.57%	0.14%
14. Household electrical appliances	0.63%	0.54%	-0.09%
15. Precision instruments	0.53%	0.49%	-0.04%
16. Transportation equipment	5.79%	5.36%	-0.43%
17. Furniture and manufactured products	0.95%	0.72%	-0.23%
18. Electric, gas, and water services	1.79%	2.09%	0.30%
19. Construction	9.80%	7.29%	-2.51%
20. Wholesale and retail trade	5.89%	5.01%	-0.88%
21. Eating, drinking, and lodging	0.83%	2.95%	2.12%
22. Transportation and warehousing	3.96%	3.67%	-0.29%
23. Finance and insurance	3.84%	4.55%	0.71%
24. Information technology	**7.60%**	**11.41%**	3.81%
25. Real estate and business services	8.23%	9.00%	0.77%
26. Public administration and defense	3.05%	3.13%	0.08%
27. Educational and research services	3.14%	3.00%	-0.14%
28. Medical, health, and social services	1.62%	2.23%	0.61%
29. Culture and recreational services	0.70%	0.86%	0.16%
30. Other services	1.02%	1.34%	0.32%
31. Dummy sectors	2.51%	2.15%	-0.36%
Total	100%	100%	

A.3.Eemployment elasticity, direct displacement, change in output, and the rate of change in average labor productivity of 1995

Ind.	elasticity	dL	L	dX	X	dln(AP_L)
1	0.0060322	-168.9296	2800445	-579.2842	31941591	4.21867E-05
2	0.061099	-500.3935	818988	1534.9458	3255599	0.001082469
3	0.0064011	-248.2529	3878279	-453.4598	41910021	5.31913E-05
4	0.0025601	-160.8986	6284875	-108.3368	34736235	2.24821E-05
5	0.0175218	-321.2295	1833314	-10.91278	13042744	0.000174381
6	0.0165681	-350.1308	2113284	25.721007	7638559	0.000169048
7	0.0142801	-102.9809	721148	496.67782	18610952	0.000169489
8	0.0213012	-1385.238	6503099	63.917047	53766171	0.000214201
9	0.0241486	-695.435	2879809	381.78055	15880630	0.000265527
10	0.0165065	-533.7866	3233789	-100.4899	41795790	0.000162661
11	0.0082723	-279.2325	3375508	-11.06751	16394772	8.2048E-05
12	0.0076718	-411.6358	5365540	26.656792	29885443	7.76104E-05
13	0.039589	-876.8084	2214779	354.95479	12046677	0.000425355
14	0.0004254	-2.408305	566179	1.242136	5275146	4.48908E-06
15	0.0181758	-143.1588	787633	121.24925	4424530	0.000209162
16	0.0020568	-143.1792	6961229	59.965255	48718011	2.1799E-05
17	0.0039615	-66.35132	1674907	-35.62849	7953638	3.51354E-05
18	0.0171407	-279.6663	1631592	-113.9069	15070349	0.000163849
19	0.0028554	-581.2122	20354621	-75.75604	82508217	2.76361E-05
20	0.0123715	-1656.652	13390903	-260.9787	49598665	0.000118453
21	0.0127923	-261.3537	2043051	-36.1832	7008297	0.00012276
22	0.0110026	-1069.472	9720144	-149.1526	33320065	0.00010555
23	0.0156053	-2506.682	16063008	528.93854	32282831	0.000172438
24	0.1741674	-16683.74	9579144	5796.6755	63944358	0.001832325
25	0.0186893	-1849.613	9896652	-1163.774	69216877	0.000170079
26	0	0	14797057	0	25702390	0
27	0.0198603	-3909.317	19684098	140.06212	26420651	0.000203904
28	0.0017074	-105.6183	6186093	-45.95552	13601056	1.36947E-05
29	0.0048776	-86.3255	1769842	-44.13515	5870856	4.12582E-05
30	0.0020801	-57.5539	2766878	-42.07711	8603753	1.59105E-05
31	0	0	0	-307.4558	21093689	0
	Col.1: number of industry. Col. 2: labor employment elasticity affected by IT innovation. Col.3: reduced labor cost from displacement effect obtained from Col.2. Col.4: labor cost of raw data from IO table. Col.5: change in output due to the change in labor use of Col.3. Col.6: output of raw data from IO table. Col.7: the derived value of d(APL)/APL= (dx/x)-(dL/L) * Col. 3,4,5, and 6 indicate values of million won.					

A.4. Employment elasticity, direct displacement, change in output, and the rate of change in average labor productivity of 2000

Ind.	elasticity	dL	L	dX	X	dln(AP_L)
1	0.0073823	-242.49	3284756	-915.5857	38286604	4.99088E-05
2	0.2192408	-1270.003	579273	16257.027	2648206	0.008331291
3	0.0071671	-327.8365	4574206	-840.7244	59086107	5.74419E-05
4	0.004072	-318.5446	7822855	-189.1807	46871861	3.66836E-05
5	0.0263347	-509.2633	1933810	371.71049	16863033	0.00028539
6	0.0234475	-485.2573	2069544	156.98393	9897778	0.000250336
7	0.0165977	-217.5123	1310500	8882.5749	53147849	0.000333106
8	0.0270316	-2324.822	8600389	2732.7993	88626862	0.000301151
9	0.0308705	-836.5801	2709964	1437.7052	17173290	0.000392423
10	0.0272425	-1100.133	4038296	2902.9281	57688957	0.000322745
11	0.0145258	-601.4851	4140801	317.22286	21007052	0.000160359
12	0.0089577	-600.3516	6702088	333.01113	43132012	9.72975E-05
13	0.0566208	-2012.168	3553760	896.04694	21917620	0.000607091
14	0.0006037	-5.059867	838117	9.1201035	7506444	7.25215E-06
15	0.0379604	-367.902	969174	300.54196	6804980	0.000423769
16	0.0019072	-172.3984	9039149	510.57816	74613704	2.59154E-05
17	0.0060224	-111.4136	1849999	-20.34042	10004276	5.81904E-05
18	0.0208048	-433.4355	2083347	2000.0409	29160431	0.000276635
19	0.0037154	-1003.575	27011500	-65.20747	101596525	3.65118E-05
20	0.019114	-3504.101	18332641	-783.1747	69844226	0.000179927
21	0.0158671	-1550.313	9770590	-404.3721	41143520	0.000148843
22	0.0113356	-1417.951	12508848	414.05054	51160891	0.000121449
23	0.0209123	-5214.863	24936773	949.92747	63435436	0.000224098
24	0.1707041	-35326.31	20694465	10878.994	158951238	0.001775484
25	0.0252133	-4380.329	17373120	-3043.305	125375453	0.000227859
26	0	0	21157304	0.00E+00	43601282	0
27	0.0203471	-5887.97	28937627	-150.7574	41762394	0.000199861
28	0.0020133	-238.5401	11848449	-85.15915	31045248	1.73895E-05
29	0.0138917	-469.3575	3378686	-191.3555	11917074	0.00012286
30	0.0031177	-158.5141	5084331	-54.33572	18675118	2.82675E-05
31	0	0	0	-376.8776	29982300	0
	Col.1: number of industry. Col. 2: labor employment elasticity affected by IT innovation. Col.3: reduced labor cost from displacement effect obtained from Col.2. Col.4: labor cost of raw data from IO table. Col.5: change in output due to the change in labor use of Col.3. Col.6: output of raw data from IO table. Col.7: the derived value of d(APL)/APL= (dx/x)-(dL/L) * Col. 3,4,5, and 6 indicate values of million won.					

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The Bank of Korea, 2004, "2000 Input-Output Tables

Notes

[1] This rate is the highest in the economy followed by Eating, drinking, and lodging industry, having grown from 0.83% to 2.95%(growth of 2.12%). The Eating, drinking, and lodging industry is followed by Petroleum and coal products industry having grown from 2.21% to 3.83%(growth of 1.61%) and all other industries show increase or decrease in their growth within 1%.

2 The 2000 Input-Output table released by the Bank of Korea is the latest data available at this time.

3 This analysis is to find the effect of IT innovation. If the projections of consumer' demand, firms' investment and international demand in the final demand were done, then the gains would be independent of IT(Stiroh, 2002, p.1566).

4 Whitley and Wilson(1982), "Changes in the pattern of consumption and intermediate demand may also play important role although we have not found so in this particular exercise; further research is required", p.494 , Futures 14(6).

5 Liew & Liew(1988), p. 570

6

$$d\ln L_K = (\hat{w}_k \hat{L}_k)^{-1}\left[\hat{\beta}_k (I-A)^{-1}\hat{p}\hat{f}\right]\cdot\left[(I-A')^{-1}\sum_{j=1}\hat{\beta}_j d\ln w_k\right] - d\ln w_k$$

$$= \left\langle (\hat{w}_k \hat{L}_k)^{-1}\left[\hat{\beta}_k (I-A)^{-1}\hat{p}\hat{f}\right]\cdot\left[(I-A')^{-1}\sum_{j=1}\hat{\beta}_j\right] - I \right\rangle d\ln w_k$$

7 In this paper, IT is arranged as the 24^{th} industry.

8 For a graphical description about Leontief's works, see P. A. Samuelson, Activity Analysis of Production and Allocation(Wiley, 1951), p.142

9 It is difficult to deal with the product innovation, because it needs a new row and column for this new commercialized product in the I-O table.

10 The exactly same test as the case of $dlnAP_L$ and dlnx is done for the initial labor displacement(dlnL). The statistical test result shows values of t(-1.81) and its p (4.04%). The labor displacement rate due to the process innovation has increased(an increase in unemployment) for five years at the significance level of 5%.