The Economic Importance of the Information and Communications Technology (ICT) Industry in Korea: A CGE Approach

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Abstract

A dynamic CGE model is used to investigate the economic importance of information and communication technology (ICT) industry in Korea. The basic framework used in the model is ORANI-F. The model is calibrated to Korean input-output (I-O) data for 1995, and the base year 1998 I-O data are updated by historical simulation in order to be utilized as a basis for forecasting.
Forecasting is carried out until 2004. Major findings include high growth of ICT industry leading high share in output and value added in the year 2004. However, high import dependence in intermediate input and capital goods turned to greatly offset the positive role of ICT manufacturing in earning foreign currency.

Keywords: IT industry, ICT industry, Korean economy, CGE model, input-output data

1. Introduction

Recent development of information and communications technology (ICT) is changing our economy and society in a rapid way. Electronic commerce, internet and related activities demand more data-processing power, more memory and more speed. Due to this surging demand for ICT, the industries which provide ICT goods such as computer, software, telecommunications equipment are growing enormously and are becoming to have growing importance.

The research regarding 'information sector' has begun from an attempt to identify the importance of knowledge and information in 1960's. Machlup (1962) was a pioneer work on the economic importance of knowledge and related activities in the U.S. economy. Porat (1977) introduced a concept of 'information sector' and utilized input-output (I-O) table for thorough measurement of the sector in the economy. Porat's method was applied to find out the weight of 'information sector' in Japan, Australia, Singapore and Korea by Engelbrecht (1989), Karunaratne (1986, 91), Heng and Low (1990) and Engelbrecht (1988). Also, Engelbrecht (1988, 89) and Karunaratne (1991) tried to measure the effect of economic policy to information sector by using ORANI-type computable general equilibrium (CGE) model.

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Recently, there are studies to measure the share and economic impact of ICT industry. US DOC (1998, 1999) attempt to measure the contribution of 'IT-producing' industries to the economy and draw implications herein. OECD (2000) examines the growing importance of IT in OECD economies from various angles.

To measure the importance of IT industry, forecast is needed as well as current and previous values. Especially fast-growing industries like IT, there is a constant need to get updated picture of the industry. Also, we often need industry forecast, which is consistent with other industries' growth prospect. For these two purposes, a dynamic CGE model is a useful and an essential tool. In CGE modeling literature, the static ORANI model constructed by Dixon et al. (1982) has been improved to dynamic ORANI-F (Horridge, Parmenter and Pearson (1993)), and recently to MONASH model ((Adams et al (1991), Dixon and Rimmer (1999)). This line of CGE modeling is also wildly adopted to the study of world trade model such as global trade analysis program (GTAP).

The purpose of this paper is to identify the economic importance and characteristics of ICT industry in Korea in recent years and in the near future. For this purpose, a dynamic CGE model is utilized and forecast is carried out for the year 2004.

Section 2 discusses definition of ICT industry and recent status of ICT industry in Korea. In section 3, model and simulation procedure is introduced. In section 4, findings on ICT industry are discussed.

2. ICT Industries in Korea

The terminology 'ICT industry' seems to come with convergence of computing and telecommunications technologies. Conventionally, computer and software industries have often been referred to as IT industry. And ICT industry may seem to be regarded as IT industry together with communications industry.
In defining the ICT industry, the U.S. DOC (1998, 1999) and OECD (2000) include 'wholesale and retail trade of computers and software' and also include industries like 'industrial instruments for measurement'.

In this study, ICT industry include manufacturing of computer and office machines, electronic components, telecommunications equipment and audio-video equipment, and services such as telecommunications, broadcasting and computer related services. (See appendix 1.)

ICT industry is also one of the so-called 'knowledge-intensive industries', which is highly value-added. Also it is an industry which, itself, intensively uses IT technology.

In many countries, ITC industry contributes a lot to the economy. U.S.DOC (1999) points out that "IT producing industries are a critical source of U.S. economic strength" and "the IT-producing industries contributed on average, more than one-third of total real economic growth".[1] Also, the report predicts that ITC industry's share of GDP will be 8.2% in 1999 from 5.8% in 1990.

Korea is one of the major economies as far as manufacturing section of ITC industry is concerned. According to OECD (2000), Korea is third in the production of ICT goods following U.S. and Japan. However, the gap between Japan and Korea is large. As is shown in Table 1, U.S. produced 266 billion dollars' worth of ICT hardware. Japan produced 217 billion and Korea produced 48.3 billion. Among Korean production, 'Electronic data processing (EDP) and office equipment' production was 8.2 billion, 'radio communications, telecommunications and audio-video equipment' amounted to 11.9 billion, and component production reached 28.2 billion dollars.

Table 1. ICT goods production by major countries (1997)

(Unit: Mil. US Dollars)

Rank	EDP & Office equipment	Radio Comm., Telecom & Audio-Video Equipment	Components	Total
1	U.S. (87,449)	U.S.(100,137)	U.S. (79,212)	U.S. (266,798)
2	Japan (73,901)	Japan (59,711)	Japan (84,380)	Japan (217,992)
3	Singapore (25,335)	France (16,487)	Korea (28,187)	Korea (48,310)
4	Taiwan (17,936)	Germany (13,935)	Singapore (13,361)	Germany (42,756)

Source: Reed Electronics Research (1999), quoted from OECD (2000).
Note: EDP: Electronic Data Processing

As is shown in Table 1, Korea is major producer of electronic components, and especially is a major supplier of DRAM.[2]

Table 2 shows that ICT manufacturing industry in Korea has grown rapidly. In production, ICT manufacturing accounted for 2.3% of production in 1985. And in 1995 the share became about 5.0%.
The share of value added in ICT manufacturing has grown from 1.5% to 4.1% in ten years. And the share of export sored from 7.13% to about 21%. Especially, due to the worldwide shortage of semiconductor supply in 1995, the price of DRAMs increased sharply. Mainly due to the price increase, share of semiconductor production jumped from 0.5 to 2.1%. In export, semiconductor, which is 'a single product', became to constitute '13.6%' of total exports of the economy. The semiconductor boom led to short term 'overheat' of Korean economy in 1995.

[1] U.S.DOC (1999), p.15.
[2] SERI (2000) reports "Korea has been no. 1 in world DRAM production since 1998. In 1998, share of major Korean chipmakers like Samsung, LG and Hyundai is about 38%."

One of the characteristics of Korean ICT manufacturing is that portion of production for export is significant. It is obvious if we remind that most of DRAM production is for export. Besides DRAM, Korea is one of the major supplier computer peripherals like monitor and CD-ROM drive.

Table 2. Share of ICT Manufacturing Industries in Korean Economy
(Unit: %)

	Production		Value Added		Export	
	1985	1995	1985	1995	1985	1995
Telecom Equipment	0.75	0.98	0.54	0.66	1.15	1.71
EDP Equipment	0.30	0.83	0.16	0.26	1.69	2.68
Semi-conductor	0.51	2.08	0.33	2.46	2.97	13.58
Other Component	0.71	1.07	0.47	0.69	1.32	3.03
Sum	2.27	4.96	1.50	4.07	7.13	21.0

Source: Hong, Kim and Jeong (1999).
Note; In this classification, video-audio equipment and office equipment are not included.

Since ICT manufacturing is most important 'strategic' industry, there has been a need for future prospects of the industry from policy makers and industry alike. Since future prospects of an industry is often interrelated with other industries, the industry forecast is best done in the context of general equilibrium. That is why model like ORANI is needed for the forecasting of ICT industry.

3. Model and Simulation

3.1 Model

Conventional CGE model is based on the optimization behavior of various economic agents like consumer and producer. The model adopted in this study is from Kim and Moon (2000). It is a slightly modified version of ORANI-F and it has two different specifications as follows.

First, it differentiate domestic good and export good. For each industry *i*, relevant equations with regard to supplies to domestic and export markets (q^i_{dom} and $q^i_{\exp}$) are formally given as followings in percentage change form:

$$q^i_{dom} = x^i + \sigma^i \left(p^i_{dom} - p^i\right) + f^i_{dom}, \qquad (1)$$

$$q^i_{\exp} = x^i + \sigma^i \left(p^i_{\exp} - p^i\right) + f^i_{\exp}, \qquad (2)$$

$$s^i_{dom} f^i_{dom} + \left(1 - s^i_{dom}\right) f^i_{\exp} = 0. \qquad (3)$$

Supply to each market is proportional to the industry's activity level, x^i, and to

a price term which is an elasticity of transformation, σ^i, multiplied by the percentage change in a price ratio, $p^i_{dom} - p^i$ or $p^i_{\exp} - p^i$, representing the price of the good at each destination relative to the overall price level of products by the industry. f^i_{dom} and $f^i_{\exp}$ are shift variables related to supplies to domestic and export markets. They represent peculiar determinants of supply to each market. Equation (3) ensures that these shifts take place along the given transformation curve. s^i_{dom} is the share of products destined to domestic market in the total value of products by industry *i*.

Second, it adopts the MONASH-MRF type capital accumulation specification. Rather than assuming, as ORANI-F does, that investment in the time span 0-T follows a straight-line path, we set the growth in the industry specific capital stock between the forecast year (year T) and the following (year T+1) equal to the average annual growth rate over the forecast period. That is, for each industry *i*:

$$\left(\frac{K^i_{t+1}}{K^i_t}\right) = \left(\frac{K^i_t}{K^i_0}\right)^{1/T} F \,, \qquad (4)$$

where K^i_t is the capital stock operational at time t, and *F* is a shift term. This shift term is required because we exogenize aggregate investment in our simulations. *F* is determined endogenously to ensure sufficient growth in capital stock to absorb the given aggregate level of investment. The capital accumulation relation is:

$$K^i_{t+1} = (1-\delta)K^i_t + I^i_t, \qquad (5)$$

where I^i_t is investment at time t, and δ is the depreciation rate.

3.2 Database and Parameters

The original 402-sector database is aggregated to the level of 33 commodities and industries.[3] ICT industries were separately specified in greater details. ICT industry consist of 'C14. Electronic components', 'C15. Video, audio and telecom. equipment', 'C16. Computer and office machines', 'C25 Communications', 'C26 Broadcasting' and 'part of C29 Business services.' 'Part of C29 Business services' is 'Computer-related services' like software industry. Due to lack of statistical data, it could not be separated.
To calculate share of Computer related service, some assumptions are introduced.

One of the difficult jobs facing modelers applying an ORANI type model to other economies is the selection of appropriate values for various parameters. There are fourteen types of parameters required in the model. They are Armington elasticities for intermediate users, investors, and households; investment parameters; elasticities of output transformation; capital

[3] See the appendix 2 for the 33 industry (commodity) classification.

depreciation rates; total/supernumerary expenditure ratios for consumers; ratios of gross to net rate of return; investment/capital ratios; marginal budget shares for consumers; world interest rate factor; substitution elasticities of labor for capital; the debt/GDP ratio; and export demand elasticities.

We use values contained in the ORANI-F database for investment parameters, total/supernumerary expenditure ratios. Capital depreciation rates and investment/capital ratios for the 33 industries are given in the annual Financial Statements Analysis by BOK. The debt/GDP ratio for the base year is taken from Korea Statistical Yearbook.

As for other parameters, it is desirable to use results obtained from independent empirical research. As far as we know, such empirical studies for the Korean economy are existent only for two parameters, i.e, Armington elasticity and substitution elasticity of capital for labor. In the case of substitution elasticity of capital for labor, most of the existing studies were conducted for overall manufacturing sectors. As for Armington elasticity for three types of users, we took the numbers from a recent study conducted by Moon (1999). As for the substitution elasticity, we referred to a recent estimate by Nam (1990) and modified them through the process of repeated experiments and historical simulation. ORANI-F data being taken as a source of reference, numbers for marginal budget shares are chosen so that expenditure elasticities are within economically reasonable ranges for each commodity.

In sum, a guesstimate procedure has been guided by economic reasoning and available information on various industries. Initial numbers for various parameters have been modified several times; indeed, hundreds of experimental simulations were conducted to ensure that finally adopted parameter settings did not violate prior beliefs about the likely responses of the Korean economy to various shocks. Simulations were eventually carried out in a condensed system of 9,315 variables and 6,359 equations with an automatic accuracy level of 95%.

3.3 Update Simulation

Original I-O table for the year 1995 is unlikely to be a suitable database for forecasts or policy simulation for a rapidly changing economy such as Korea. Therefore, we follow the pioneering work of Dixon and McDonald (1992) on historical simulation to produce 1998 I-O table that is consistent with all relevant data from reliable sources for the period 1995 to 1998.

Specifically, I-O table for 1998 is estimated by using our CGE model to compute a solution to a simulation in which exogenous shocks consist of observed percentage changes between 1995 and 1998 in a large number of variables. Percentage changes in endogenous variables obtained from the simulation are used to update the I-O database. The model is refined in the

process of historical simulation and becomes a more complex system as shift variables are added to various activities in the model to allow for the impact of technology or taste changes. These shift variables capture some extra changes in output or consumption not explained by the mechanism of the economic model. Historical simulation, therefore, serves as a technique for measuring technological development and change in consumers' preferences. Comparison between the original 1995 I-O table and the I-O table generated by historical simulation can then be made to identify how the industrial structure of the country has changed.

The following are some of the variables for which we used observations for 1995 to 1998 in the historical simulation: nominal GDP, total nominal investment, nominal government consumption, consumer price index, nominal aggregate import, employment by industry, and nominal investment by using industry.

For many vector variables, reliable numbers are available only at more aggregated level and we are not able to gather price information for service industries. Information, for example, on the price indexes for domestic supply, exports and imports are available only for 19 commodities (C1-C19). Without any a priori reason to conjecture otherwise, we assume no change in the export and import price indexes for service industries[4]. For the remaining missing pieces, we let the model work out what those numbers should be.

In Table 3, a comparison of observed and simulated growth rates for key endogenous macroeconomic variables from 1995 to 1998 confirms that the model behaves well at the macro level in simulating the past growth rates and may therefore also do well in forecasting the future. Without any information on the realized values, it is not possible to make a full assessment of model's behavior at individual industry level. However, we can say that our updated I-O table is produced by using explicit and economically reasonable assumptions that underlie the theoretical structure of the model, and is consistent with all published data on the structure of the economy for 1998.

Table 3. Variation of macro variables

Symbol	Variable	Total % change during the period 1995 – 1998	
		Actual value	Simulated value
w0GDPexp	Nominal GDP	19.1	
x0GDPexp	Real GDP	5.60	5.58
phi	Nominal exchange rate	81.43	73.73
w3tot	Private consumption(nominal)	17.92	18.33

4 Since the total value of exports and imports for service industries is relatively minor, our assumption would not affect the simulation result in any serious way.

x4tot	Export volumes	55.80	41.45
x0cif_c	Import volumes	-11.68	-10.51
p0GDPexp	GDP deflator	13.00	12.80
p4tot	Export price index	34.10	34.29
p0cif_c	Import price index	41.40	42.70
w4tot	Total value of exports (FOB)	92.51	89.96
delNTDF	Level Change in Trade deficit (million won) (million U.S. dollars)	-61,682,100 -44,094	-70,202,360 -50,185

Note: w0GDPexp is an exogenous variable that takes the actual values.

The period update simulation is carried out includes the so-called IMF crisis period for the Korean economy. Therefore, real GDP growth rate is in total 5.6% during the period and the number of employed has decreased. Value of won against U.S dollars depreciated by 81.43% during the period, which caused immediate decrease of imports. Per capital GDP plummeted from $10,823 in 1995 to $6,823 in 1998. And the share of total investment among GDP decrease from 37% in 1995 to 21% in 1998, due to the uncertain economic situation and sharp rise of cost of financing capital.[5]

3.4 forecasting simulation

The mid-term forecast is carried out until 2004 using the updated 1998 I-O table. In the forecast, the exogenous variables were carefully selected to form a reasonable closure.
It was necessary in forecast to generate similar results for important variables such as real private consumption, real total investment, real government expenditure, export and import value, and growth rate of employment. To achieve that, shocks were given to shift variables related to those variables. By doing this way, more precise results were obtained, and in this forecasting simulation, the degree of precision is more that 95%.

As for the exogenous variables, the following variables were selected: population growth rate, exchange rate, consumer price index, aggregate nominal investment, ratio between public demand and real private consumption, change of trade deficit.

For setting future paths of the exogenous variables, actual data during 1998 to 1999 and various forecast results were examined and selectively adopted. As is shown in appendix 3, exchange rate is assumed to depreciate by 10% during the forecasting period of 1998 to 2004. The ratio of government expenditure and private expenditure, (f5tot), is assumed to decrease by 17% to reflect government's need for balanced public finance.

[5] Interest rate represented by rate of return from 3-year corporate bond reached to more than 20% in the early 1998.

For ICT industries, growth forecast of export and domestic demand by KISDI is adopted through 'nominal supplies of export goods' (w4fexp) and 'domestic demand shifter (fdom)'.[6] For other manufacturing industries, export supply (fq_ex) is assumed to increase by 10%. Shock for the change of foreign import prices (pf0cif) is calculated based on the past trends during 1991 to 1995. Among vector of pf0cif, shock of the foreign import price for C2 (mine) is set 80% reflecting recent price hike of world crude oil prices.

4. Result of Forecasting

The forecasting result is summarized in table 4. From 1998 to 2004, GDP increases from 463 trillion won to 753 trillion won. Real growth rate of GDP is 56.46, which means average 7.75% per year.[7] In fact, Korean economy has recovered quite well for the past two years since the foreign exchange crisis. In 2004, per capita GDP is expected to be $ 12,260.

Consumption, which has been depressed during 1998, is shown to pick up in 2004. Also, investment that has shrinked much during 1998 is expected to increase to 24% of GDP. To reduce budget deficit, government expenditure is forecast to be the level of 9% of GDP.
Export will increase at the rate of 4.3% per year. But due to rapid increase of import due to appreciation of Won and increase of investment, trade surplus turns to be deficit of 30 trillion won.

Table 4 Major Macroeconomic variables

(unit: bil. won)

	1995	1998	2004
GDP (V0GDPINC)	388,688	462,928	752,998
Private Consumption (V3TOT)	203,003	238,731	480,959
Investment (V2TOT_I)	143,428	95,953	177,513
Government Expenditure (V5TOT)	37,751	50,699	68,192
Export (V4TOT)	113,852	217,756	280,662
Import (V0CIF_C)	116,304	148,520	310,662
Trade Balance (Mil. won)	-2,452	62,235	-30,000
Won-dollar exchange rate (Average)	771.04	1,398.88	1,258.99
Per Capita GDP ($)	11,179	7,128	12,260

Note: For 1995, numbers are actual ones. For 1998 and 2004, the numbers are simulated ones.

In terms of change of industrial structure, the weight and importance that has been carried by manufacturing industries seem to go on in year 2004.[8] ICT

[6] Refer to Hong et al. (2000).
[7] This appears quite large number. However, if we remind that the real growth rate of GDP during 1998 to 1999 is 10.1%, and that it is expected to be over 8% during '99 to 2000, it is not very unrealistic.
[8] In this aspect, the result differ from observation by Bank of Korea, which expects the increase of

industry is expected to account for 15.7% of sales in 2004 from 7.7% in 1995. Also, share of value added increases from 7.4% to 18.1% in year 2004. If we divide ICT industry into manufacturing and service, manufacturing industry constitutes 11.0% and service constitutes 4.7%.[9]
As is mentioned earlier, the importance of electronic components is also shown again. That sector represents 4.6% in production and 5.4% in value added.

Table 5. Output and value added share trend by industry groups (%)

	Output		Value Added	
	1995	2004	1995	2004
Agr., Fishery, Mining	4.3	3.5	6.6	4.7
Manufacturing	41.3	43.4	26.3	33.6
Utility & Constr.	11.5	5.3	10.8	2.9
Service	35.2	32.0	48.9	40.7
ICT	7.7	15.7	7.4	18.1
ICT Manufacturing	5.9	11.0	4.5	10.7
ICT Service	1.8	4.7	2.9	7.4
Total	100.0	100.0	100	100.0

Due to recovery of the economy, total employment is expected to increase by 18.4% during the forecasting period. As shown in table 6, employment in manufacturing other than ICT turns out decreasing. The increase of output share and decrease of employment share could mean substitution of labor for capital and increase of labor productivity.
ICT service employment is expected to increase due to our assumption of rapid increase in the computer-related service sector..

Table 6. Employment share trend by industry group (%)

	1995	1998	2004
Agr., Fishery, Mining	0.7	0.7	0.8
Manufacturing	24.9	21.6	20.4
Utility & Constr.	7.6	6.2	4.0
Service	63.1	67.2	67.2
ICT	3.8	4.3	7.6
ICT Manuf	2.4	2.4	3.2
ICT Service	1.4	1.9	4.4
Total	100.0	100.0	100.0

ICT manufacturing export is expected to jump from 50.1 trillion won to 95.1 mainly due to assumed shock on nominal supplies of ICT goods. In 2004, ICT

service sector of the economy in the future.
[9] For computer related services, we assumed that it will grow from 1998 to 2004 at about the same growth rate during 1991 to 1995. According to that assumption, that industry is expected to account for about 2% of sales and GDP and 2.5% of employment.

exports accounts for 33.9% of total export. Considering the 11% of output share, it tells the high degree of export orientation of ICT manufacturing.

Also, I-O tables of 1995 and 2004 show a heavy import dependence on intermediate inputs and and investment goods. In 1995, Share of imported intermediate input for ICT manufacturing (42.1) is far greater than manufacturing (including ICT manufacturing.) average (28.2) and, moreover, the share (46.4) is expected to increase in 2004.

Table 7 Share of imported intermediate input and capital goods in ICT industry

	1995	1998	2004
Share of Imported Intermediate Input			
ICT Manufacturing	42.1	43.9	46.4
All Manufacturing	28.2	30.0	29.6
Share of Imported Investment Goods			
ICT Manufacturing	37.5	46.1	41.5
All Manufacturing	33.7	41.0	37.0

Also, share of of imported investment goods for ICT manufacturing industry is bigger and expected to last. Especially, the share for 'C15 Electronic component' has highest number of 0.508. This is presumably due to imported facilities for semiconductor manufacturing.[10]

Under this high dependency for imported input and capital goods, the high growth of ICT industry will imply also high growth of imports. Due to this structural characteristic together with appreciation of Korean Won implies the trade deficit of 2004. And this characteristic is one of reason why Korea has foreign currency crisis in 1998. Kim and Moon (2000) describes that "Excessive expansion by conglomerates (*chaebols*) fueled by easy credit caused the rapid increase in reliance on imported intermediate and capital goods. At the same time trade deficit during 96-97 left Korea more vulnerable to a foreign exchange shortage."

4. Conclusion

In this work, attempts have been made to forecast industry structure using a dynamic CGE model. From the I-O table and forecast result, some characteristics of ICT industry in Korea was shown as follows.
First, the growth of ICT industry is quite rapid and the industry is expected to account for high share of output, value added and employment.
Second, semiconductor such as DRAM has significant share in Korean ICT industry. Considering the variation of DRAM price shown during the decade,

[10] Around 1998, 90% percent of semiconductor facility is imported.

the high proportion of DRAM could cause instability to the economy.
Third, export proportion of ICT manufacturing is quite large.
Fourth, due to the high dependency to imported intermediate and capital goods, export is likely to be offset by the imports.

Regarding the fourth characteristic, measures to enhance the domestic content of intermediate input and capital goods seem necessary. It would involve continued R&D activities and human resource development as is often prescribes. Also, policy measures to supply enough IT workforce for the future need of ICT industries as well as other industries should be prepared. Considering that industries other than ICT would need IT workforce, excess demand for skilled IT workforce could be large in few years.

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Appendix 1. Definition of ICT Industries

Below is the definition of ICT industries adopted in this paper in terms of the International Standard Industrial Classification(ISIC) Revision 3.

3000 Manufacture of office, accounting and computing machinery
3210 Manufacture of electronic valves and tubes
and other electronic components
3220 Manufacture of television and radio transmitters and apparatus for line
telephony and line telegraphy
3230 Manufacture of television and radio receivers, sound or video
recording or reproducing apparatus, and associated goods
6420 Telecommunications
7200 Computer and related activities
4830 Broadcasting

The definition of ICT industries by OECD(2000) includes industries such as 3130 (insulated wire and cable), 3312 (measuring and checking instruments), 3313 (industrial process control equipment), 5150 (wholesale of machinery, equipment), and 7123 (renting of office machinery and equipment) in addition to the above. Also it excludes Broadcasting industry. Definition of 'IT-producing' industries by U.S. DOC (1999) is more or less similar to OECD's definition. However, it includes retail trade of computer/software and broadcasting service.

Appendix 2. Classification of Industries

C1.	Agriculture, forestry, and fisheries
C2.	Mining and quarrying
C3.	Food and kindred products, and tobacco
C4.	Textile products, apparel, and leather
C5.	Paper and wood products
C6.	Print, Publishing and Duplication
C7.	Petroleum and coal products
C8.	Chemicals and allied products
C9.	Stone, clay, and glass products
C10.	Primary metal products
C11.	Fabricated metal products
C12.	General machinery and equipment
C13.	Electric equipment
C14.	Electronic components
C15.	Video, audio and telecommunications equipment
C16.	Computer and office machines
C17.	Precision instrument
C18.	Transportation equipment
C19.	Furniture and other manufacturing products
C20.	Electricity, gas and water
C21.	Construction
C22.	Wholesale and retail trade
C23.	Restaurants and hotel
C24.	Transportation and warehousing
C25.	Communications
C26.	Broadcasting
C27.	Finance and insurance
C28.	Real estate
C29.	Business service
C30.	Public administration and defense
C31.	Educational and health services
C32.	Social and household services
C33.	Others

Appendix 3. List of Shocks to Exogenous Variables in Forecasting

Scalar Shocks (% changes)

symbol	Variable	Shock
q	The number of households	5.07
phi	Won-dollar exchange rate	-10
p3tot	Consumer Price Index	17.42
w2tot_I	Aggregate nominal investment	85
f5tot2	Ratio between public demand shift and real private consumption	-17
delNTDF	Change of trade deficit (Level change)	99,235,360

Vector Shocks (% changes)

Industry	1	2	3	4	5	6	7
C1. Agriculture, forestry, and fisheries			985	20			29.33
C2. Mining and quarrying			985	20			80.00
C3. Food and kindred products, and tobacco	25	10		20			33.83
C4. Textile products, apparel, and leather	25	10	985	20			0.62
C5. Paper and wood products	25	10	985	20			37.31
C6. Print, Publishing and Duplication	25	10	985	20			
C7. Petroleum and coal products	25	10	985	20			-21.56
C8. Chemicals and allied products	25	10	985	20			15.99
C9. Stone, clay, and glass products	25	10	985	20			-5.16
C10. Primary metal products	25	10	985	20			6.91
C11. Fabricated metal products	25	10	985	20			0.41
C12. General machinery and equipment	25	10	985	20			9.68
C13. Electric equipment	25	10	985	20			17.80
C14. Electronic components		10	985	20	30	81.92	-2.56
C15. Video, audio and telecom. equipment		10	985	20	30	229.70	-23.24
C16. Computer and office machines		10	985	20	30	117.26	-18.81
C17. Precision instrument	25	10	985	20			10.35
C18. Transportation equipment	25	10	985	20			18.56
C19. Furniture and other manuf. products	25	10	985	20			35.59
C20. Electricity, gas and water							
C21. Construction							
C22. Wholesale and retail trade							
C23. Restaurants and hotel							
C24. Transportation and warehousing			985				
C25. Communications					30		
C26. Broadcasting					10		
C27. Finance and insurance							
C28. Real estate							
C29. Business service					30		
C30. Public administration and defense							
C31. Educational and health services							
C32. Social and household services							
C33. Others			985				

Note: 1. (f4q) quantity shift in export demand; 2. (fq_ex) export supply shifter; 3. (f_delx6) shifter in inventories(level changes; billion won); 4. (f1lab) wage shift; 5. (fdom) domestic demand shifter; 6. (w4fexp) nominal supplies of export goods in dollars; 7. (pf0cif) CIF foreign currency import prices.