

# **KOREA'S EXPORT PERFORMANCE: THREE EMPIRICAL ESSAYS**

by

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## **Abstract**

This dissertation constructs three empirical essays. The first essay illustrates the causality on the relationship between output (GDP) growth and exports. By using the Modified Wald (MWald) test we observe unidirectional causality from exports to GDP. More specifically, for the robustness we use a Vector Error Correction Model (VECM) model and the Generalized Impulse Response Function Analysis (GIRA). The VECM and the GIRA yield bidirectional causality between exports and GDP, which weakly supports the unidirectional result of the MWald test. Meanwhile, we confirm that there is structure break by using the structural break test. These results are plausible and consistent with the expectations of our study for the Export Led Growth Hypothesis (ELGH). However, compared with previous studies on the ELGH for Korea, our results are different. Other studies show a bidirectional causality relationship but this study only has unidirectional causality. These differences may be caused from different observation data, various variables, and use of different econometric methodologies. Also, model selection and omitting variables can also significantly change the results of causality testing.

The second essay investigates a degree of competition between Korea's and China's exports in the U.S. market by using the substitute elasticity on a simple demand model. The market share of Korean exports has been decreasing while that of China's has been increasing. The results of this study are as follows. First, we find that Korea has a dominant market share of only goods group code 27 in commodity groups over that of China, otherwise having China's dominant market shares over those of Korea for other export sections by using historical trade data. Second, most estimates of substitute elasticity between both countries' exports in the U.S. market are small (inelastic). However, 61 (apparel articles and accessories, knit or crochet), 62 (apparel articles and accessories, not knit etc) and 85 (electric machinery etc, sound equipments, TV equipment, parts) commodity groups' substitute elasticities are large (elastic) and are competitive in the U.S. market compared with those of China. A small value of the elasticity of substitution may be due to an identification problem for a simple standard model as well as measurement errors in prices as a unit value in this study. So, in order to avoid problems such as these, we may need to use appropriate instrumental or proxy variables in the simple standard

model, which highly correlate with the independent (unit price) variables and are uncorrelated with measurement error terms. In practice, it is not easy to find good instrumental variables.

The final essay evaluates the roles of price and income as important factors that affect Korea's exports by using the most recent monthly data. By using the Autoregressive Distributed Lag (ARDL) bounds testing approach we find the long-run relationship of variables and estimate the long-run price and income elasticities. However, the estimates of these long-run elasticities are statistically insignificant. This may be due to some misspecifications or measurement errors in our model. Meanwhile, due to the existence of the long-run relationship between variables, we construct the Error Correction Model (ECM) in order to observe the short-run dynamics of the elasticities. Specifically, we add a dummy variable into our export demand model to achieve more efficient estimations since the dummy variable reflects a shock in Korea's export; Korea's economic crisis in 1997. In contrast to the long-run elasticity, we find that the short-run elasticities' estimates are more statistically significant. When we use the structure break test to check the structural stability of Korea's export demand, we find that there is no structural break point of 1997. Therefore, a shock of Korea's economic crisis in 1997 might not significantly affect Korea's export demand in a given sample. However, the Information Technology (IT) bubble of the world economy in 2001 and the entry of Korea into the OECD had triggered an increase in Korea's export demand due to existing structural break points of both events. In addition, we find that income elasticities are larger than price elasticities in the short run. This implies that income has more of an impact than that of price for the export demand model in the short run. This also implies that the change of Korea's exports in the short run is more sensitive to changes in foreign income (industrial production) compared with that of price (exchange rate). An interesting result, thus, is that Korea's exports in the short run may have higher export performance on income than that of price (exchange rate). This might be a consequence of the dependence of an increase in foreign income in recent years. In recent years, developing countries have greatly increased their economic growth compared with that of developed countries and Korea's exports have increased into these developing countries. Thus, we confirm that an increase in Korea's exports is mainly affected by income compared with price, specifically in the short run by using recent data.

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# **ESSAY 1 - Economic Growth of a Small Open Economy: Is There Export-led Growth in the Korean Economy?**

## **I. Introduction**

Many economists in the economic development and growth fields have shown much interest in the economic growth of either a country or the world economy. Why are they concerned and what are the reasons for their research on economic growth? It may be because they believe that economic growth can improve the standard of living of mankind or advance personal quality of life. They hope to assist in creating the best economic consulting policy for the underdeveloped countries in order to reach their ultimate goal: an affluent society of welfare.

Economists try to investigate and illustrate how a country could accelerate its economic growth rate and how the economic policy of the country can perform to improve its economy. Specifically, they have used a model, representing relationship between exports and growth, to demonstrate a change in economic growth<sup>1</sup>. For instance, the New Industrializing Countries (NICs) performed the trade policy of the outward orientation, the Export-Led Growth (ELG), and stimulated their economic growth. This resulted in high economic growth for the country. Economists have often employed the NICs to determine whether the ELG in these countries exists.

To test the Export-Led Growth Hypothesis (ELGH), many studies<sup>2</sup> in the past have used different econometrics procedures, from simple OLS to multivariate cointegration. However, they have not been consistent with the consequence; that is, they have achieved mixed results on the property (character) and direction of the causality on the relationship between output and exports. These inconsistencies are due to using different research methodologies such as different time periods, missed data, and different econometric methodologies.

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<sup>1</sup> Since export role can usually lead to an increase in output in terms of various channels such as spreading knowledge and innovation technology, proffering economies of scale, and guiding toward measure of trade liberalization, the ELG policy is often referred to as the Export-Led Growth hypothesis (ELGH) in development and growth literatures.

<sup>2</sup> “Export-led Growth; a Survey of the Empirical Literature and Some Non-causality Results,” part I & part II written by Giles and Williams (2000a, 200b) investigated that numerous articles are treated on the ELGH. In particular, recent studies for testing the ELGH are Foutas (2000) for Ireland, Abudal-Foul (2004) for Jordan, Awokuse (2005) for Japan, Siliverstovs, Herzer (2006) and so on.

In the early 1960s, Korea began its economic reform with a blue print<sup>3</sup> for the economic development plan (strategy) every 5 years. At that point in time Korea had little economic prerequisites such as natural resources and capital. So, the Korean government pursued the export-driving orientation and import substitution policy for promoting its economic growth. With this decision, Korea achieved the rapid economic growth through an increase of export growth<sup>4</sup>, thus providing a test of the ELGH in the Korean economy.

The purpose of this study is to demonstrate the empirical evidence that supports the ELGH for the small open economy as Korea. Only a few studies have tested the ELGH for the Korea economy including Jung and Marshall (1985), Chow (1987), Bahamni-Oskooee (1993), Sengupat and Espana (1994), Jin (1995), Holman and Grave (1995), Ekanayake (1999), Awokuse (2005a, 2005b), and Mahadevan and Saurdi (2007). Our study extends empirical research for Korea on the ELGH by examining the relationship between output and exports. Results of this study contribute to the current existing literatures on the ELGH. To this end, econometrics methodology of Modified Wald (MWald) test and the Vector Autoregressive (VAR) model is used to test the causality on the relationship between exports and output. Specifically, for the robustness of estimated results, the Generalized Impulse Response Function Analysis (GIRA) is employed to observe how long a shock may persist and whether causality exists. Furthermore, in order to test the structural stability and to obtain a more significant estimation, we use the structural break test, which tests whether any structural changes exist, and the dummy variable, which represent shocks that give rise to make any structure change of economy.

The development of this paper is as follows. Section II outlines the theoretical framework and empirical literatures. Data and econometric methodology techniques are in Section III and Section IV includes the empirical results. Finally, conclusions are drawn in the Section V.

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<sup>3</sup> This means ‘master plan’ for economic development.

<sup>4</sup> In terms of the rapid increase of exports, the ratio of exports to GDP increased from 15.6% in 1970 to 44.8% in 2006. The average annual rate of economic growth was 9.8% in 1960, 9.7% in 1970, 8.3% in 1980, 7.8% in 1990, and 8.9% in 1995. Remarkably, from 1962 to 1985 an increase of the real GDP was 15 times and per capita GDP went over 8.5 times in real terms.

## II. Reviews of Literature

### 1. Directions on the Relationship between Trade and Output

Broadly speaking, most economists agreed upon three directions on the relation between exports and output. The first direction states that a wide extension of international trade increases output by using technical effectiveness with specialized production factor (Romer of 1990, Gross and Helpman of 1991 and so on)<sup>5</sup>. The second direction states that there is a possibility that output leads to trade because economic scale leads to swell trade (Kunt and Martin, 1989). The last direction states that there can be mutual feed back effect between trade and output (Sharma *et al.*(1991)).

### 2. Previous Studies

As sophisticated econometric methodologies have been developed in recent years, economists, who are interested in applied economics using econometrics tools, are concerned that there can be a spurious interpretation on regression results if stationary tests on any level variables used in the model are not performed. However, since the early literature used only the simple single linear model, which analyzes the causal relationship between trade and economic growth without such stationary test on level variables, it seems that these could cause the spurious results. In order to obtain approaching true results, recent literatures try to use a cointegration test and an error correction model based on a VAR model as well as stationary tests.

Most previous studies have tested the relationship between trade and output growth<sup>6</sup>. Recent empirical studies on the Export-Led Growth Hypothesis (ELGH) include articles such as Darrat *et al.*(2000) for Taiwan, Hatemi-J and Irandoust (2000) for Nordic countries, Khalafalla *et al.*(2001) for Malaysia, Balaguer *et al.*(2001) for Spain, Panas and Vamvoukas (2002) for Greece, Abu-Qarn, A.S. and Abu-Bader, S.(2004) for MENA region, Abual-Foul (2004) for Jordan, Mah (2005) for China, Al Mamum and Nath (2005) for Bangladesh, Awokuse (2005a) for Korea and (2005b) for Japan, Love and Chandra (2005a) for South Aisa, Siliverstovs and Herzer (2006) for Chile, Halicioglu (2007) for Turkey, and Mahadevan (2007) for Japan and

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<sup>5</sup> See Doyle (1998). He refers to early previous literatures on the contents related with this idea. Our study handles only authors in recent literatures.

<sup>6</sup> See Giles *et al.*(2000a, 200b) and Lewer (2003).

Asian tigers. These studies have not been consistent for they have achieved mixed results on the property (character) and direction of the causality on the relationship between output and exports.

A few representative empirical studies test the causality of the relationship between trade and output of Korea. Jung and Marshall (1985) discover the evidence of statistical validity on the export-led growth for Korea among 37 other developing countries in their sample by using Granger causality technique. They employ available annual time series data from 1950 to 1981<sup>7</sup>. Chow (1987) investigates the causality on the relationship between export growth and growth in manufacturing output by using Sims' causality technique on eight Newly Industrialized Countries (NICs)<sup>8</sup> by using a time series data set from 1960 and 1970.<sup>9</sup> Both studies find a bi-directional causality between export growth and growth in manufacturing output. By using White causality test technique<sup>10</sup> and annual time series data from 1955 to 1982, Darrat (1987) demonstrates satisfying causality implication of the ELGH for Korea among other NICs<sup>11</sup>. Bahmani-oskooee and Alse (1993) also use cointegration and Error Correction Model (ECM) techniques to test whether there is a relationship between export growth and output growth. They use quarterly time series data of nine developing countries<sup>12</sup> from 1973:I to 1988:IV. Their results show a bi-directional causality on the relationship between export and output growths for the Korean economy.

Jin (1995) illustrates the short-run and long-run effects of exports on growth by employing Sims' VAR model (1980)<sup>13</sup> and the quarterly time series data from 1973:I to 1993:II for the four little dragons of Asia, that is, Korea, Hong-Kong, Singapore and Taiwan. He finds that the variance decompositions have a reciprocal relationship between output and exports but show statistically invalid results for the cointegration test on Korea among the four dragons of Asia. His conclusion states that a long run relationship does not exist between exports and output but rather transitory impacts. Holman and Graves (1995) discover the bi-directional causality on

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<sup>7</sup> Observation data period of Korea was from 1953 to 1980.

<sup>8</sup> NICs are Argentina, Brazil, Hong Kong, Israel, Korea, Mexico, Singapore, and Taiwan.

<sup>9</sup> This is like a F statistic test.

<sup>10</sup> This uses a vector of residuals from the regression on variables and this is inserted into the original model.  $R^2$  from this regression is used to test causality by using  $\chi^2$  distribution.

<sup>11</sup> In his study NICs only included Hong Kong, Korea, Singapore and Taiwan.

<sup>12</sup> These countries are Colombia, Greece, Korea, Malaysia, Pakistan, Philippines, Singapore, South Africa, and Thailand.

<sup>13</sup> For the analysis of the relationship between exports and growth hypothesis he used econometric methodologies such as cointegration, variance decomposition and impulse response function.



the relationship between exports and output for the Korean economy by using the Granger causality technique on a time series from 1953 to 1990. Ekanayake (1999) shows bi-directional causality on the relationship between output growth and export growth for Asian developing countries including Korea.<sup>14</sup> They employ cointegration and ECM techniques on an annual time series from 1960 to 1997. Awokuse (2005) find bi-directional causality between exports and output for the Korean economy by applying the Vector Error Correction Model (VECM) and the augmented level VAR model of Toda and Yamamoto on quarterly time series data during 1963:I to 2001:IV

The most recent study on the ELGH has been performed by Mahadevan and Saurdi (2007). They examine the relationship among imports, exports and output growths in a stochastic environment for the Asian Tigers<sup>15</sup> and Japan. They conclude no causality between output growths and exports in a non-stochastic environment. However, bi-directional causality between exports and output no longer holds with uncertainty.

The literature on the ELGH on Korea seems to reach a common conclusion that there is bi-directional causality among exports and output growths, amidst different time series techniques used to test causality. The conclusion reached so far in the literature to testing causality between exports and output growths for the case of Korea confirm bi-directional causality. This is in sharp contrast with the Latin American case and other developing countries. These Latin American countries' case has causality or no causality the relationship between exports and output growth.

With the exception of Korea empirical studies on the ELGH, it seems that bidirectional causality between exports and output does not exist elsewhere. This reason could be attributed by time series econometric methodology, measurement errors, identification and misspecification problems.

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<sup>14</sup> These nations are Pakistan, Philippines, Sri Lanka, Korea and Thailand.

<sup>15</sup> Hong Kong, Taiwan, and Korea.

### 3. Theoretical Frame Work for Testing the Relationship among Variables

#### 3.1 Basic Concept Model

In order to represent the causality on the relationship between output and exports in a logical form, we use a general augmented production function<sup>16</sup>. Our study uses the following expression applied to a VAR model.

$$RGDP = f(C EXP^\alpha IMP^\beta LAB^\gamma NER^\delta IV^\theta) \quad (1)$$

Where: RGDP, C, EXP, IMP, LAB, NER and IV represent real GDP, constant, real export, real imports, labor, nominal exchange rate, and real capital respectively. This augmented production function (1) is transformed into the log linear output demand function in equation (2) below.

$$\ln RGDP = C + \alpha \ln EXP + \beta \ln IMP + \gamma \ln LAB + \delta \ln NER + \theta \ln IV + \varepsilon \quad (2)$$

In equation (2) above, all coefficients ( $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ ,  $\theta$ ) are elasticity measures for the exogenous variables in the system. C is the intercept.

#### 3.2 Granger causality Test

The Granger causality test is developed by Granger (1969), which is very useful in testing the causality on the relationship between variables. A key idea of Granger causality test is to check whether lagged values of one variable do or do not affect the present prediction of another variable or the same variable in the system. In general, the Granger causality model test for a two variable case can be represented in the following equation.

$$\begin{aligned} \ln RGDP_t &= \sum_{i=1}^n \alpha \ln RGDP_{t-i} + \sum_{i=1}^n \beta \ln EXP_{t-i} + \varepsilon_{1t} \\ \ln EXP_t &= \sum_{i=1}^n \chi \ln EXP_{t-i} + \sum_{i=1}^n \delta \ln RGDP_{t-i} + \varepsilon_{2t} \end{aligned} \quad (3)$$

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<sup>16</sup> This augmented production is derived from Cobb-Douglas production function.

Where:  $\ln RGDP$ ,  $\ln EXP$  represent the two variables of interest (the log of real GDP and the log of exports respectively),  $\varepsilon_{1t}$  and  $\varepsilon_{2t}$  are the error terms in the system and  $\alpha, \beta, \chi, \delta$  are coefficients on each variable. In equation (3),  $\ln RGDP$  and  $\ln EXP$  each contains lagged values as exogenous variables in the system. If the coefficients on lagged values of  $\ln EXP$  are statistically significant in the first equation above for instance, it implies lagged values of the log of exports can explain variation in the log of current value of real GDP. A joint F-test on the coefficients on the lags of exports in the first equation is used to check whether exports Granger causes real GDP. In Granger causality test, the null hypothesis is that lagged values of one variable do not Granger cause variation in the present value of some other variable. The null hypothesis against alternative hypothesis is  $H_0 = \beta_{12}^{(1)} = \beta_{12}^{(2)} = \dots = \beta_{12}^{(n)} = 0$ , where  $\beta_{12}^{(n)}$  are coefficients on  $\ln EXP_{t-i}$  in the first equation.

### 3.3 MWald (Modified Wald) Test

The Mwald test was exploited by Toda and Yamamoto (1995) for testing Granger causality. This method overcomes problems of econometric procedures, such as the low power of likelihood ratio test when the lag length is over-specified and the invalid F-statistic when variables are integrated and the test statistic is not normally distributed (Shan and Sun, 1998). Due to the development of the MWald test, it is possible to obtain valid regression results if the essential variables for estimation are included in the system (model), regardless if variables are integrated or cointegrated. This method is often used when it is difficult to discriminate whether integration or cointegration exists among variables in the model. A key idea for testing the MWald test is derived from equation (4) below.

$$\begin{bmatrix} RGDP_t \\ EXP_t \\ IMP_t \\ LAB_t \\ EXR_t \\ IV_t \end{bmatrix} = B_0 + \sum_{i=1}^n B_i \begin{bmatrix} RGDP_{t-i} \\ EXP_{t-i} \\ IMP_{t-i} \\ LAB_{t-i} \\ EXR_{t-i} \\ IV_{t-i} \end{bmatrix} + \sum_{j=n+1}^{n+1+d \max} B_j \begin{bmatrix} RGDP_j \\ EXP_j \\ IMP_j \\ LAB_j \\ EXR_j \\ IV_j \end{bmatrix} + \begin{bmatrix} \mu_{RGDP_t} \\ \mu_{EXP_t} \\ \mu_{IMP_t} \\ \mu_{LAB_t} \\ \mu_{EXR_t} \\ \mu_{IV_t} \end{bmatrix} \quad (4)$$

In order to use this method, the first requirement is to find a maximum order of integration ( $d_{\max}$ ) and build a VAR model in level with a total lag  $p=(n + d_{\max})$ , where  $n$  is the lag length of a system (model) chosen by using the lag selection criteria, such as Shwartz Information Criterion (SIC) and Akaike Information Criterion (AIC). Since for the Granger causality test this method is applied into Seemingly Unrelated Regression (SUR) form<sup>17</sup>, this method seems to have the SUR procedure. In other words, this method means that each variable regresses on all lagged variables from one to  $p=(n + d_{\max})$  lags in the SUR system. The MWald test is then performed, which puts restrictions on variables to test causality and uses an asymptotic  $\chi^2$  distribution. Equation (4) is an estimation from using this method, which can be described as follows.

In order to test that the EXP (exports) does not Granger cause the RGDP (output), the null hypothesis is  $H_0= a_{12}^{(1)}=a_{12}^{(2)}=\dots=a_{12}^{(n)}=0$ , where  $a_{12}^{(n)}$  are coefficients of the EXP in the first equation of this system (model). The other null hypotheses we desire to test are similar to the description above.

### 3.4 VECM (Vector Error Correction Model)

According to Engle (1980), if a cointegration relationship (that is, a long run relationship (equilibrium)) between variables exists, then a VAR model can be reformulated by means of all level variables and an error correction term to determine a short-run relationship among variables. In other words, it can be constructed with an Error Correction Model (*ECM*). The *ECM* is usually used to reveal a short-run relationship among variables. An Error Term (*ET*) in the *ECM* can be treated as the equilibrium error since there may be disequilibrium in the short-run. Thus, a new modified equation is formed by using the error correction term and level variables. The general form of this modified equation by employing variables of our study is expressed below.

$$\begin{aligned} \Delta RGDP_t = & \alpha + \beta ET_{t-i} + \sum_{i=1}^n \gamma \Delta RGDP_{t-i} + \sum_{i=1}^n \delta \Delta EXP_t + \sum_{i=1}^n \varphi \Delta IMP_{t-i} \\ & + \sum_{i=1}^n \eta \Delta LAB_{t-i} + \sum_{i=1}^n \lambda \Delta EXR_{t-i} + \sum_{i=1}^n \pi \Delta IV_{t-i} + \varepsilon_t \end{aligned} \quad (5)$$

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<sup>17</sup> Rambaldi and Doran (1996) expresses this method as a model that tests Granger causality. They extended the research of Toda and Yamamoto (1995). See Rambaldi and Doran (1996).

Where, the  $ET$  is equal to  $\Delta RGDP_{t-i} - (\Delta EXP_{t-i} + \Delta IMP_{t-i} + \Delta LAB_{t-i} + \Delta EXR_{t-i} + \Delta IV_{t-i})$  and is interpreted as the long-run effect. The changes of the lagged independent variables are interpreted as the short-run effect. Equation (5) means that changes of the dependent variable is affected by  $ET, \Delta RGDP_{t-i}, \Delta EXP_{t-i}, \Delta IMP_{t-i}, \Delta LAB_{t-i}, \Delta EXR_{t-i}$  and  $\Delta IV_{t-i}$ . In other words, the short-run effects of the lagged variables and the long-run effect of the  $ET$  can cause changes in the dependent variable,  $\Delta RGDP_t$ .

### 3.5 Generalized Impulse Response Function (GIRF)

Koop *et al.* (1996) and Pesaran *et al.* (1999) developed the Generalized Impulse Response Analysis (GIRA) against Cholesky's decomposition analysis. Sims (1980)' orthogonalized impulse responses based by Cholesky decomposition can be employed to analyze the dynamic effect of a VAR model. However, this method, through determining ordering by researcher's subjectivity (research purpose), is significantly arbitrary and the change in order may affect the result of the analysis. According to Pesaran *et al.* (1998), we should consider the VAR(p) model to draw the GIRF.

$$Y_t = \sum_{i=1}^p B_i Y_{t-i} + \xi_t \quad (6)$$

Where  $Y_t$  is a vector of endogenous variables with  $(m \times 1)$ ,  $p$  is size of lag length,  $B_i$  is matrices of coefficients with  $(m \times m)$  and  $\xi_t$  is a vector of innovation. Equation (6) assumes  $E(\xi_t) = 0$ ,  $E(\xi_t \xi_s') = \Sigma$  in all  $t = 1, 2, \dots, T$ , and  $E(\xi_t \xi_s') = 0$  when  $t \neq s$ , where  $s$  is a different period compared with a  $t$  period.

In order to obtain the impulse response function, VAR ( $p$ ), equation (6) is changed into the VMA (Vector Moving Average)( $\infty$ ) process.

$$Y_t = \sum_{j=1}^{\infty} C_j \mu_{t-j} \quad (7)$$

Where  $C_j$  is matrices of coefficients with  $(m \times m)$  and is calculated by a recursive method as represented below:

$$C_j = \sum_{i=1}^p \varphi C_{j-i} \quad (8)$$

Where  $j=1,2, \dots$  and  $C_0 = I_m$ ,  $C_j=0$  for  $j < 0$ .

The Impulse Response Function (IRF) chases the influence about current and future values of other endogenous variables and itself on a (one standard deviation) shock to a specific endogenous variable. For instance, if occurred a shock to  $k$  endogenous variables at  $t$  time and created the shock,  $\delta=(\delta_1, \dots, \delta_k)'$  of  $(k \times 1)$ , how the influence of shock affects a value of  $Y_{t+n}$  period after random  $n$  period can be traced by the IRF.

In order to induce the IRF, Koop *et al.*(1996) and Pesaran *et al.*(1998) assumed that past economic conditions from  $t$  period to  $t-1$  period have a information set,  $(\Omega_{t-1})$ , which is with a non-decreasing character of information, and then defined the GIRF as represented below.

$$GIRF_Y(n, \delta, \Omega_{t-1}) = E\langle Y_{t+n} | \mu_t = \delta, \Omega_{t-1} \rangle - E\langle Y_{t+n} | \Omega_{t-1} \rangle \quad (9)$$

Where,  $\delta=(\delta_1, \dots, \delta_k)'$  is a vector of shock.

Where  $n$ : the number of periods ahead;  $\mu_t$  : innovation;  $\delta$ : arbitrary shock ;  $\delta = \sqrt{\sigma_{kk}} = \sigma_{kk}^{\frac{1}{2}}$ ;  $\Omega_{t-1}$  : available all information in the moment of the shock;  $E$ : conditional expectation. In the GIRF all contemporaneous and future shocks are integrated out.

Equation (7) above is plugged into equation (9) and then,  $GIRF(n, \delta, \Omega_{t-1}) = C_n \delta$ , which does not depend on  $(\Omega_{t-1})$  but depends only on  $\delta$ <sup>18</sup>. The GIRF does not shock as all information (factors) of  $\mu_t$  but directly uses equation (9). When we assumes  $\mu_t \sim N(0, \Sigma)$ , according to Koop *et al.*(1996) there are  $E(\mu_t | \mu_{jt} = \delta_j) = (\sigma_{1j}, \sigma_{2j}, \dots, \sigma_{kj})' - \sigma_{jj}^{-1} \sigma_j$  and  $\sigma_j = \sum e_j \sigma_{jj}^{-1} \delta_j$ . Here, if  $e_j$  is a vector of  $(m \times 1)$  with 1 of  $j$ th element and zero other elements, and a shock to  $j$ th equation is introduced, the GIRF after  $n$ th period can be represented as follows:

$$\left[ \frac{C_n \sum e_j}{\sqrt{\sigma_{jj}}} \right] \left[ \frac{\delta_j}{\sqrt{\sigma_{jj}}} \right], n=0,1,2,\dots \quad (10)$$

<sup>18</sup> See Pesaran and Shin (1998) and Koop *et al.* (1996).

When  $\delta_j = \sqrt{\sigma_{jj}}$  and one standard deviation shock to the  $j$ th equation at  $t$  period is introduced, expecting the effect of  $Y$  at  $t+n$  period; that is the GIRF ( $v_j^g(n)$ ) can be expressed by  $v_j^g(n) = \sigma_{jj}^{-\frac{1}{2}} C_n \sum e_j$ ,  $n=0,1,2,\dots$

### III. Data and Econometric Methodology Techniques

#### 1. Data and Variable Definitions

The variables and definitions in our study for constructing a VAR system for examining the validity of the ELGH are as follows: The RGDP (Real GDP) is used as a proxy for output; the REX (Real Exports) is deflated by the unit price index of exports for exports; the RIMP (Real Imports)<sup>19</sup> is divided by the unit price index of imports for imports; the RIV (Real Gross Fixed Capital)<sup>20</sup> is used for a proxy of investment; the LAB (Labor) or, economic active population is a proxy of labor force<sup>21</sup> and the NER (Nominal Exchange Rate) is employed as a shock of foreign environment.

The quarterly time series data set is obtained from the Bank of Korea and the International Monetary Fund (IMF). In estimating a VAR model, we employ the seasonally adjusted data set<sup>22</sup>. We conduct a logarithmic transformation of the data in real terms over the period 1970:I to 2005:I. All variables in our study are in 2000 constant prices.

#### 2. Estimation Methodology

Before the innovation of various time series computational methods is used, earlier studies, to test causality between export and output, are mainly based on simple traditional statistical methods, while the recent innovation in times series is applied to more sophisticated

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<sup>19</sup> Riezman and Whiteman Summers (1996) refer that if an import variable is not included into the VAR system for the ELGH, there would be invalid results because the import variable has explanation power in the VAR model for the ELGH.

<sup>20</sup> Jin and Yu (1996) and Shan and Sun(1998) use a foreign output variable as shocks for testing the validity of the ELGH.

<sup>21</sup> Labor force is contributed to productive activities of output and growth.

<sup>22</sup> Quarterly series instead of annual data in this study is used to avoid the problem of the degree of freedom for estimation.

models in testing the causality and long run co-movement between variables such as the Vector Error Correction Model (VECM) and cointegration such innovations.

There are generally two categories of methods that test for ELGH. The first category is based on the time series data, and the second is a cross-sectional country data<sup>23</sup>. However, recent studies have used the time series data more often than the cross-sectional approach. Studies based on a cross-sectional country data assume that each different country has a common economic structure and a similar production technology for all countries although an individual country may have different economic environments. Thus, these estimated results may be biased and inconsistent (Shan and Sun, 1998).

Many earlier studies employ the Granger causality test on the ELGH but there are disadvantages in using this technique. The studies by Shan and Sun (1998) and Shan and Tina (1998) discuss some of the problems of using the Granger causality test in this context. The first problem is associated with the arbitrary choice of the appropriate lag length. According to Bahmani-Oskooee and Alse (1993), causality tests' results are sensitive to changes in different lags. Secondly, most time series studies, based on the ELGH, utilize the F-statistic for testing causality among variables but the F-statistic may be invalid if time series are integrated as suggested by Toda and Yamamoto (1995) and Zapata and Rambaldi (1997). Thirdly, some of the studies employ a simple model with only two variables. These studies use only export and output (GDP) variables in order to observe the relationship between both variables. The output, however, is in fact not affected by only exports but is influenced by various factors such as imports, investment, and labor. For instance, Riezman *et al.*(1996) suggests including import in models where Granger causality is to be applied. He argues that omission of the import variable may result in spurious relationships because imports usually impact income and exports. It is known that model selections and the choice of appropriate functional form can significantly affect the estimation results used for testing casualty among variables in the model. Finally, some studies ignore the endogeneity problem between exports and GDP (Greenway and Sapsford, 1994). Due to above such problems, time series models, in order to correctly conduct causality tests on the ELGH, should be constructed in a way that avoids econometric misspecification.

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<sup>23</sup> See Giles and Williams (2000a, 200b). They well arrange early literatures to have illustrated the relationship between export and output using either cross-section data or time series data.



In this study, we conduct unit root tests on the variables to ensure stationary or same order of integration in the model system. To this end, we use the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests. The results from these two tests help us to conduct the Modified Wald (MWald) test and fit specification of the VAR model.

Choice of lag length is vital before estimating the MWald test and the VAR model. There are various methods for choosing lag length. Usually, arbitrary lag length can set enough until  $t$ -values of coefficients are reached to validity. Lag length could also be set enough until residuals are White noise<sup>24</sup> by using Q stochastic of Ljung-Box. The other is to use Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC), Hanna-Qinn (HQ), and Likelihood Ratio (LR) to determine a lag length. This study uses SIC, AIC, HQ, and LR to determined a lag length for our VAR model and MWald test. We observe HQ and SIC have lag length of one while AIC and LR have six lags, respectively. So our study chooses six lags for the MWald tests and all VARs.

Toda and Yamamoto (1995) for the Granger causality test suggest a method with no requirement of pre-testing of cointegration. This method is commonly called the ‘Modified Wald (MWald)’ test<sup>25</sup>. We employ the MWald test to illustrate the causality among variables, especially the relationship between output (GDP) and exports. We also use the VECM as an alternative method for the robustness to the results of the MWald test. Since we are currently interested in seeing how the change in exports affected the output, we perform the Granger causality test through setting zero restrictions on variable coefficients in the VECM after regression of the VECM.

Furthermore, we introduce dummy variables to the MWald test and the VECM since previous literatures on causality tests between output and exports for the Korean economy did not deal with dummy variables reflecting some shocks to its economy. These shocks might have given rise to changes in the Korean economic structure. So, in order to test the structural stability, we also use the structural break test, which tests whether any structural changes exist.

The ADF and PP tests for level variables in this study show that all time series  $I(1)$  have an unit root with the exception of imports  $I(0)$ <sup>26</sup>. Cointegration among variables does not seem to

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<sup>24</sup> When autocorrelation’s coefficients on residuals are White noise (zero), a lag length is chosen.

<sup>25</sup> Toda & Yamamoto (1995) and Rambaldi & Doran (1996) create the name of the MWald test by this method.

<sup>26</sup> Import variable rejects the null hypothesis with existing unit root at significance level of 5% but is not rejected when it at significance level of 1%.

exist but there is a possibility that the five variables with I(1) respectively, with the exception one (imports) I(0), are cointegrated with each other<sup>27</sup>. This study uses the Johansen and Juselius cointegration test (1990) to test whether or not cointegration exists among five variables with I(1) and one variable with I(0), namely total variables in model.

Finally, we use the impulse response function for the robustness for results with the ELGH of the MWald test since the impulse response function has a causality concept of a VAR model since it traces the effect of a one standard deviation shock to one of the innovations on the endogenous variables. A shock to one variable in the impulse response function directly affects itself and then all other variables as well through the dynamic structure of a VAR model. In particular, since innovations are usually correlated, it is known that they may have a common factor (trend). In order to analyze this common trend, the ordering in variables is vital. Sims (1980) refers that economic theories, based on study purpose of researchers, can be employed to set ordering of variables in a VAR model, and the orthogonalized impulse responses can be used to analyze the dynamic effects in a VAR model. Many studies use the Cholesky decomposition method when errors are orthogonalized and covariance matrix of the resulting innovations is diagonal. However, a change in order may significantly affect different results of the analysis. The change of this ordering depends on researcher's subjectivity (purpose). So, in order to avoid this problem another method is suggested by Koop *et al.* (1996) and Pesaran and Shin (1999).

In order to avoid the ordering problem in the Cholesky decomposition, Pesaran and Shin (1999) suggest an alternative procedure (method), the Generalized Impulse Response Analysis (GIRA). The GIRA is not sensitive to change in the ordering of variables in the VAR models due to employing a random variable, which is a conditional average on shock to endogenous variables. In terms of Pesaran and Shin (1997) the generalized impulse responses are generated by the  $j$ th variable from an innovation using a specific calculated variable. Therefore, this study employs the GIRA for the dynamic analysis of a VAR because of the difficulty to determine an appropriate ordering of variables in a VAR model of our study.

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<sup>27</sup> Toda and Phillips (1993) suggest that causality tests in difference VARs are effective when variables are I (1) but variables are not cointegrated with each other since causality tests in difference VARs are likely to get higher power in the finite samples. Enders (1995) refers that the Granger causality test may yield a spurious result if variables are not integrated.

## IV. Results

### 1. Stationary and Proper Lag Length Tests

In order to determine whether level variables are integrated or cointegrated, this study uses two unit root tests: ADF and PP tests. The ADF test assumes that error terms have autocorrelation. The PP presumes autocorrelation and heteroscedasticity of the error terms. In general, the unit root tests are supposed by three models: the first model is a simple model with exception of trend and constant, the second model includes only a constant, and the last model involves a constant and a trend. In selecting a model for unit root tests, this study selects a model with a constant and a trend for testing the unit root for variables since there is no standard for choosing models for the unit root tests<sup>28</sup>. In addition, this study supposes the lag length of four to determine a proper lag length in the unit root tests<sup>29</sup> due to no rejection on the null hypothesis of unit root test from zero lag to twelve lags for most level variables. Since there are five variables I(1) with the exception of imports with I(0) by using unit root tests<sup>30</sup>, this study finds that these variables are stationary after the first difference<sup>31</sup>.

### 2. Results of the MWald Test

In order to select proper lag length in a VAR model and the MWald test this study uses SIC, AIC, LR and HQ criteria tests<sup>32</sup>. Table 1-1 reports that both HQ and SIC<sup>33</sup> take the same lag length of one but AIC and LR select lag length of six, respectively.

(Insert)[Table 1-1 VAR Lag Length Selection Criteria]

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<sup>28</sup> Models for unit root tests also can be selected by researcher's subjectivity and an economic theory on time series data. In general, it is determined by using AIC or SIC.

<sup>29</sup> Usually, annual time series uses one to four lag lengths, quarterly series uses one to eight and monthly series is chosen with lag length of twelve from one.

<sup>30</sup> As noted above, Import variable rejects the null hypothesis with existing unit root at significance level of 5% but does not reject it at a significance level of 1%.

<sup>31</sup> We do not proffer these results here due to space constraints but we would provide them if any reader would request them.

<sup>32</sup> Our study selects proper order by using an unrestricted VAR model.

<sup>33</sup> To decide a proper order of a VAR model, our unrestricted VAR model includes trend as well intercept since all variables seemed to have a linear trend in graphs of variables in level.

It is known that when a small sample size is used the SIC is more superior to the AIC since the SIC provides parsimonious models compared with the AIC. This has enough sample observation<sup>34</sup>. So, k=6 is chosen by means of two lag criteria of AIC and LR and this study finally accepts lag length of seven (k=6 + d<sub>max</sub>=1) to get an appropriate lag for the MWald test based on a VAR<sup>35</sup>.

Meanwhile, as noted in an earlier section, we introduce dummy variables as shocks into a VAR to catch any changes in economic structure. In our study, the dummy variables reflect that the Korean economy had experienced an oil shock in 1974, surplus trade balance<sup>36</sup> and surplus balance on current account<sup>37</sup> in 1986, and economic crisis in 1997.

The results of the MWald test<sup>38</sup> for Granger Causality are reported by table 1-2. The null hypothesis with no Granger causality from exports to output is rejected at a 5% level of significance, but is not rejected from output to exports. So, this suggests that the ELGH for Korea is supported from 1970:I to 2005:I. However, there is no significant level of causality in other variables. Thus, we imply that there is unidirectional causality from exports to output.

(Insert)[Table 1-2 MWald Tests of Granger Causality]

<sup>34</sup> The number of this study's sample observation is 141.

<sup>35</sup> After choosing the order of the VAR, it is also vital to check the residuals of unrestricted VAR model for residual correlation whether residual correlation is reduced or not. Our study discovers that there is no significant evidence of residual correlation. We do not proffer these results here due to space constraints but we would provide them if any reader would request them.

<sup>36</sup> Surplus of foreign trade was 5% of GDP at that time.

<sup>37</sup> Surplus trade balance and surplus balance on current account were given rise to by means of low oil price, low interest rate and depreciation of exchange rate at that time.

<sup>38</sup> The MWald test is on Seemingly Unrelated Regression (SUR) estimation of the equation. It is possible to take true results of regression if very important variables for estimation are included in the system model no matter what variables are integrated or cointegrated. This method is often used when there is difficulty in discriminating whether integration or cointegration exists among all variables in the model. A key idea for testing the MWald test is derived from the equation below.

$$\begin{bmatrix} RGD P_t \\ REX P_t \\ RIM P_t \\ LAB_t \\ EXR_t \\ IV_t \end{bmatrix} = B_0 + \sum_{i=1}^n B_i \begin{bmatrix} RGD P_{t-i} \\ REX P_{t-i} \\ RIM P_{t-i} \\ LAB_{t-i} \\ EXR_{t-i} \\ IV_{t-i} \end{bmatrix} + \sum_{j=n+1}^{n+d_{max}} B_j \begin{bmatrix} RGD P_j \\ REX P_j \\ RIM P_j \\ LAB_j \\ EXR_j \\ IV_j \end{bmatrix} + \begin{bmatrix} \mu_{RGDP_t} \\ \mu_{EXP_t} \\ \mu_{IMP_t} \\ \mu_{LAB_t} \\ \mu_{EXR_t} \\ \mu_{IV_t} \end{bmatrix} + D74 + D86 + D97$$

The first requirement for the procedure of this method is to find a maximum order of integration (d<sub>max</sub>) in a model and then to build a VAR model in level with a total lag p=(n + d<sub>max</sub>), where n is a lag length of system chosen by using the lag selection criteria such as SIC and AIC. Since for Granger causality test this method is applied into SUR form, this method has the SUR procedure. In other words, this method is that each variable is regressed on all lagged variables from one to p=(n + d<sub>max</sub>) lags in the SUR system and then the MWald test is performed, which puts the restrictions of variables to test causality by using an asymptotic  $\chi^2$  distribution.

### 3. Structural Stability Test

As noted in an early section, the Korean economy had experienced an oil shock in 1974, surplus trade balance<sup>39</sup> and surplus balance on current account in 1986, and economic crisis in 1997. These events might have affected the Korean economy and there may be structural change of its economy. So, in order to test the structural stability of estimated coefficients and misspecification we use the CUSUM of square test<sup>40</sup>, by using an output function, which uses information of estimated residuals. Figure 1-1 represents the graph of the CUSUM of square test. There is no strong evidence of structural stability or misspecification in the Korean economy since the result of the CUSUM of square test rejects the null hypothesis. This also implies that a VAR model may have no signs of structural stability through the graph of figure 1-1. So, in order to obtain more efficient estimation, we introduce dummy variables<sup>41</sup> into the VAR model to reflect structure change. To this end this study uses the LR test whether dummy variables are interposed in the VAR model. The results of LR tests for dummy variables of D74, D86 and D97 reject the null hypothesis at a 5% level of significance and thus we insert the dummy variables into the VAR model.

(Insert)[Figure 1-1 Structure Stability Test]

### 4. Robustness

Since we observe the same order integration among all variables, namely there is a long-run relationship among variables, the variables are cointegrated with each other<sup>42</sup>. In order to confirm cointegration among variables we employ the Johansen and Juselius cointegration test (1990) for all variables.

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<sup>39</sup> As noted above, surplus of abroad trade was 5% of GDP at that time.

<sup>40</sup> The null hypothesis of CUSUM of square test is no structural break. If a line of information of the estimated residuals is crossed to either of two lines on figures, the null hypothesis is rejected, which means that there is structural break.

<sup>41</sup> These dummy variables are D74, D86 and D97. For significant statistic test for these dummy variables our study uses LR tests. The null hypotheses are  $H_0: D74=0$ ,  $H_0: D86$ ,  $H_0: D98$ , respectively.

$\chi^2_{0.05} = 3.64$  at degree of freedom one.  $LR = 2(\log \text{unrestricted likelihood} - \log \text{restricted likelihood})$ .

$D74 = 2(1659.928 - 1651.853) = 16.15$ ,  $D86 = 2(1661.882 - 1659.928) = 3.908$ , and  $D97 = 2(1679.123 - 166.882) = 34.482$

<sup>42</sup> If cointegration between variables exists, it means that cointegration implies the causal relation between variables and our study tries to employ cointegrating tests.

Table 1-3 shows the results of the Johansen and Juselius' cointegration test<sup>43</sup>. We perform the Johansen and Juselius' cointegration test under the conditions of intercept and trend for cointegration test and then discover two cointegrations among variables since trace statistic<sup>44</sup> rejects the null hypothesis with no cointegration among variables (namely it  $r=0, 1, 2$ ). This result of existing cointegration implies long-run relations among variables, namely there is common stochastic trend among variables. However, these long relationships do not show the direction of causality in variables although there is long-relationship and indication of Granger causality in these variables. So, this study constructs the VECM through the result of Johansen and Juselius' cointegration test.

(Insert)[Table 1-2 Johansen's Cointegration Results]

Table 1-4 reports the results of multivariate Granger causality and t-values of the Error Correction Terms (ECTs) in the VECM. In this study, Granger causality tests in the VECM show the results of the Granger causality tests, in that each lagged endogenous variable to each dependent variable (endogenous variable) is treated as an exogenous variable respectively under the null hypothesis with zero for all coefficients of lagged endogenous variables. For each equation in the VECM we employ values of  $\chi^2$  distribution for whether or not joint significance of lagged endogenous variable as an exogenous variable to the dependent variable exists. If this null hypothesis is rejected, these lagged variables can be treated as endogenous variables and also implied causality in the short run for the dependent variable in the VECM.

In the table 1-4, it seems very reasonable that the REXP causes the RGDP in a short run due to causality from the REXP to the RGDP by using Granger causality/Wald tests that have effective value of 12.75 (p-value of 0.05)<sup>45</sup>.

(Insert)[Table 1-4 Granger Causality/Wald Test in the VECM Granger Causality]

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<sup>43</sup> Johansen's method determines the number of cointegrating equation.

<sup>44</sup> Trace statistic ( $\lambda$ ) determines cointegration rank compared with critical value.

<sup>45</sup> Also, other variables with the exception of labor and imports were significant in the short run.

Meanwhile, the coefficient of the ECT on the RGDP is statistically significant. This implies a long-run relationship. So, based on this result, our study confirms that there is evidence that the export variable, as well as other variables in the VECM, Granger causes to the RGDP in the long-run, namely an evidence to ascertain an increase of the RGDP from the expansion of the REXP and also from the RDGP to the REXP is certainty on the case of exports due to a valid value of coefficient of its ECT as that of the RGDP.

This study, therefore, regards that the RGDP and the REXP has bidirectional causality between them in the VECM and this weakly supports the result of the MWald test that support the ELGH for Korea.

## **5. Impulse Response Functions (IRFs) for the Robustness**

We also use the impulse response functions (IRFs) for the robustness on results with the ELGH because the impulse response function has causality concept. That is, the impulse response function traces the effect of one standard deviation shock to one of the innovations on the endogenous variables. A shock to one variable in the impulse response function directly affects itself and all of the other variables as well through the dynamic structure of a VAR model.

In general, the IRFs signify the direction and size of effect of one standard deviation's shock to one variable on the other variables in a VAR system. So, it is possible to check a causality direction either exports on output or output on exports or both by using the direction of effect of a shock through calculation of the IRFs. Thus, this study uses the IRFs for knowing a causality direction between variables. Specifically, we use the Generalized Impulse Response Analysis (GIRA)<sup>46</sup> rather than the orthogonalized impulse response analysis<sup>47</sup> advanced by Sims (1980) since determination on the ordering of variables of Cholesky decomposition is difficult and may not be relevant if there are many endogenous variables in VAR models as this study.

Figure 1-2 and Figure 1-3 show the responses of each variable when introduced to a shock to the REXP and the RGDP. Since we are interested in the relationship between the REXP

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<sup>46</sup> The GIRA is computed by using a Monte Calo simulation with 1000 iteration under assumption of normal distribution of innovations.

<sup>47</sup> Since VAR models are not structural equations and often have a difficult interpretation for the results of regression, the impulse responses and variance decompositions are usually employed to overcome this. The impulse response shows how long and what degree of a shock to a given equation has effectiveness on all variables in a VAR equation. The variance decompositions give proportion of movements of dependents in terms of influence of shocks to independent variables and their own variables (dependent variables).

and the RGDP, this study focuses on only impulse response of the REXP and the RGDP on a shock to the REXP and the RGDP, respectively. In figure 1-2, effects of the REXP from a shock to the RGDP are significantly positive in initial quarters and then negative. Finally, these effects die out gradually with repeatedly positive and negative over time. In figure 1-3 the effects of the RGDP generated by a shock to the REXP, as that of the REXP, are significantly positive during the first quarter, trivial positive from two to three quarters, and then positive and negative repeatedly. Eventually, these effects go toward zero over time.

(Insert)[Figure 1-2 Response of REXP to Generalized One S.D. RGDP Innovation]

(Insert)[Figure 1-3 Response of RGDP to Generalized One S.D. REXP Innovation]

From such information above it seems that the results of the GIRFs show that the REXP expansion had initially a significant impact of the RGDP growth and the expansion of the RGDP had early the impact of the REXP growth. In addition, these reciprocal positive effects between the RGDP and exports in the GIRFs in initial periods (quarters) are consistent with old literatures with bidirectional causality for Korea. Also, repeatedly trivial effects and significant effects over time converging to zero implies consistency with a long-run relationship between variables by cointegration test.

Therefore, based on these results, we consider that initial bidirection effects of the GIRFs in this study are weak evidence for the robustness of results of the ELGH from the MWald test. More specifically, this difference may occur that any shock in the GIRFs should influence changes in other variables in initial periods, namely it seems that there must be responses in variables from any shock in initial periods.



## V. Conclusions

Our finding, by using methodology as the MWald test, supports the ELGH for Korea and to the existence of the long-run relationship among variables. In particular, for the robustness of the MWald test's results we use the VECM and the GIRA. As robustness results, the ELGH for Korea in the VECM is supported in the short run and sustained as well in the long run. This means that there is causality of the relationship from the REXP to the RGDP in the short run and the long run. So, there is mutual causality direction between the REXP and the RGDP in the VECM. Meanwhile, the GIRF also has reciprocal feedback effect between the REXP and the RGDP. Thus, the results from the VECM and GIRF for robustness weakly support for the ELGH of MWald test due to having unidirectional causality of the MWald test against bidirectional causality results of the GIRF and VECM respectively.

Our results are different from that of earlier studies with testing of the ELGH for Korea. The results of earlier studies have bidirectional causality on the relationship between output and exports, but that of our study has unidirectional causality (the exports-led growth) from exports to output. These differences are due to different observation data, various variables, and different econometric methodologies. It is well known that model selection and omitting variables can also significantly change the results of causality testing.

In addition, a limitation of this study is that the causality test on the ELGH on the Korean economy has not been compared to other country cases about results of the causality test on relationship between output and exports. So, more useful research may be necessary to construct either econometric techniques of this study or some more sophisticated econometric techniques. Such research results may provide great assistance to other undeveloped or developing countries and help set a direction of their economic policy for reaching their final destination: an affluent welfare (society).

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## Appendix A

**Table 1-1 VAR Lag Length Selection Criteria**

Criteria Lag	LogL	LR	FPE	AIC	SC	HQ
0	612.0287	NA	5.82E-12	-8.842537	-8.320970	-8.630592
1	1627.816	1878.824	2.33E-18	-23.57618	-22.27226**	-23.04631**
2	1672.848	79.22939	2.04E-18	-23.71200	-21.62573	-22.86422
3	1716.868	73.47792	1.83E-18	-23.83261	-20.96399	-22.66691
4	1754.592	59.56313	1.82E-18	-23.85852	-20.20755	-22.37491
5	1796.486	62.36904	1.72E-18**	-23.94716	-19.51384	-22.14563
6	1834.105	<b>52.60950**</b>	1.76E-18	<b>-23.97150**</b>	-18.75583	-21.85205
7	1866.907	42.91480	1.96E-18	-23.92342	-17.92540	-21.48605
8	1899.130	39.24867	2.26E-18	-23.86662	-17.08625	-21.11133

Notes: 1) Endogenous variables are RGDP, REXP, RIMP, LAB, LAB, NEXR, RIV and exogenous variables are Constant, D74, D86 and D98.

2) FPF is final prediction error, AIC is Akaike information criterion, SC is Schwarz information criterion, and HQ is Hanna-Quinn information criterion

3) LR is test statistic of a sequential modified LR test at 5% of significant level.

4) Two asterisks (\*\*) mean an optimal lag length chosen by each criteria.

**Table 1-2 MWald Tests of Granger Causality**

Indep.variables Dept.variables	RGDP	REXP	RIMP	LAB	NEXR	RIV	d.f
RGDP		17.49677 (0.0145)*	13.81697 (0.0545)*	11.03160 (0.1372)	25.09966 (0.007)*	18.47928 (0.0100)*	7
REXP	10.31545 (0.1714)		5.340924 (0.6184)	8.866961 (0.2623)	6.417087 (0.7192)	4.512967 (0.4920)	7
RIMP	7.485917 (0.3891)	9.476761 (0.2202)		8.078056 (0.3258)	20.39689 (0.0048)*	3.670498 (0.8169)	7
LAB	12.13693 (0.0961)	4.138627 (0.7637)	5.224674 (0.6326)		10.21487 (0.1767)	15.69516 (0.0281)*	7
NEXR	11.55901 (0.1160)	8.013248 (0.3314)	10.94834 (0.1409)	1.847401 (0.9678)		3.953552 (0.7851)	7
RIV	12.62021 (0.0819)	7.429455 (0.3856)	10.46849 (0.1635)	7.920240 (0.3397)	18.55224 (0.0097)*		7

Notes: 1) Asterisk (\*) of the test is valid only for lags larger than the VAR lag order.

2)  $\chi^2_{0.05} = 14.0671$  at 7 degree of freedom.

3) Parentheses ( ) are p-value.

**Table 1-3 Johansen's Cointegration Results**

Model	H <sub>0</sub>	H <sub>1</sub>	Eigen value	Trace statistic ( $\lambda_{trace}$ )	Critical value	
					5%	1%
Model Contained Intercept & Trend	<b>r=0</b>	r>0	0.363674	<b>156.6220</b>	114.90	124.75
	<b>r≤1</b>	r>1	0.231955	<b>96.04806</b>	87.31	96.58
	<b>r≤2</b>	r>2	0.210267	60.68454	62.99	70.05
	Cointegrating Coefficients	CoinEQ1	RGDP REXP RIMP LAB NEXR RIV Trend	1.0000 0.0000 -1.116487 -6.937413 -0.753045 0.927999 0.035760		
CoinEQ2		RGDP REXP RIMP LAB NEXR RIV Trend	0.0000 1.0000 -13.58883 2.431288 -2.028888 2.431288 0.055164			
Log likelihood		1827.593				

Notes: r means # (number) of cointegrating equation

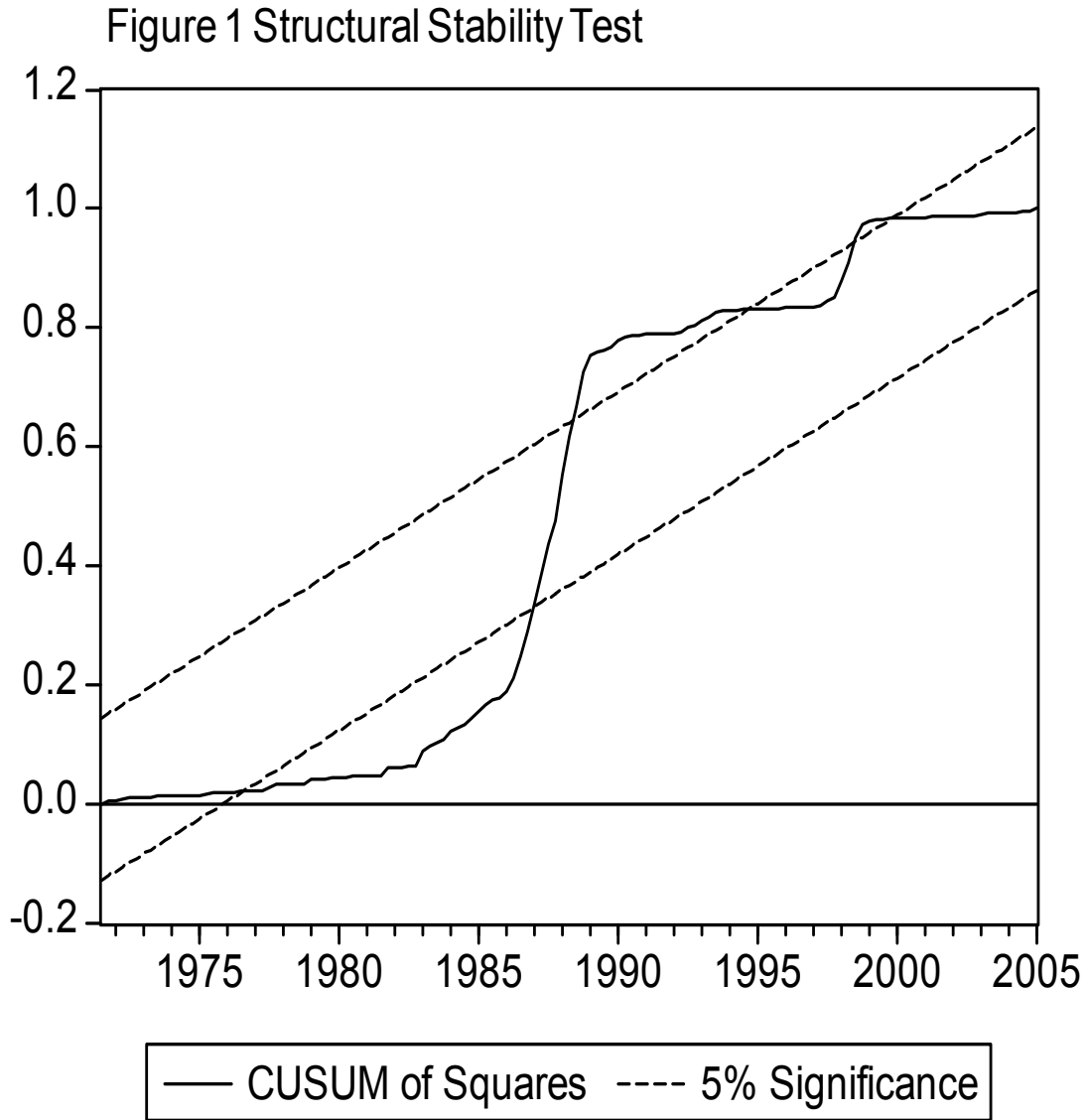
**Table 1-4 Granger Causality/Wald Test in the VECM Granger Causality /Wald Test in the VECM**

Dependent variables	Short-run lagged differences term						Long-run term
	$\Delta$ RGDP	$\Delta$ REXP	$\Delta$ RIMP	$\Delta$ RIV	$\Delta$ LAB	$\Delta$ REXR	ECTs
$\Delta$ RGDP		6.999492 (0.3209)	4.506958 (0.6084)	15.97625 (0.0139)*	8.104822 (0.2305)	6.170488 (0.4044)	<b>3.32630*</b>
$\Delta$ REXP	12.74480 <b>(0.0473)*</b>		9.310908 (0.1568)	11.88502 (0.0646)	4.255977 (0.6421)	9.452900 (0.1497)	<b>3.26343*</b>
$\Delta$ RIMP	10.62700 (0.1006)	2.613024 (0.8556)		7.673620 (0.2630)	3.575464 (0.7339)	5.089722 (0.5324)	0.83592
$\Delta$ RIV	7.386889 (0.2865)	10.49426 (0.1053)	7.591050 (0.2696)		9.941354 (0.1271)	3.671590 (0.7210)	1.54482
$\Delta$ LAB	23.93230 (0.0005)*	3.726950 (0.7136)	2.889620 (0.8226)	5.550100 (0.4754)		4.454846 (0.6154)	2.59481*
$\Delta$ NEXR	27.71301 (0.0001)*	2.823701 (0.8306)	22.60734 (0.0009)*	30.93665 (0.0000)	4.456748 (0.6151)		-0.27399

Notes: 1)  $\chi^2_{0.05} = 12.5916$  at degree of freedom of 6.

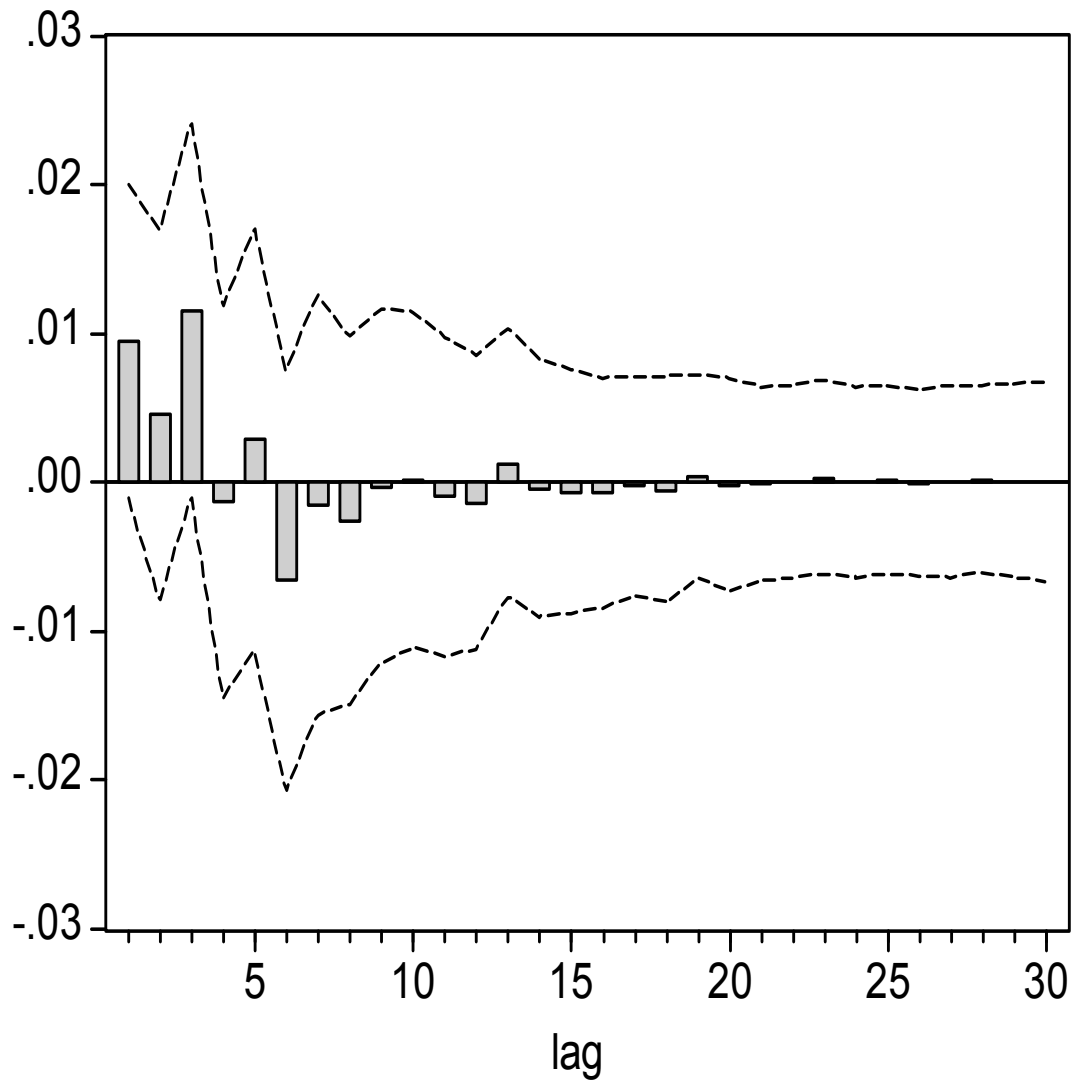
2) Parentheses ( ) are p-value.

Figure 1-1 Structural Stability Test



**Figure 1-2 Response of REXP to Generalized One S.D. RGDP Innovation**

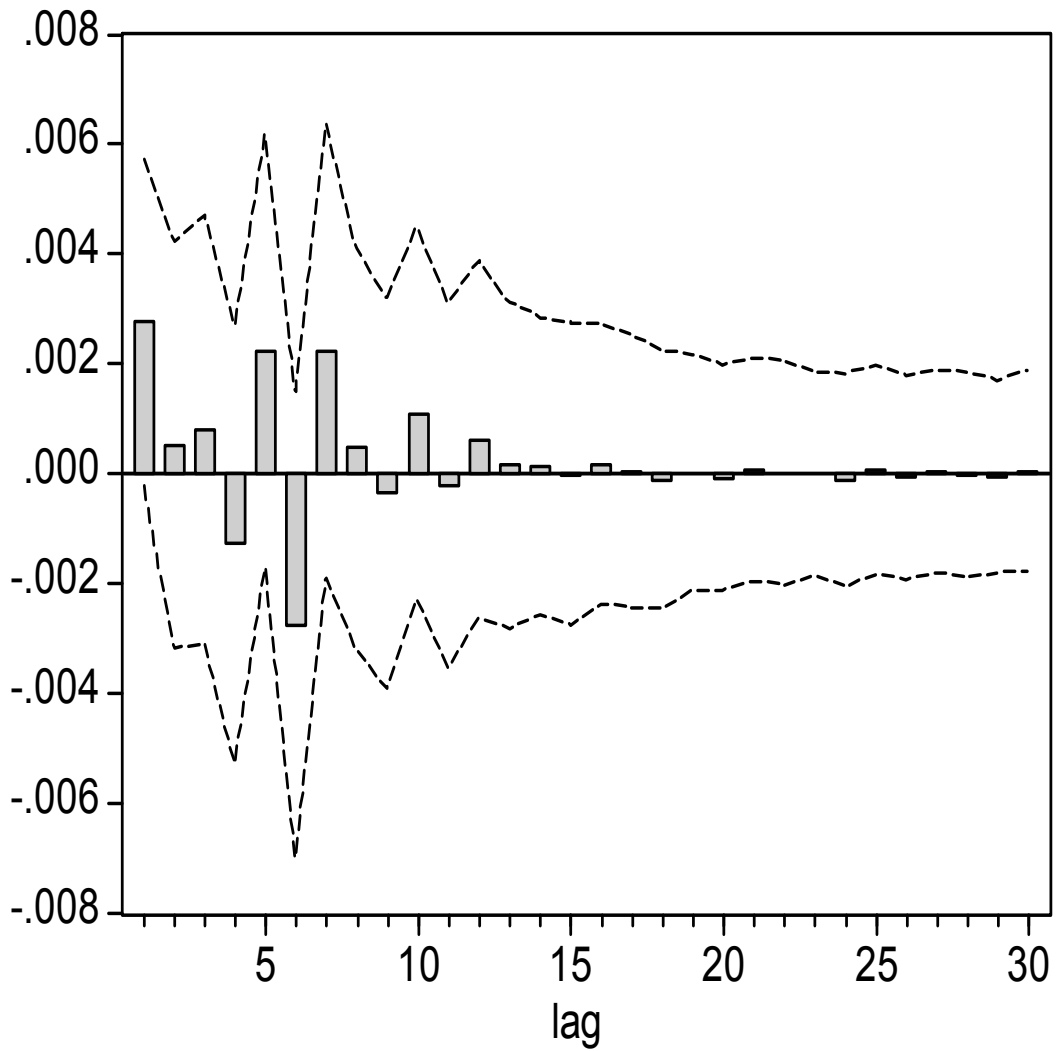
Figure 2 Response of REXP to Generalized One S.D. RGDP Innovation





**Figure 1-3 Response of RGDP to Generalized One S.D. REXP Innovation**

Figure 3 Response of RGDP to Generalized One S.D. REXP Innovation



## **ESSAY 2 - Competition between Korea's and China's Exports in the U.S. Market**

### **I. Introduction**

In the past, China and Korea<sup>48</sup> cooperated in various fields such as politics, economy, and culture, as Korea is located very close to China. However, after the royal regime of China was destroyed in the 1920s, and the start of communism in the 1930s, the relationship between the two countries weakened. Currently, however, the communist government of China has been developing its industry for economic recovery and has been remaking economic ties with Korea through economic cooperation between them.

Specifically, in the 1990s, China's economy became very open to foreign countries. On December 11, 2001, China joined the World Trade Organization (WTO)<sup>49</sup> aspiring to accelerate its economic development and gain some economic progress related with world countries.

As China's economy become more powerful in world economy, Korea, as well as other Asian countries<sup>50</sup>, has faced more and more difficulties competing with China in world trade (market) since trade goods between China and these countries have similar characteristics through the rapid economic development of China in the past 20 years. In other words, as a result of China's rapid growth, Korea and other Asian countries have been faced by competitive pressure with China in international trade markets.

In particular, Korea's industrial structure shares many similarities to those of China, such as the light and manufacturing industries. China, in order to develop its economy, has performed benchmarking to experience Korea's economic development in the past several years. Competitive pressure of Korea's exports from China's exports in international markets may have

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<sup>48</sup> In this paper, unless otherwise noted, Korea refers to South Korea; that is the Republic of Korea.

<sup>49</sup> China became the 143rd member of the WTO.

<sup>50</sup> China's rapid integration into the world economy and its high economic growth have been significantly impacting South and East Asian countries' economies in international trade flow. China's economic development has given rise to an increase of China's export competition in the world markets relative to these Asian countries, which have been losing their export share in the world market (Na and Yeats, *et al.*2001).

an adverse impact on the Korean economic industry, especially those that also have a competitive advantage in cheap labor intensive goods<sup>51</sup>.

Therefore, we investigate competition between Korea's and China's exports in an international market since a market share of Korean exports has been decreasing but that of China's has been increasing. This implies that Korea's export commodity competition against that of China or other countries in the international market has been losing.

Specifically, we investigate whether or not Korea's exports decreased over those of China in the U.S. market by means of measuring competition between both countries' exports. We focus only on the U.S. market for both countries' exports since the U.S. is the second best trade partner for Korea and is the best trade partner for China<sup>52</sup>. Moreover, it is a trend that Korea's export share in the U.S. market has been losing while that of China has been increasing.

We use the elasticity of substitution to measure the competition between Korea's and China's exports in the U.S. market since it is usually used for measuring the competitive degree between both countries' exports in an international trade market. In general, in order to know the degree of competition between two countries' exports in a third market (an import market), the elasticity of substitution in international trade is used to compare either one market (good) with another market (good). If there is a high elasticity of substitution between two countries' exports in a third market, this means that one country's exports are substituted for another country's exports and also implies losing the competitive power (advantage) of one country's exports to another country's exports in the third market.

This study will proceed as follows: section II will show the economic background between both Korea's and China's exports to the U.S. market and the market share of each country's export sections in the U.S. market. Section III will provide literature reviews and a theoretical framework. Data, methodology, and results will be in section IV. Lastly, section V will have conclusions.

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<sup>51</sup> Past labor intensive goods of Korea apply competition pressure from those of China and competition has been gradually changing from these to high-tech industrial products such as semi-conductors and information technology products.

<sup>52</sup> Although all other countries' exports are competitive with one another in the U.S. market, we are just concerned about measuring competition between Korea's and China's exports due to similar industrial structures between both countries. Due to problems in data collection, it is hard to measure competition between all other countries.

## II. Economic Background

### 1. Recent Economy of China

To begin, we simply check the recent economy of China. China has experienced rapid economic growth; a rate with an average of over 10% for the past 10 years. This has been the best growth rate in world countries in recent years<sup>53</sup>. Figure 2-1 shows the variation of China's and Korea's economic growth rate from 1995 to 2005. An average of Korea's economic growth rate is about 4.5% but that of China is over 10% as referred above. So, it is evident that there has been a rapid growth rate of China in recent years, compared with those of Korea and other world countries.

(Insert)[Figure 2-1 Economic Growth Rate of Both Countries]

Since China has had an enormous economic growth rate through an export-driven policy, its international trade has also increased significantly. Figure 2-2 represents a change in China's increased trade from 1970 to 2002. China's exports have continued to grow strongly during these periods, even as world trade had grown slowly, thus increasing China's export share of world markets. Its imports, as well as exports, steadily grew as well. So, we see that China's economic growth and trade have sprouted up coincidentally in these periods. We feel that these had been highly significant compared with that of other world countries.

(Insert)[Figure 2-2 Growth in Trade (Index, 1970=1)]

According to the International Monetary Fund (IFM) (2004), trade turnover accounted for more than 40 percent of China's GDP by the end of the 1990s, making it a relatively open large economy. China's merchandise exports had increased from about \$10 billion in the late 1970s to \$326 billion in 2002, which is about 5 percent of the total world exports at that time.

Therefore, we can see that China has rapidly and significantly increased its growth and trade compared with those of other countries.

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<sup>53</sup> An average world economic growth rate is about 2.3% from 1995 to 2005.

## 2. Challenge of Korea's Exports

China's rapid integration into the world economy and its continued high growth has a major impact on other Asian economies including Korea's economy. Both China and these countries have cooperated mutually in international trade because China usually imports raw materials or intermediate goods from these countries and exports final goods into the world market.

The strong economic growth of the Chinese economy and its rapid integration into the world economy inversely impact these Asian countries, including Korea. Both China and these countries have similar industrial structures, such as a labor intensive of industry in South Asian countries and a heavy industry in Korea and Taiwan, and their exports compete with one another in the world market.

Specifically, Korea has an opportunity to increase its export into China's market (table 1-1)<sup>54</sup>, while China can raise its exports at the expense of Korea's exports in third markets, such as the U.S. (table 2-2, 2-3, and 2-4). Trade between both countries can mutually affect both countries' trade but a decrease of Korea's export share through an increase in China's export share in the world market has evoked a big concern for the Korean economy.

(Insert)[Table 2-1 Korea's Trade Flow with Partner Countries]

Our first goal is to investigate the market share of Korea's and China's exports in the U.S. market. Table 2-2 shows a change in difference in the ratio of U.S. imports from China relative to U.S. imports from Korea from 1994 to 1998. China's exports had definitely increased for these periods while that of Korea had decreased in the U.S. market<sup>55</sup>. Therefore, we expect that if China continues to have strong economic growth in the future and its exports increase in the U.S. market, Korea's exports, as well as other countries' exports that have a competitive relationship with those of China, may decrease in the U.S. and world markets.

(Insert)[Table 2-2 U.S. Imports from China and Korea, 1994-1998]

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<sup>54</sup> China is number one for Korea's export market in 2006.

<sup>55</sup> Korea's exports were predominantly those of China in the U.S. market until the late 1980s.

In this context, table 2-3 confirms that the ratio of U.S. imports from China increased with the exception of textile apparel & leather products, while that of U.S. imports from Korea decreased (except textile apparel & leather products) from 1994 to 1998<sup>56</sup>. This implies that Korea's exports are inferior to those of China, which suggests that Korea's exports are vulnerable in the U.S. market.

(Insert)[Table 2-3 the Ratio of U.S. Imports from China and Korea to Total Imports for Selected Goods]

In addition, table 2-4 represents a change in Korea's and China's export market share in the world market from 1990 to 2000. China's export market share in the world market steadily increases whereas Korea's exports decrease or increase, respectively, at that time. From the information covered in table 2-4, we extract that China's exports in the world market overtook those of Korea at the beginning of 1992. Table 2-5 shows additional information of contents in table 4. According to table 2-4, China's exports share to world exports has continually increased from 2000 to 2005 while the rate of increase in that of Korea was smaller even though Korea has been raised to world exports. Table 2-5 also provides information on China's import share to world imports. Its import increase was slower than the increase of its export share for these periods.

(Insert)[Table 2-4 Exports of Korea and China in the World Mkt, 1990-2000]

(Insert)[Table 2-5 Korea's and China's Trade Shares as a Percentage of the World's Exports]

In summary, a share of Korea's exports over that of China has been losing either in the U.S. market or in the world market or both.

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<sup>56</sup> In this case, it looks as though Korea's textile apparel & leather products had an advantage over that of China at that time in the U.S. market.

### **III. Literature Review**

#### **1. Definition and Factors of Competitiveness**

In order to check the competition between Korea's and China's exports in the U.S. market, we need to know how competition is in international trade. Economists in international trade fields say that a country's competitiveness is increased when an amount (volume) of its exports is increased compared with that of other countries' exports in a given international trade market by means of change in export supply conditions. These conditions can include instances such as an increased efficiency of export production, or change in demand conditions as a favor of goods which are imported from a special country.

According to these economists, the variation of competitiveness of a country in the international trade can be incurred by several factors, such as (1) changes in exchange rate, (2) different growth rates of different countries' export production, (3) changes in subsidization or taxation on exports, (4) changes of different qualities of export goods or different development of new export goods, (5) different changes in export order from a country to another country (imports commodities that are transferred immediately), (6) changes in export price, and so on. However, only one of these factors does not completely affect changes in competition of a country's exports. Changes in export price of a country through an increase in labor cost can vary a country's competitiveness in an export market but does not completely impact change in competitiveness of the country's exports since other factors (as suggested from (1) to (6)) can affect these changes as well.

In addition, import demand conditions can change the competitiveness of a country's exports, such as its share in international markets. For instance, aggregation demand from a country's exports can be affected by a change in an import country's income and by restricting the demand of its importing goods for protecting its industries against imports.

#### **2. The Elasticity of Substitution in International Trade**

In order to investigate the competition between Korea's and China's exports in the U.S. market, we will use the elasticity of substitution, as previously indicated.

In general, the elasticity of substitution in international trade is often used to compare one market (good) with another market (good) in order to find the degree of competition between

two countries' exports in a third market. For instance, if there is a high elasticity of substitution between two countries' exports in a third market, this means that one country's exports are substituted for another country's exports, and also implies losing the competitive power (advantage) of one country's exports to another in the third market. Therefore, the elasticity of substitution is often used to investigate competition degree between one country's export goods and that of another country in international markets.

There are two well-known models used to measure the elasticity of substitution between goods or markets in international trade. The first model is the Classical Model used by Tinbergen (1946), Harberger (1957), and the Armington Model (1969)<sup>57</sup>. The Classical Model in international trade handles only a demand side without a supply side due to an assumption that all variables are flexible in this demand model, which is based on the framework of Classical thinking<sup>58</sup>. This Classical Model also assumes the homogeneity of all goods in the same good groups regardless of where the goods are produced or imported. That is, the model assumes that all goods in the same good groups are perfect substitutes of one another although goods are produced in different countries. These assumptions are based on Leontief's Mixed Commodity Theorem. According to Leontief (1936), it is possible to treat all goods in the same industry as a single good if the prices move coinstantaneously (Brakman and Jepma, 1990).

However, in practice, goods' prices determined by different countries can't move completely together in international trade and are not perfect substitutes of one another in either a domestic good market or an international market. In order to avoid this problem, Armington (1969) argues that all goods should be treated differently in a given importing country since imported goods, which are imported from different countries for goods in the same good groups, are produced by different foreign countries. For example, we can assume that there is a consumer in a given importing country. This consumer can discriminate differences between domestic and imported goods even though domestic and foreign countries produce the same goods since each

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<sup>57</sup> We call 'Classical Model' with classical thinking to their models to discriminate this from the 'Armington Model.'

<sup>58</sup> Classical thinking assumes that market equilibrium always comes true in an economic system by means of flexible economic variables given in a market. This Classical Model has a similar concept as Walars' law. Walars' law shows that if there exists  $n$  markets, only  $(n-1)$  markets is required to reach a market equilibrium because the final one market will automatically accomplish the equilibrium market when  $n-1$  markets reach equilibrium due to market flexibility. So, one can say that a general equilibrium always exists in a market based on the ideas of classical thinking and Walars' law.



country may use different skills and endowments to produce these same goods due to different production conditions in each country. In other words, the consumer may feel there is an imperfect substitution between domestic goods and imported goods even though domestic and foreign goods are in the same good groups. The genesis of the imperfect substitution is due to having different resources in each country that make the same goods and to existing differences, such as a design between these goods. Armington (1969) suggests a new concept of the elasticity of substitution using the concept of supply side<sup>59</sup> based on a consumer's recognition to distinguish between domestic goods and imported goods or between any goods in a domestic market in the demand side. Specifically, in order to measure the elasticity of substitution in international trade, he used the utility maximization subject to expenditure<sup>60</sup>, assumed a consumer's differentiation (discrimination) on goods produced by different locations (countries), and a constant elasticity of substitution. This is generally called the 'Armington elasticity (model).'

### 3. Previous Studies

Many previous studies have tried to discover a trade pattern for a country or several countries in international trade by using income and price elasticities. The elasticity concept in international trade is used to investigate which factor between foreign incomes and export good prices of a country affects export goods. After deciding a trade pattern of a country, the country may set some trade policies to help guide and stimulate its exports in foreign markets. Income and price elasticities are a hot issue to international trade economists.

However, it is also very important to know the degree of competition between domestic and foreign products after determining trade patterns of a country by using the substitute elasticity as well as income and price elasticities in international trade. However, due to problems in gathering data for empirical analysis between countries' export commodities in international trade, it has not been proven significant as an important factor to measure the

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<sup>59</sup> Here, supply side in his model means that a consumer's total expenditure to maximize its utility in aggregated demand side is the same as the total sales of domestic good and imported good suppliers in aggregated supply side by means of the consumer's utility maximization model. See the appendix section with more detailed information about the Armington Model.

<sup>60</sup> In this case, expenditure means total expenditure of a country (consumer), which is the same as total import and domestic good amounts. In this situation, the consumer wants to consume these goods to maximize its utility.

degree between products in empirical studies by using the elasticity of substitution compared with that of price and income elasticities.

Nevertheless, there have been some studies related to the elasticity of substitution in international trade<sup>61</sup>. For example, in order to investigate the competitive relationship between national crops in a world market, Tinbergen (1946) estimated the elasticity of substitution on crops between various countries.

In general, earlier research did not include an income term into an international trade demand model to measure the elasticity of substitution since they assumed the same income elasticity for exporting countries. In order to estimate the elasticity of substitution, they used only price terms in the international demand model. However, income, as well as price, also affects changes in demand of importing commodities in the international trade. So, in order to study the competitive relationship between various countries' crops, Polak (1950) had performed the elasticity of substitution by using a demand model with income and price terms in international trade. In other words, he inserted income terms into a demand model (equation) with price terms and then estimated the elasticity of substitution by using U.K. and U.S. data of agriculture products in order to see the competitive relationship between both countries' agriculture products<sup>62</sup>.

Meanwhile, MacDougall et al., (1951, 1952) used a different way to estimate the elasticity of substitution in an export demand model. They employed relative input prices of labor per unit to total output in different industries between two countries and relative exports of two countries in these industries. They proposed to use this labor per unit price as a relative price of goods in a demand model to estimate the elasticity of substitution (since they found low elasticity of substitution) by using this method compared to that of relative prices of goods for the same relative quantities of goods between both countries.

However, there may be measurement errors or misspecifications originated by the researchers' mistakes such as using wrong variables, fallible constrained parameters, or both in estimating a model for their research purpose. Measurement error can give rise to spurious

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<sup>61</sup> Most empirical studies estimated price and income elasticities from a total demand model for exports or imports in domestic or foreign markets. In general, most studies measure elasticities in international trade by using either cross sectional data or panel data of import goods of countries for analyzing trade flows in a point of time since it is difficult to get time series data in the international trade field.

<sup>62</sup> If one does not consider an income term in a demand model to estimate the elasticity of substitution in international trade field, there may be spurious regression results.

regression results and researchers should be careful not to generate such errors. For example, Richardson (1972) adjusted using data to estimate the elasticity of substitution between both countries in international trade since he believes there are possible spurious results<sup>63</sup> on regression estimation by measurement error created by wrongly adjusting data use, such as rectifying C.I.F<sup>64</sup> and F.O.B<sup>65</sup> or by misspecification raising by erroneous constraints of parameters in a model<sup>66</sup>. So, we believe that there may be a suitable value for the elasticity of substitution when desirable data or right adjustments of data are employed.

In order to estimate price and income or substitute elasticities in a demand model in international trade, most previous studies had used a simple demand model with only price variable or both price and income variables for the demand side (end-users or consumers). These studies do not include any variable for the supply side (suppliers of goods) based on an assumption on a partial equilibrium, which has an advantage of easily approaching the researcher's purpose by means of collecting data of the demand side without that of the supply side and using a simple model, compared with that of a general equilibrium which includes all available variables in demand and supply sides.

However, Arimington (1969) pointed out that price and income elasticities considered by only the demand side are mis-specified<sup>67</sup>. According to him, a domestic country could identify and treat differently between domestic goods and foreign goods, or between foreign goods imported from different countries (import suppliers) due to a possible existing character (quality) of goods produced by using different technologies and endowments even though different countries produce the same goods. In order to understand his argument, we assume that there is one consumer in an import country. This consumer recognizes the difference between domestic and imported goods due to possible differences, such as design and quality, by using each country's different producing technological skills and endowments to make the same goods (even though domestic and foreign countries produce the same goods). In other words, this

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<sup>63</sup> There is a possible quantitative difference of the elasticity of substitution by measurement errors or misspecifications, rising from either a fallible hypothesis or theory or both, and by choosing inaccurate quantity data.

<sup>64</sup> C.I.F (Cost, Insurance and Freight) is a trade term requiring the seller to arrange for the carriage of goods by sea to a port of destination.

<sup>65</sup> F.O.B (Free On Board) is a trade term requiring the seller to deliver goods on board a vessel designated by the buyer.

<sup>66</sup> There is also possibly collinearity of variables in an estimating model due to the likelihood of a linear relationship between variables in this estimating model.

<sup>67</sup> He suggests that income and price elasticities of the demand side without export side effects lead to over-estimation.

country (consumer) feels there is an imperfect substitution of goods due to using different producing skills and endowments even though domestic goods and foreign goods are in the same goods groups. In this condition, this country can purchase domestic goods, imported goods, or both to maximize its utility subject to constrained expenditure. The other assumption is that its total expenditure, to maximize its utility, is the same as total sales of suppliers, which refers to the supply side. This means a factor of the supply side considered his model (Armington Model)<sup>68</sup>.

Although previous research has used either the framework or concept of the Armington Model since 1968, we simply introduce a few representative articles<sup>69</sup>, based on the Classical Model or concept, because we are only focusing on the Classical Model for our research due to problems in data collection<sup>70</sup>. For example, Stern et al., (1976) estimated the elasticity of substitution for 3-digit International Standard Industrial Classified (ISIC)<sup>71</sup> in U.S. imports from the developed countries to investigate the competitive relationship between imports and domestic products. Gallaway et al. (2000), in order to investigate the competitive relationship between imports and domestic commodities, performed disaggregated and comprehensive estimates of substitution by using 311 industries in the 4-digit Standard International Classified (SIC) level<sup>72</sup>. In addition, Lopez and Pagoulatos (2002)<sup>73</sup> have provided estimates of the elasticity substitution between domestic and imported goods in U.S. food manufacturing industries.

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<sup>68</sup> The main difference between the Classical Model and the Armington Model, in order to estimate elasticity, is whether or not a factor of supply side is included into a demand model. Specifically, the Armington Model suggests that in order to maximize its utility in a domestic market, a consumer is related with demand side on domestic or foreign goods, or both. In order to minimize its expenditure for purchasing goods, which are supplied by domestic or foreign suppliers or both suppliers who provide the same goods or similar goods to a domestic market, the consumer regards both demand and supply sides simultaneously by using the utility and expenditure functions.

<sup>69</sup> In order to see the competition degree between imports and domestic products in the same commodity groups, most previous studies have used the elasticity of substitution.

<sup>70</sup> This study will use data from Korea and China to estimate the elasticity of substitution between both countries. However, it is important to note that there is difficulty in gathering China's data.

<sup>71</sup> The ISIC is a United Nations (UN) system that efficiently classifies commodities in the world economy.

<sup>72</sup> The SIC is the UN government system that efficiently classifies industries by using a four-digit code.

<sup>73</sup> They showed different substitution elasticities in inter-industries and explained these reasons to be from foreign direct investment, expenditure on advertising and existence of import quota when changes in relative prices.

## IV. Estimation Methodology and Data

### 1. Methodologies

We use a simple demand model to investigate the competitive relationship between Korea's and China's exports in the U.S. market by using the elasticity of substitution. A basic framework of this demand model is developed by Tinbergen (1946) and Harbergen (1957).

First, in order to understand this simple demand model, we need to know a basic concept of the elasticity of substitution. We suppose a function as follows.

$$X = F(Y), \text{ where } X = \begin{pmatrix} Q_1 \\ Q_2 \end{pmatrix} \text{ and } Y = \begin{pmatrix} P_1 \\ P_2 \end{pmatrix} \text{ or } \begin{pmatrix} Q_1 \\ Q_2 \end{pmatrix} = F \left( \begin{pmatrix} P_1 \\ P_2 \end{pmatrix} \right) \quad (1)$$

Where,  $Q_1$  and  $Q_2$  = the amounts of each good,  $P_1$  and  $P_2$  = respective prices.

In order to derive the elasticity of substitution, we take the elasticity of  $\begin{pmatrix} Q_1 \\ Q_2 \end{pmatrix}$  with respect to  $\begin{pmatrix} P_1 \\ P_2 \end{pmatrix}$ , that is,

$$e \text{ (the elasticity of substitution)} = \left( \frac{Y}{X} \right) \left( \frac{dX}{dY} \right) = \begin{pmatrix} \frac{P_1}{P_2} \\ \frac{Q_1}{Q_2} \end{pmatrix} \left( d \begin{pmatrix} \frac{Q_1}{P_1} \\ \frac{Q_2}{P_2} \end{pmatrix} \right) \quad (2)$$

So, equation (2) is 'the elasticity of substitution.' Since we know the elasticity of substitution through equation (2), we need to estimate a parameter of the elasticity of substitution in a regression demand model. We need to transfer a concept of the elasticity of substitution of equation (2) into a log-linear equation (model) (4) by using equation (3) with a log form. The reason for changing a log linear demand form from equation (1) is to see a linear relationship among parameters in a regression demand model and, to then observe any increases or decreases of the relationship among parameters in the regression demand model. Specifically, this log

linear equation (model) in this study assumes a linear relationship among parameters, in order to estimate the elasticity of substitution.

We derive the log equation (3) from equation (2) by using a log form to show the elasticity of substitution. Equation (3) implies the elasticity of substitution between two commodities and two prices, which has an interpretation on responding the ratio of the quantities of the commodities to the ratio of prices of these commodities. Thus, equation (3) is the elasticity of substitution form by using a log form.

$$d \left( \frac{\ln \left( \frac{Q_1}{Q_2} \right)}{\ln \left( \frac{P_1}{P_2} \right)} \right) \quad (3)$$

We can then induce a relationship between the relative quantities and relative prices for individual commodities as an equation form,  $Q_1/Q_2 = (P_1/P_2)^\lambda$ . When we take logarithms of both sides to this equation form, it can be rewritten as  $\lambda = d \ln(Q_1/Q_2) / d \ln(P_1/P_2)$ , where  $\lambda$  means the elasticity of substitution. This equation form is the same as equation (3). To estimate the elasticity of substitution, this equation form, as a regression model, can be modified as equation (4) by taking the logarithms.

$$\ln \left( \frac{Q_1}{Q_2} \right) = \beta + \lambda \left( \ln \left( \frac{P_1}{P_2} \right) \right) + \zeta \quad (4)$$

Where,  $\beta$  is constant and  $\zeta$  is error term. Other parameters' definitions are the same as the above equations.

Equation (4) is an estimating model used to investigate the relationship between Korea's and China's exports in the U.S. market. So, this equation, for the purpose of our research, is specified as follows.

$$\ln\left(\frac{KV_k}{CV_c}\right) = \beta_1 + \lambda \left( \ln\left(\frac{KUV_k}{CUV_c}\right) \right) + \zeta \quad (5)$$

Where,  $KV_k$  = quantity of Korea's good exports into the U.S. market

$CV_c$  = quantity of China's good exports into the U.S. market

$KUV_k$ <sup>74</sup> = price (U.S. \$) of Korea's good exports into the U.S. market

$CUV_c$  = price (U.S. \$) of China's good exports into the U.S. market

$\lambda$  = elasticity of substitution between both countries' exports in the U.S. market

$\beta_1$  = constant,  $\zeta$  = error term

Meanwhile, we may have suspicion whether equation (4) with only two variables (parameters) of price and quantity is appropriately used to estimate the elasticity of substitution since other terms (variables), such as income and exchange rate, may also affect values of the elasticity of substitution. We expect that there may be a bias if only price term to the quantity term is used. In general, levels of income and exchange rate as well as price levels of importing goods can be considered as main factors to determine a country's demand of importing goods from foreign countries in international trade.

More theoretically, income level of people in a country to importing goods causes more effects for the demand of importing goods compared with that of exchange rate since the determining level of their income is connected directly with the desire of purchasing imported goods. But a change in exchange rate may affect indirectly to their willing to buy imported goods because an impact of change in exchange rate is connected primarily to change in the price of imported goods compared with changes in their income. So, we will only add the income term (variable) into equation (5) in this study. Therefore, equation (5) can be rewritten as equation (6) if only the income term is inserted into equation (5).

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<sup>74</sup> Due to the lack of direct price data, the usual proxies for prices of unit value (value / quantity) are based on aggregated magnitudes and quantities since they may reflect composition and quality changes as they do price changes (Richardson, 1972). In general, a unit value, import values/quantities (tons, cubic feet, number, etc.), is used as a proxy of price in the regression model because the real price of aggregated imports is hard to find.

$$\ln\left(\frac{KV_k}{CV_c}\right) = \beta_1 + \lambda\left(\ln\left(\frac{KUV_k}{CUV_c}\right)\right) + \beta_2 \ln Y + \zeta \quad (6)$$

Where,  $KV_k$  = quantity of Korea's good exports into the U.S. market

$CV_c$  = quantity of China's good exports into the U.S. market

$\beta_1$  = constant,  $Y$  = GDP (industrial production index) of the U.S., and  $\zeta$  = error term

$\lambda$  = the elasticity of substitution between both countries' exports in the U.S. market

$KUV_k$ <sup>75</sup> = price (U.S. \$) of Korea's good exports into the U.S. market

$CUV_c$  = price (U.S. \$) of China's good exports into the U.S. market

In order to investigate the competitive relationship between both countries' exports in the U.S. market, we will first estimate the elasticity of substitution by using equations (5) and (6), respectively. This is so we can see changes in the estimates of substitute elasticity since there may be differences in estimated values of the elasticity of substitution from these equations depending on if variable terms are added into the model equation. Then we can choose the best model between both models (equations (5) and (6)) by the size of estimates of substitute elasticity<sup>76</sup> based on a statistical validity.

A size of estimates of substitute elasticity through these equations (5) and (6) provides us the relationship of a competitive degree between Korea's and China's exports in the U.S. market. If there is a high elasticity of substitution between two countries' exports in a third market, this means that one country's exports are substituted for another country's exports and also implies losing the competitive power (advantage) of one country's exports to another country's exports in the third market. So, knowing the elasticity of substitution of China's exports for Korea's exports in the U.S. market might provide us a signal on a change in Korea's competitive status of exports in the U.S. market through a change in Korea's export volume by a change in the relative price of China's exports.

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<sup>75</sup> Due to difficulties obtaining direct price data, Richardson (1972) alerts that the usual proxies for prices of unit value (value / quantity) are based on aggregated magnitudes and quantities since they may reflect composition and quality changes as they do price changes. He says, "A unit value, import (export) values/quantities (tons, cubic feet, number, etc.), is used as a proxy of price in a regression model since the real price of aggregated imports (exports) is hard to find in international trade."

<sup>76</sup> After we discern whether estimated values of the substitute elasticity are statistically valid or not, we choose the best model between both models by a size of estimates of the substitute elasticity.



## 2. Empirical Specifications

A regression equation to the elasticity of substitution has the price, as an import (export) price of goods, as a key variable in international trade. However, the import (export) price of goods is not easy to find. So, as previously indicated, the elasticity of substitution is usually used by the import (export) price of goods (a unit value), which is obtained by dividing the total value of imports (exports) by the total volume of imports (exports). Most previous studies have used unit value price data<sup>77</sup> due to limitations in obtaining a direct import (export) price of goods in order to estimate the elasticity of substitution in the international trade.

However, in the short run, the unit value of imports (exports) as an indicator of competitiveness in the international trade may have the disadvantage of being influenced to a greater extent by changes in demand conditions, such as an increase or decrease of demand to changes in an import (export) price in international markets<sup>78</sup> and the instable effects of demand changes raised by the changes in a unit price. Demand conditions may not reflect a real trend for price competitiveness of imports (exports) for research analysis in international trade markets. In order to avoid this problem, a wage cost index of goods, as an alternative way, could be used to measure the price competition for research analysis in international trade markets<sup>79</sup>.

In general, an index of wage cost in manufacturing comes from both an index of hourly wage rates and an index of employment multiplied by an index of hours worked per week. These are multiplied to each other and are then divided by an index of output. Wage cost index may have a merit of reflecting only domestic costs of an importing (exporting) country without changes in demand conditions in international trade markets.

## 3. Data

In order to analyze the competition between Korea's and China's commodities in the U.S. market, both countries' goods export prices are obtained from Korea International Trade Association (KITA). The industrial production index, as a proxy for the U.S. GDP (income), is found from the International Monetary Fund (IMF)'s International Financial Statistics (IFS)

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<sup>77</sup> Some studies have used tariff and transport cost data extracted from price data, which includes benefits and all costs needed for making goods as well as tariff and transport costs.

<sup>78</sup> In fact, declining export prices of one country more than those of other countries may not increase competitiveness but reduce the demand of world markets to this country's exports.

<sup>79</sup> Wholesale and retail prices can be used as one of the possible indicators of competitiveness. However, these have a possible correlation with trade share compared with either an export (import) unit value or wage cost.

database, and information data on a share of products imported from Korea and China in the U.S. market is extracted from TradeStates Express<sup>80</sup>. A data set, which is broken down by 2-digit commodities in the Harmonized System (HS) from 1998:01 to 2008:01, is used from KITA. We use monthly data of both countries' goods export prices into the U.S. market. Industrial production index in the time series monthly data is a seasonally-adjusted time series data but unit price variables are not seasonally adjusted due to no existing seasonality. All time series variables are changed into logarithms<sup>81</sup> to represent a concept of elasticity.

#### 4. Estimation Procedure

In this study, there is a problem in investigating the elasticity of substitution between Korea's and China's exports in the U.S. market. The difficulty is how we choose lists of commodities of both countries, which are exporting into the U.S. market. We don't need lists of all commodities since all commodities of both countries have not necessarily faced a competitive relationship in the U.S. market<sup>82</sup>. To avoid this problem, we use their relative share in world total imports imported by the U.S. market to see relative shares of their commodities in the U.S. market. This study investigates a share of both countries' major export commodities into the U.S. market by using commodity lists of a 2-digit code classified by the Harmonized Commodity Description and Coding System (HS)<sup>83</sup> from 1998:01 to 2008:01.

(Insert)[Table 2-6 Lists of Harmonized Commodity Description and Coding System (HS)]

In order to see a trade pattern of commodity between Korea's and China's exports in the U.S. market from 1998:01 to 2008:01, we use a historical trade data based on a 2-digit code of commodity lists<sup>84</sup> in the HS about both countries' exports into the U.S. market. We then find a feature of Korea's exporting commodity pattern into the U.S. market by using an average share

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<sup>80</sup> This provides national trade data. The web address is as follows: <http://tse.export.gov>

<sup>81</sup> Transforming all time series to logarithms is performed to avoid heteroscedasticity. Logarithms of variables represent either an increase or a decrease of the relationship between variables.

<sup>82</sup> If we handle all commodities of both countries for our research's purpose in the U.S. market, it will take a lot of time and endeavors. It looks like an inefficient thing to do.

<sup>83</sup> The HS is an international standard of names and numbers that classify trade commodities.

<sup>84</sup> See table 2-6.

of its exporting commodity by using 2-digit codes<sup>85</sup> in the HS as follows. It is that 85, 97, 84, 27, 61, 73, 62, 72, 39, 40, 98, and 90 in figure 2-3 are lists of Korea's main exporting commodities into the U.S. market from 1998:01 to 2008:01<sup>86</sup>. Those of China into the U.S. market are 84, 85, 87, 90, 39, 98, 29, 71, 27, 30, and 38 are shown by figure 4<sup>87</sup>. We focus only on these commodity categories to investigate the competition between both countries' exports into the U.S. market since these commodity categories are their main exports into the U.S. market and may be competitive with one another.

Based on figures 2-3 and 2-4, we investigate the relative shares of Korea's and China's commodity categories in the U.S. market by using the relative shares of their commodity categories in the amount of world total commodity categories imported by the U.S. market.

Afterwards, we only use these commodity classifications (lists) chosen in order to analyze the competition between Korea's and China's exporting commodities in the U.S. market. To this end, we compute the unit value of each commodity category by using the import value divided by import quantity for the relative price of commodities between Korea and China. To check the stationarity for these unit value variables, as well as other variables, we perform the unit root test. Finally, after the unit root test, we perform regression on a demand model including the ratios of the amount of commodities with respect to ratios of unit values of commodity groups in order to get the elasticity of substitution for competition between both countries' commodity categories respectively in the U.S. market.

## **5. Relative Share of Both Countries' Commodity Categories in the U.S. Market**

We investigate relative shares of both countries' exports in the U.S. market to estimate the elasticity of substitution between commodity groups of both countries in the U.S. market.

Figures 2-3 and 2-4 show the relative shares of both countries' 2-digit commodity groups (categories) to world total commodity groups (categories) imported by the U.S. market. In figure 3, a top commodity category in 2-digit commodity categories of Korea into the U.S. market is 85 and that the top second is 97, while those of China are 84 and 85.

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<sup>85</sup> The commodity classification name lists of 2 digits in the HS excluded in this study are those in which Korea and China have a small amount of their exports into the U.S. market.

<sup>86</sup> See table 2-7 on goods lists of these commodity group codes.

<sup>87</sup> See table 2-7 on goods lists of these commodity group codes.

(Insert)[Figure 2-3 the Avg. Share in Korea's Commodities Imported by the U.S. Mkt (1988-2007)]

(Insert)[Figure 2-4 the Avg. Share in China's Commodities Imported by the U.S. Mkt (1988-2007)]

Specifically, a sum share of 85 and 97 in Korea's export commodity categories is 52.11% and these commodity categories take over half (%) in total top export commodity categories of Korea into the U.S. market. So, it seems that Korea's exports into the U.S. market are lopsided toward a part of commodity categories. Meanwhile, a sum of the top two commodity categories to the total top commodity categories of China is 34.51%, which is not half (%) of the total top export commodity categories of China in the U.S market.

In figures 2-3 and 2-4, we find that half of the top export commodity categories such as 85, 84, 27, 39, 98, and 90 between both countries overlap each other in the U.S. market. This implies that there may be competition between these commodity categories in the U.S. market.

Meanwhile, in order to see these commodity groups' shares of both countries in the U.S. market, we investigate shares of commodity categories of these countries to world total commodity categories imported by the U.S. market. These are presented in figures 2-6 through 2-17.

Figure 2-5 shows that China's exports have significantly increased in the U.S. market whereas that of Korea has mildly decreased from 1998 to 2007. Figures 2-6 through 2-17 show a change in a relative share of Korea's and China's commodity categories to each world total category imported by the U.S. market from 1998 to 2007. Shares of these commodity groups in these figures come from the relative shares of Korea's and China's exports for 2-digit breakdown of HS and are computed for the period of 1998 to 2007. The world total commodity groups in the U.S. market and their relative shares of commodity groups are normalized by using the amount of their commodity groups imported by the U.S. market<sup>88</sup>.

(Insert)[Figure 2-5 Change (%) in Share of Korea's and China's Total HS in the U.S. Total Imports]

By using figures 2-6 through 2-17, we find that Korea's most commodity categories (groups), with the exception of 27, do not have an advantage (priority) market share over those

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<sup>88</sup> In other words, figures 2-6 to 2-17 show the relative shares of both countries' export commodity groups that are computed by dividing the country's export commodity groups (import groups of the U.S.) to the world total imports of U.S. in the same commodity groups.

of China although some commodity groups such as 40, 98, and 72 of Korea takes a mild market share in initial periods compared with those of China but these market shares are lost over time. So, figures 2-6 through 2-17 definitely show that most commodity groups of Korea in the U.S. market have been a relative advantage of ratio over that of China over time.

Specifically, (based on figures 2-6 through 2-17) when comparing a share of each commodity group of China with that of Korea in the U.S. market, it seems that most commodity groups for Korea do not have a priority market share compared with those of China in the U.S. market from 1997 to 2007 due to Korea's relatively small exporting commodity. This implies that there has been an increase in shares of China's commodities at the expense of Korea's commodities in the U.S. market and shows that commodities of China over those of Korea may have more competition in the U.S. market.

(Insert)[Figure 2-6 Change in Share of 85 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-7 Change in Share of 97 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-8 Change in Share of 84 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-9 Change in Share of 27 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-10 Change in Share of 61 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-11 Change in Share of 73 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-12 Change in Share of 62 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-13 Change in Share of 72 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-14 Change in Share of 39 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-15 Change in Share of 40 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-16 Change in Share of 98 for Both Countries in the U.S. Mkt]

(Insert)[Figure 2-17 Change in Share of 90 for Both Countries in the U.S. Mkt]

Table 2-7 shows lists of commodity groups selected by Korea and China that have a large share of their total exports in the U.S. market based on figures 2-3 and 2-4. However, commodity group codes 97, 61, 73, 62, 72, and 40 mean that these have highly relative ratios from Korea's exporting commodity groups in the U.S. market. It does not mean that these have more relative ratios of market shares against those of China in the U.S. market. Also, it does not indicate that these have Korea's dominant commodity groups against those of China in the U.S. market. Similarly, commodity group codes 87, 88, 29, 71, 30, and 38 in China's exporting

commodity groups into the U.S. market means having highly relative ratio on its exporting commodity groups and it does not mean taking highly relative ratio of market shares in the U.S. market compared with those of Korea. Besides, commodity group codes 85, 84, 27, 39, 98 and 90 mean that top export commodity categories between both countries overlap each other in the U.S. market. As noted previously, this implies that there may be competition between these commodity categories in the U.S. market.

(Insert)[Table 2-7 2 Digit Commodity Groups Chosen for Analysis]

Based on this information, we find that with the exception of commodity group code 27, most commodity categories (groups) of Korea over China in the U.S. market have not been a predominated market share from 1998 to 2007<sup>89</sup>. This implies that Korea's exporting commodity groups into the U.S. market have been losing its competition against China's exports during these periods. Thus, we anticipate the low elasticity of substitution on Korea's exporting most commodity groups against those of China in the U.S. market. As referred in an earlier section, if there is a high elasticity of substitution between two countries' exports in a third market, this means that one country's exports are substituted for another county's exports and also implies losing the competitive power (advantage) of one country's exports to another country's exports in the third market.

In order to catch the substitute elasticity (a degree of competitive position) of Korea in the U.S. market through the change in volume of Korea's exports due to relative price changes by factors such as a result of the entry of China's cheap or quality goods in the U.S. market from 1998:01 to 2008:01, this study estimates the elasticity of substitution of China's exports for Korea's exports. This elasticity of substitution means to estimate the change in the ratio of the amounts (volumes) on the same commodity groups to the variation in the ratio of their export prices over time.

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<sup>89</sup> It looks as though this situation will keep going over time if Korea does not take any merits, such as priority technological technique and innovation commodities over those of China's commodity over time in the U.S. market.

## V. Results

Before we estimate the elasticity of substitution between Korea's and China's exports in the U.S. market, we need to perform unit root tests for each level variable. In order to decide whether level variables are integration or cointegration, we use the augmented Dickey-Fuller (ADF) and Philip-Perron (PP) tests<sup>90</sup>. We assume a model with a constant and a trend for testing the unit root for level variables since there is no standard for choosing models for the unit root tests<sup>91</sup>.

Table 2-8 shows the results of the unit root test for each unit price of level variables for commodity groups chosen by this study to estimate the elasticity of substitution. With the exception of 38, 61, 62, 88, and 97, other commodity groups have at least one unit root either the amount of export variables or export price variables in these commodity groups or both. So, we take the first difference for level variables with a unit root, and then find that these are stationary after the first difference. Thus, we use both first difference variables (if these have a unit root) and other level variables with no unit root to estimate the elasticity of substitution.

(Insert)[Table 2-8 Results of Unit Root Test for Each Unit Price Variable for Commodity Groups]

After we use the unit root test for level variables, we estimate the substitute elasticity by using a simple (standard) demand model (equation 5) with only export volumes and price variables related with commodity groups selected by this study. Table 2-9 shows the regression results on this standard model. We find that all statistical values of both 84 and 90 in commodity groups were statistically insignificant but 39, 40, 72, and 73 have a statistically significant constant. However, all coefficients and constants of 29, 30, 38, 61, 62, 85, 88, and 97 are statistically significant at a 1%, 5%, and 10% significance level, but only the coefficients of both 27 and 29 are statistically significant at a 5% significance level.

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<sup>90</sup> If we use level variables without testing unit roots in spite of existing unit roots between level variables, we could obtain spurious results because something existing in between these unstable variables may not have a true trend. Unstable variables do not go back to an original trend when given a shock and these unstable variables may not possess a trend.

<sup>91</sup> In general, the unit root tests are supposed by three models: the first model is a simple model with the exception of trend and constant, the second model includes only a constant, and the last model involves a constant and a trend. Models for the unit root test are also chosen by the researcher's subjectivity and an economic theory on time series data.

In table 2-9, some estimates of coefficients are insignificant (such as zero coefficients) but the level of significance of the rest of the coefficients' estimates is approximately moderate. Meanwhile, the coefficient signs of the elasticity of substitution are negative for only 29, 61, 62, and 71. These negative signs are consistent with an economic theory, which means that export volume is negative with respect to change in price<sup>92</sup>.

(Insert)[Table 2-9 Elasticities of Substitution for Commodity Groups]

Table 2-9 also shows statistical results on coefficient estimates of the elasticities of substitution<sup>93</sup>. Specifically, we find that all coefficient values of the substitute elasticity results belonged in a range from 0.0568 to 2.3302, which means a lower (minimum) value and an upper (maximum) value respectively in valid results of regression<sup>94</sup>. In fact, this is consistent with previous literatures because the change in relative export volumes is much smaller than that of the relative price<sup>95</sup>. Low coefficient estimates may be due to an identification problem in a simple (standard) model equation as well as measurement error in prices as a unit value. In order to avoid these problems, we may need to use appropriate instrumental or proxy variables (IVs) in this simple (standard) model. When well-suited instrumental variables are used in this simple (standard) model, we believe that appropriate values of the elasticity of substitution would be the result. In practice, however, it is not easy to find good IVs, which are highly correlated with the independent (unit price) variables and are correlated with measurement error terms. Besides, it is not easy to find out whether the chosen proxy variable is independent on the error terms. In this situation, although it can be used by wage cost per unit of output or labor per unit of output as an

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<sup>92</sup> Our interest is not sign of price changes but is only in the absolute measurements of elasticities of substitution because we want to see a degree of competition by size of estimates of the substitute elasticity. If there is a high elasticity of substitution between two countries' exports in a third market, this means that one country's exports are substituted for another country's exports and also implies losing the competitive power (advantage) of one country's exports to another country's exports in the third market.

<sup>93</sup> Commodity groups chosen by our study are applied in the simple (standard) model (5) above. The most reliable results are shown in table 2-8.

<sup>94</sup> This range implies that all values of regression coefficients represent the relationship between export unit value ratios and export volume ratios in given commodity groups may fall in this range. This range also implies that a 1% difference in ratios of export unit value between Korea's and China's export commodities may create a tendency with a difference from 0.0568 % to 2.3302 % in ratios of their export volume.

<sup>95</sup> It is known that previous researches have obtained small coefficient estimates for the elasticity of substitution.



instrumental variable in the international trade, our study can't use these due to problems in data collection.

From these regression results, as shown in table 2-9, we discover that most values of the regression coefficients on the elasticity of substitution between Korea's and China's export volume ratios and export unit value ratios on commodity groups selected by the purpose of our research in the U.S. market are small (inelastic) from 1998:01 to 2008:01. However, specifically, values of the substitute elasticity of commodity group codes 61, 62, and 85 are elastic and these values are also statistically significant. These coefficient values are 1.2532, 2.3302, and 1.9788, respectively. These imply that an increase of export price by 1% gives rise to raise a 1.2532%, 2.3302%, and 1.9788% of export volume (amount). These are elastic. Thus, these Korean commodity groups have competition against those of China in the U.S. market. Specifically, by using commodity historical data, most of China's commodity groups have dominant market shares against those of Korea in the U.S. market including commodity groups 61, 62, and 85. So, we expect that most Korean export commodity groups in the U.S. market have no competition against those of China, and these low coefficient values are consistent with our expectation with no competition. However, we find that at least 61 (apparel articles and accessories, knit or crochet), 62 (apparel articles and accessories, not knit etc) and 85 (electric machinery etc, sound equipments, TV equipment, parts) commodity groups have competition compared with those of China in the market.

Meanwhile, a simple (standard) model equation (5) has an implicit assumption that both Korea's and China's exports to the U.S. market take the same income of the U.S. because both countries export their commodities into the U.S. market and they both received an income of the U.S. by selling their commodities in the U.S. market. Therefore, we believe that in the simple (standard) model without an income variable, both countries have the same income elasticity due to having the same income of the U.S. through selling their commodities in the U.S. market.

However, only price variable in the simple (standard) model equation (5) cannot affect a change in export commodity groups in real but other factors, such as income and exchange rate can also impact the change in export commodity groups. So, we need to add income as an independent variable into the simple (standard) model equation, and then re-estimate the elasticity of substitution by using this modified model to see whether or not a change occurs in the elasticity of substitution. As referred in an earlier section, this study uses an industrial

production index as a proxy for the U.S. income to this modified model because it is difficult to obtain data on monthly personal income or monthly GDP of the U.S.

Table 2-10 shows the results of the elasticity of substitution by using the modified model including income as an independent variable.

(Insert)[Table 2-10 Newly Estimated Elasticities of Substitution for Commodity Groups]

Although the goodness of fit ( $R^2$ ) of most (half) commodity groups improved with the exception of 61, 62 and 98 of commodity groups<sup>96</sup>, the coefficients of the elasticity of substitution slightly deteriorated. That is, there is an increase or decrease of the elasticity of substitution. For instance, in the case of 30, the elasticity of substitution decreased even though constant, price, and income variables are statistically significant at a 5% significance level. Also, a sign of this coefficient is not consistent with an economic theory with the negative coefficient sign of the substitute elasticity. Moreover, there are statistically insignificant results on variable coefficients in other cases of commodity groups.

However, it is still statistically significant and elastic on the commodity group codes 61, 62, and 85 as those in the model without an income variable. Specifically, goods groups 86's coefficient value of the substitute elasticity increases compared with those of other goods groups which decrease. It seems that only 85 commodity groups are more sensitive by price factor than income factor.

Meanwhile, most coefficient values of income in commodity groups are not statistically significant. With the exception of 29, 61, 62, 71, and 98, we find that sizes of coefficients for commodity groups are larger compared with those from the simple standard model without the income variable. The reason may be that a relative explanation power of price variable to change in volumes of exports decreased since income variable affect the change in volumes of exports as well as price variables or that there are still identification problems or measurement errors in this modified model.

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<sup>96</sup> We are interested to see changes in the elasticity of substitution. Since this standard model is limited by only two variables, price and income, all conditions for this standard model may be difficult to include in international trade due to data collecting problems.

Eventually, commodity group codes of 61, 62, and 85 still have elastic elasticity of substitution. This modified model can be accepted for estimating the elasticity of substitution for our study.

## **VI. Conclusions**

This study's findings are as follows. First, in order to know a market share between Korea's and China's export sections in the U.S. market, we use historical trade data of both countries' export section and then find that Korea has a competitive market share of only 27 commodity group (mineral fuel, oil, etc; bitumen subst; mineral wax) codes over that of China, otherwise having China's competitive market shares over those of Korea for other export sections. So, due to competitive market shares of commodity groups of China compared to those of Korea, most of China's export sections may have competition power over those of Korea in the U.S. market from 1998 to 2007.

Second, estimates of elasticity of substitution between both countries' exports in the U.S. market are small (inelastic). However, we find that at least 61 (apparel articles and accessories, knit or crochet), 62 (apparel articles and accessories, not knit etc) and 85 (electric machinery etc, sound equipments, TV equipment, parts) commodity groups' substitute elasticities are elastic and thus, have competition in the U.S. market compared with those of China. A small value of the elasticity of substitution may be due to an identification problem in a simple standard model as well as measurement errors in prices as a unit value in this study. So, in order to avoid these, we may need to use appropriate instrumental or proxy variables in the simple standard model, which are highly correlated with the independent (unit price) variables and are correlated with measurement error terms. In practice, it is not easy to find good instrumental variables (IVs). Economists often discuss this situation without being able to do much about it.

In general, wage per unit of output or labor per unit of output as an instrumental variable could be used in international trade. However, it may be difficult to use appropriate instrument variables in the international trade field due to a problem of obtaining data. Similarly, our study could not perform this due to difficulties in obtaining data.

Third, this study obtains small values of the elasticity of substitution of most commodity groups. For these small values, we get ranged values from a lower (minimum, 0.0568) value to

an upper (maximum, 2.3302) value of elasticity of substitution for a change in price ratios for both Korea's exports and China's exports over a change in ratios of export volumes of both countries in the U.S. market. Based on these results, we realize that, with the exception of 61, 62, and 85, it is difficult to discriminate the competition between Korea's and China's exports in the U.S. market due to very small values of the substitute elasticity. This implies that a change in ratios of export volumes between Korea's and China's export section over a change in ratios of price between both countries' is not sensitive and can be interpreted as saying that there is no competition of Korea's commodity groups against those of China in the U.S. market. This may be due to an identification problem and measurement errors of both a simple standard model and a modified model we used in this study. In order to avoid these problems it needs to obtain the best results by solving problems such as the identification problem and measurement errors, which reflect more accurate estimates for the elasticity of substitution between both countries' export section in the U.S. market.

Finally, this study has a main weakness. Exports are disaggregated at a 2-digit level of commodity groups. In fact, we need data at the 4-digit and 6-digit levels in HS to have more useful estimates and conclusions. Due to the lack of data, this study is unable to disaggregate commodity groups at the 4-digit and 6-digit levels. We need data at these levels for these types of analysis. The lack of data limits what we can analyze concerning the elasticity of substitution between Korea and China; we need the data with more disaggregated level in HS such as 4-digit and 6-digit levels to enable researchers to undertake a more satisfactory study of the elasticity of substitution between Korea and China.

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## Appendix A

**Table 2-1 Korea's Trade Flow with Partner Countries**

Rank	Countries	Korea's trade flows			
		Export	Import	Trade balance	Trade amount
1	China	59,778	35,161	24,617	94,939
2	Japan	18,325	40,890	-22,565	59,215
3	U.S.A	32,460	26,658	5,802	59,118
4	Saudi	1,886	14,898	-13,012	16,784
5	China (Hong Kong)	9,849	5,522	4,327	15,371
6	Germany	7,078	8,108	-1,030	15,186
7	Singapore	7,016	7,112	-96	14,128
8	Indonesia	4,547	7,571	-3,024	12,118
9	United Arab Emirates	2,463	9,267	-6,805	11,730
10	Austria	3,878	7,146	-3,267	11,024

Source: IMF (2006) ; (unit: million \$)

**Table 2-2 U.S. Imports from China and Korea, 1994-1998**

	1994	1995	1996	1997	1998	Annual growth rate
Total imports of the U.S.	6,637	7,435	7,913	8,702	9,139	9.5
Imports of goods from China	388(5.4)	456(6.1)	515(6.5)	626(7.2)	712(7.8)	12.9
Imports of goods from Korea	197(2.9)	242(3.3)	227(2.9)	232(2.7)	239(2.6)	6.9

Source: KITA (2001).

( ): The figures in parentheses indicate the ratio of U.S. imports from China and Korea to total imports of the U.S.

**Table 2-3 the Ratio of U.S. Imports from China and Korea to Total Imports for Selected Goods**

	Korea		China	
	1994	1998	1994	1998
Textile apparel & leather products	5.7	→ 5.9	15.3	→ 11.4
General machinery & equipment	3.0	→ 3.0	2.2	→ 4.9
Electronic components	7.6	→ 6.6	6.9	→ 10.0
Motor vehicles	1.7	→ 1.5	4.3	→ 9.5
Basic metal products	6.4	→ 5.5	5.3	→ 9.5
Dolls & other toys and sport	1.8	→ 1.7	46.4	→ 59.2

Source: KITA (2001).

**Table 2-4 Exports of Korea and China in the World Market, 1990-2000 (unit: \$100 million)**

Item \ year	1990	1991	1992	1997	1998	1999	2000	Average
Export of Korea	650	719	766	1362	1323	1437	1723	
(%) change	(4.23)	(10.54)	(6.63)	(4.97)	(2.83)	(8.60)	(19.89)	(10.01)
Export of China	621	719	849	1829	1836	1952	2493	
(%) change	(18.18)	(15.81)	(18.12)	(20.95)	(0.39)	(6.30)	(22.92)	(15.65)
World exports	34386	35303	37579	55229	54342	56098	62556	
Korea's export share as percentage of world exports	(1.89)	(2.04)	(2.04)	(2.47)	(2.43)	(2.56)	(2.75)	(2.32)
China's exports share as percentage of world exports	(1.81)	(2.04)	(2.26)	(3.31)	(3.38)	(3.48)	(3.99)	(2.84)

Source: IMF (2004), direction of trade statistics, each year.



**Table 2-5 Korea's and China's Trade Shares as a Percentage of the World's Exports**

Year	Korea		China	
	Export	Import	Export	Import
2000	2.7	2.4	3.4	3.4
2001	2.4	2.2	3.5	3.8
2002	2.5	2.3	3.9	4.4
2003	2.6	2.3	4.3	5.3
2004	2.8	2.4	6.5	5.9
2005	2.7	2.4	7.3	6.1

Source: KITA (2006) ; (unit: %)

**Table 2-6 Lists of Harmonized Commodity Description and Coding System (HS)**

2 Digit Code	Classified Commodity Groups
01-05	Animal & Animal Products
06-15	Vegetable Products
16-24	Foodstuffs
25-27	Mineral Products
28-38	Chemicals & Allied Industries
39-40	Plastics / Rubbers
41-43	Raw Hides, Skins, Leather, & Furs
44-49	Wood & Wood Products
50-63	Textiles
64-67	Footwear / Headgear
68-71	Stone / Glass
72-83	Metals
84-85	Machinery / Electrical
86-89	Transportation
90-97	Miscellaneous
98-99	Service

Source: KITA, <http://tse.export.gov>

**Table 2-7 2 Digit Commodity Groups Chosen for Analysis**

2 Digit Commodity Group	Commodity Contents
85 (Korea, China)	Electric Machinery etc; Sound Equip, TV Equip; PTS(parts)
97 (Korea )	Works of ART, Collectors Pieces and Antique
84 (Korea, China )	Nuclear Reactors, Boilers, Machinery etc.; Parts
27 (Korea , China)	Mineral Fuel, Oil etc; Bitumin Subst; Mineral Wax
61 (Korea)	Apparel Articles and Accessories, Knit or Crochet
73 (Korea)	Articles of Iron or Steel
62 (Korea)	Apparel Articles and Accessories, Not Knit etc
72 (Korea)	Iron and Steel
39 (Korea, China )	Plastics and Articles Thereof
40 (Korea)	Rubber and Articles thereof
98 (Korea, China)	Special Classification Provisions, Nesoi
90 (Korea, China)	Optic, Photo etc, Medic or Surgical Instruments etc
87 (China)	Vehicles, Except Railway or Tramway, and Parts etc
88 (China)	Aircraft, Spacecraft, and Parts Thereof
29 (China)	Organic Chemicals
71 (China)	Nat etc Pearls, Prec etc Stones, PR Met etc; Coin
30 (China)	Pharmaceutical Products
38 (China)	Miscellaneous Chemical Products

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**Table 2-8 Results of Unit Root Test for Each Unit Price Variable for Commodity Groups**

No Unit Root	Unit Root					
	CV	CUV	KUV	CV, KUV	CV, KV	CV, KV,KUV
38						
61						
62	29			39	73	
88	30	71	27	87	90	72
97	85	40				

Note: Unit root test model: Constant and trend

**Table 2-9 Elasticities of Substitution for Commodity Groups**

HS	Regression Results	P-value (ln(KUV/CUV))	R2	D.W
27	ln(KV/CV) = -0.0599 - <b>0.1832</b> ln(KUV/CUV) (-0.2199) <b>(-1.8139)*</b>	0.0741	0.05	1.33
29	ln(KV/CV) = 0.7310 - <b>0.5452</b> ln(KUV/CUV) (1.5388) <b>(-1.7990)*</b>	0.0766	0.05	1.10
30	ln(KV/CV) = -0.4676 + 0.7988 ln(KUV/CUV) (-3.6608) <b>(3.8351)***</b>	0.0003	0.05	1.33
38	ln(KV/CV) = -1.1211 + 0.0568 ln(KUV/CUV) (-6.4090) <b>(3.6999)***</b>	0.0003	0.10	0.61
61	ln(KV/CV) = 1.6745 - <b>1.2532</b> ln(KUV/CUV) (3.9883) <b>(-6.3273)***</b>	0.0000	0.25	0.20
62	ln(KV/CV) = 2.4738 - <b>2.3302</b> ln(KUV/CUV) (1.6856) <b>(-2.8682)***</b>	0.0005	0.07	0.09
71	ln(KV/CV) = 0.1281 - <b>0.1925</b> ln(KUV/CUV) (0.2226) <b>(-2.1806)**</b>	0.0331	0.07	0.52
85	ln(KV/CV) = -4.1248 + <b>1.9788</b> ln(KUV/CUV) (-3.1884) <b>(4.8692)***</b>	0.0000	0.24	1.98
88	ln(KV/CV) = 0.7129 + 0.2067 ln(KUV/CUV) (8.5836) <b>(2.0937)**</b>	0.0384	0.04	1.52
98	ln(KV/CV) = -2.9617 + 0.7007 KUV/CUV) (-14.5869) <b>(15.4606)***</b>	0.0000	0.67	1.57

Notes: 1) Asterisk (\*, \*\*, \*\*\*) means at a 10%, 5%, and 1% of significance level.

2) Parentheses ( ) are t-value.

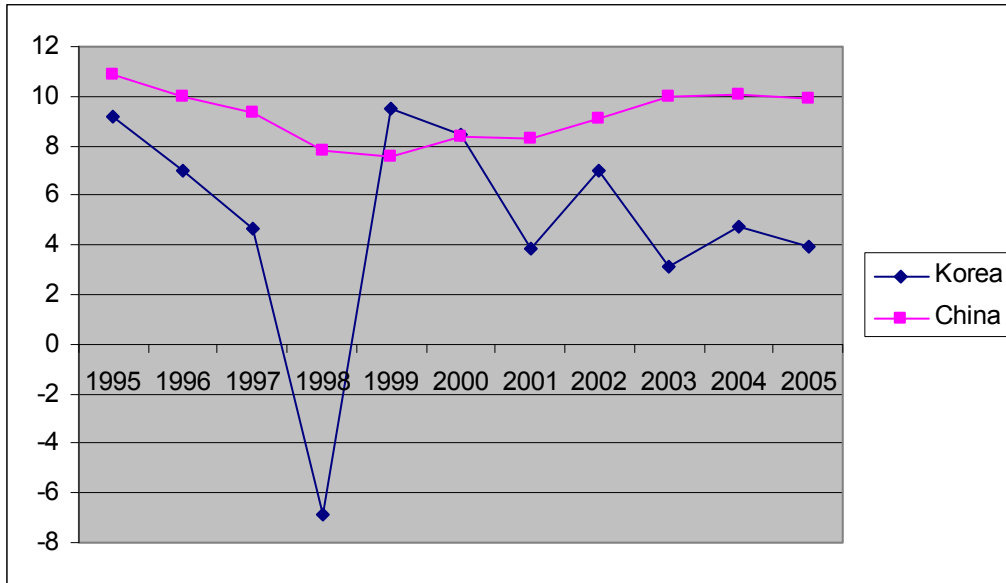
**Table 2-10 Newly Estimated Elasticities of Substitution for Commodity Groups**

HS	Regression Results	P-value (ln(KUV/CUV))	R <sup>2</sup>	D.W
27	ln(KV/CV) = -0.1366 - 0.2392 ln(KUV/CUV) + 0.1112 lnY (-0.2890) <b>(-1.3939)</b> (0.61254)	0.1717	0.07	1.67
29	ln(KV/CV) = 0.7658 - 0.4559 ln(KUV/CUV) - 0.1523 lnY (1.3232) <b>(-1.1995)</b> (-0.5551)	0.2380	0.06	1.01
30	ln(KV/CV) = -0.9912 + 0.8371 ln(KUV/CUV) - 0.4929 lnY (-4.3388) <b>(3.5328)***</b> <b>(-2.4252)**</b>	0.0011	0.30	2.61
38	ln(KV/CV) = -1.5787 + 0.3533 ln(KUV/CUV) - 0.0139 lnY (-5.7250) <b>(4.0952)***</b> (-0.2393)***	0.0001	0.20	0.66
61	ln(KV/CV) = 1.6792 - 1.2512 ln(KUV/CUV) - 0.1113 lnY (2.6465) <b>(-4.4746)***</b> (-0.8283)	0.0000	0.24	0.29
62	ln(KV/CV) = 2.0682 - 2.1824 ln(KUV/CUV) - 0.1723 lnY (0.9658) <b>(-1.8558)*</b> (-0.8975)	0.0679	0.06	0.10
71	ln(KV/CV) = -0.4548 - 0.1366 ln(KUV/CUV) - 0.2202 lnY (-0.6086) (-1.1814) <b>(-1.8258)*</b>	0.2445	0.11	0.19
85	ln(KV/CV) = -4.8432 + 2.1403 ln(KUV/CUV) - 0.1574 lnY (-2.5252) <b>(3.6549)***</b> (-0.6041)	0.0007	0.24	1.71
88	ln(KV/CV) = 0.6442 + 0.2766 ln(KUV/CUV) + 0.0329 lnY (3.8182) <b>(2.1343)**</b> (0.2496)	0.0365	0.07	1.82
98	ln(KV/CV) = -3.0700 + 0.6558 ln(KUV/CUV) - 0.1775 lnY (-11.0273) <b>(11.6361)***</b> (-1.5687)	0.0000	0.07	1.82

Notes: 1) Asterisk (\*, \*\*, \*\*\*) means at a 10%, 5%, and 1% of significance level.

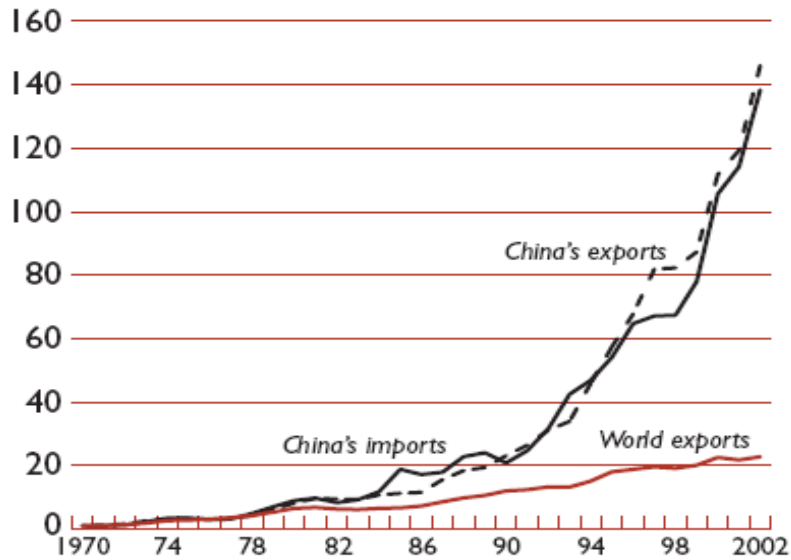
2) Parentheses ( ) are t-value.

**Figure 2-1 Economic Growth Rates of Both Countries**



Korea International Trade Association (KITA) (2007)

**Figure 2-2 Growth in Trade (Index, 1970=1)**

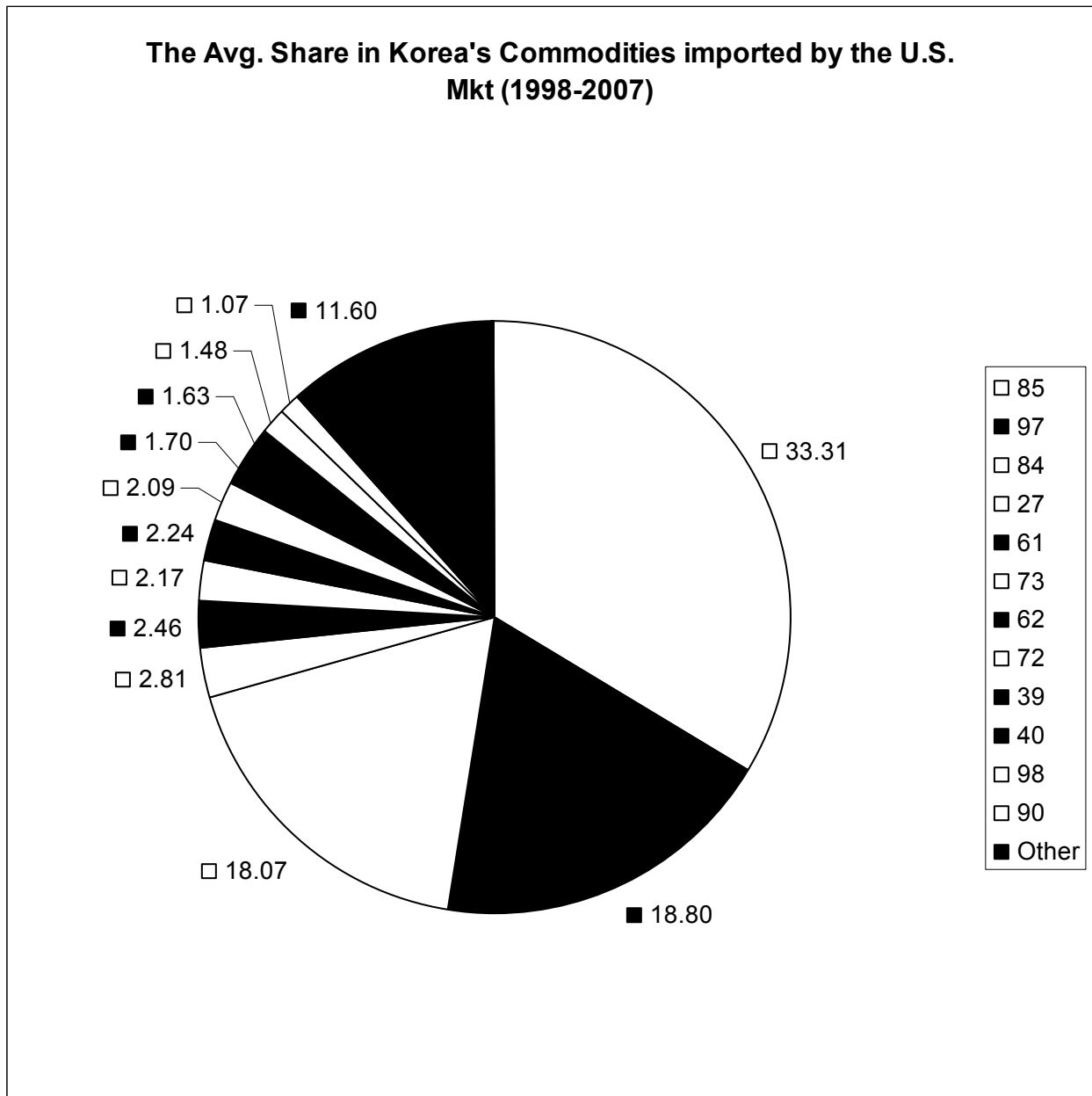


Source: IMF, *Direction of Trade Statistics*.

<sup>1</sup>Based on the value of merchandise exports (f.o.b.) and imports (c.i.f.) in U.S. dollar terms.

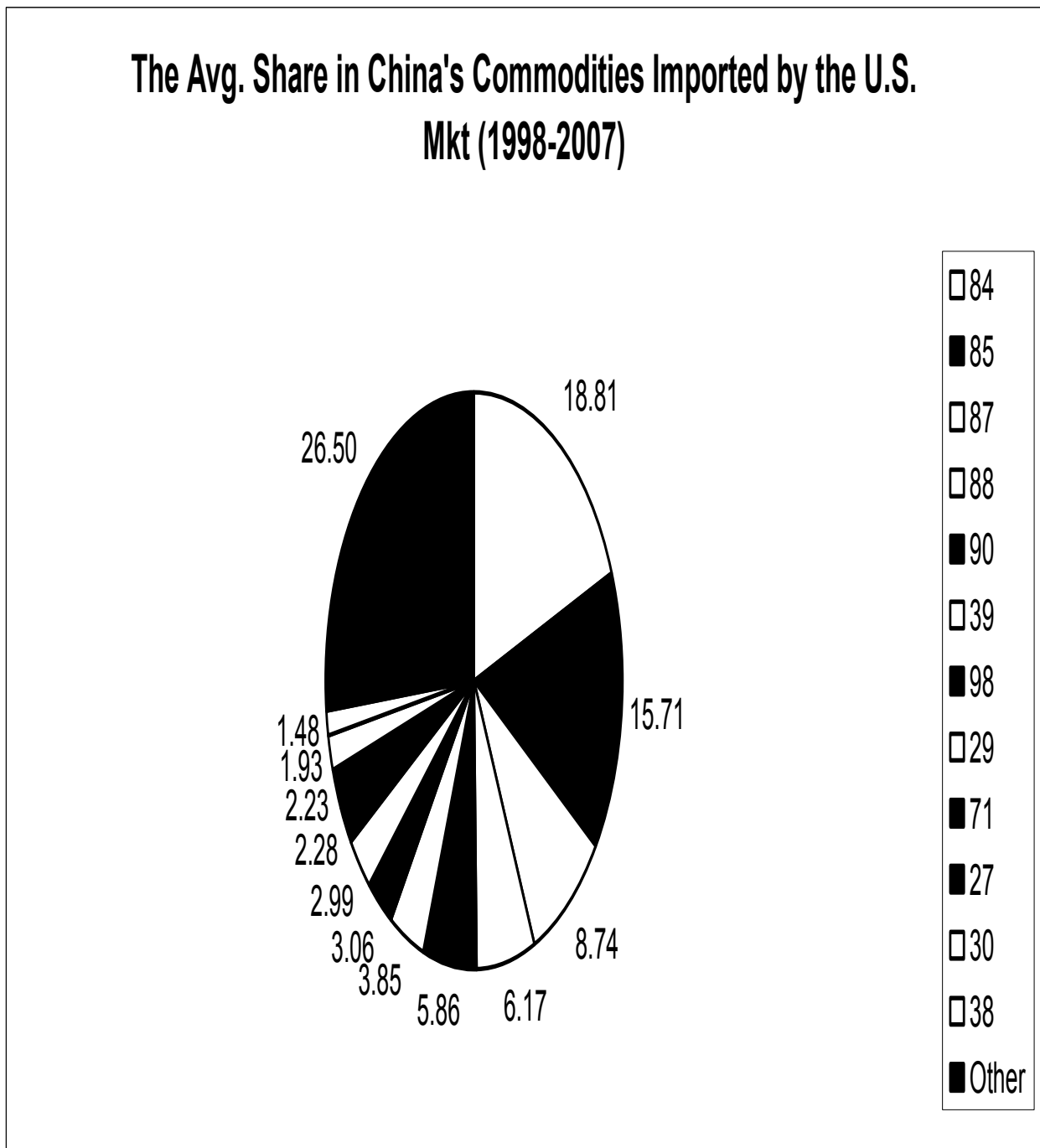
Source: "China's Growth and Integration into the World Economy: Prospects and Challenges," IMF, 2004.

**Figure 2-3 The Avg. Share in Korea's Commodities Imported by the U.S. Mkt (1988-2007)**



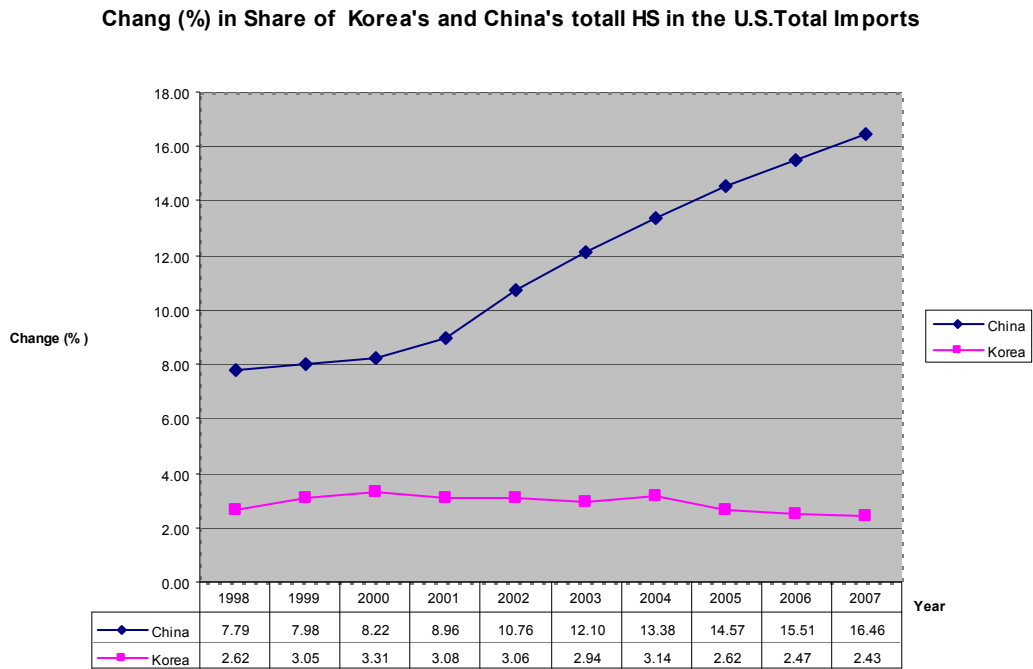
TradeStates Express™ Home, <http://tse.export.gov/>

Figure 2-4 The Avg. Share in China's Commodities Imported by the U.S. Mkt (1988-2007)

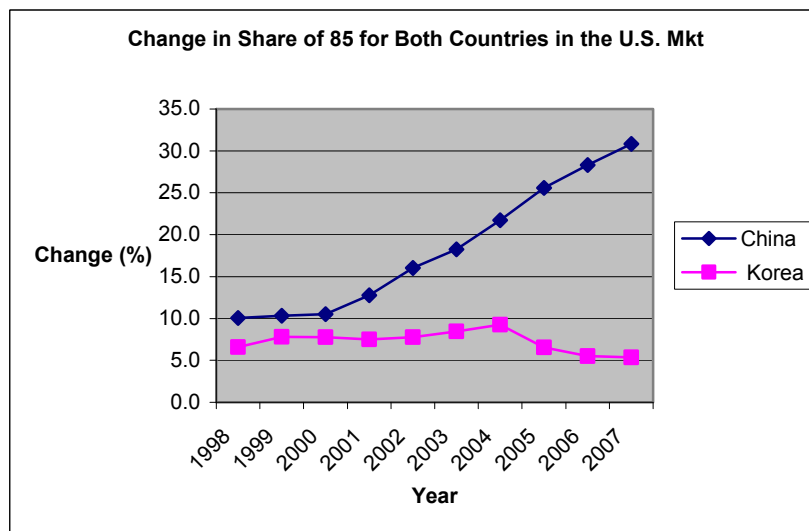


TradeStates Express™ Home, <http://tse.export.gov/>

**Figure 2-5 Change (%) in Share of Korea's and China's Total HS in the U.S. Total Imports**



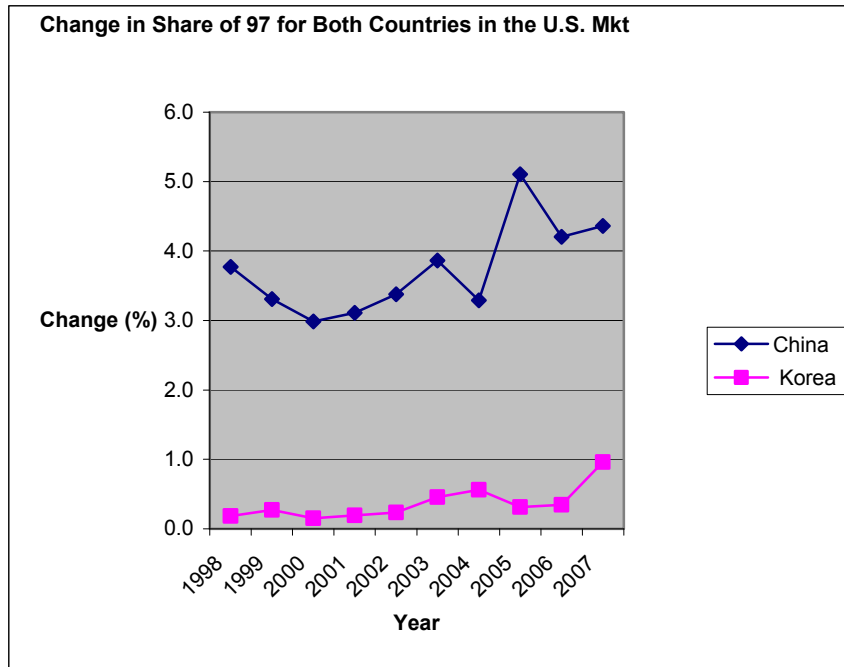
**Figure 2-6 Change in Share of 85 for Both Countries in the U.S. Mkt**



85: Electric Machinery, Sound Equip, TV Equip; PTS (parts)

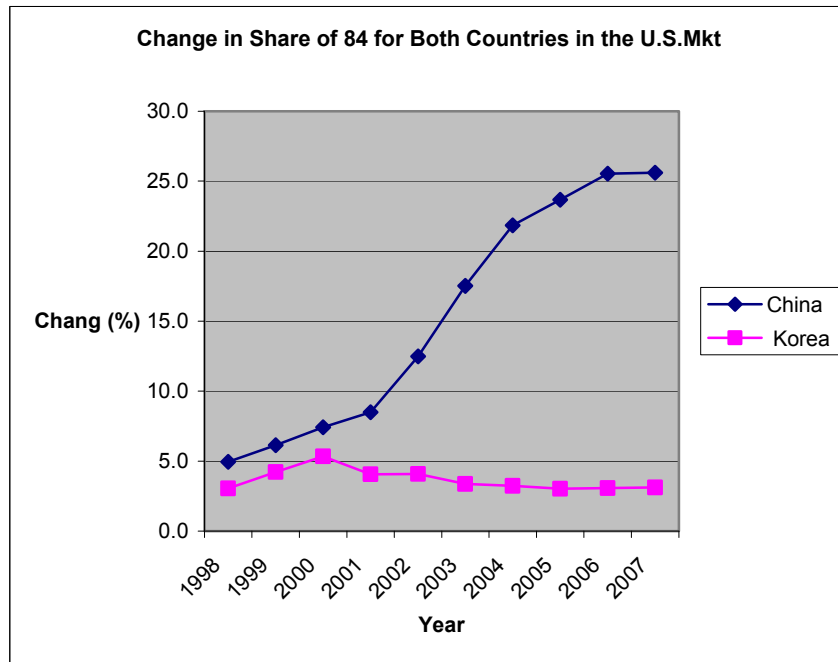


**Figure 2-7 Change in Share of 97 for Both Countries in the U.S. Mkt**



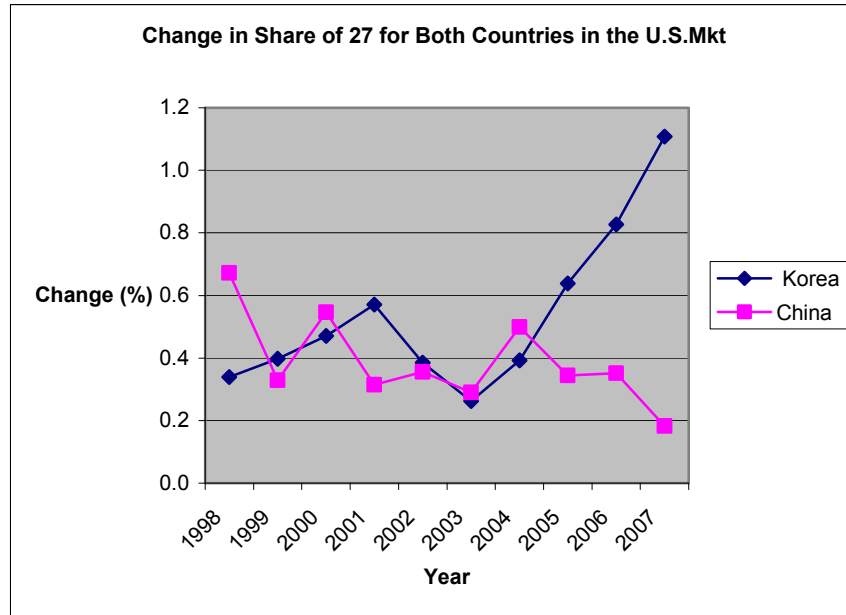
97: Works of ART, Collectors Pieces and Antique

**Figure 2-8 Change in Share of 84 for Both Countries in the U.S. Mkt**



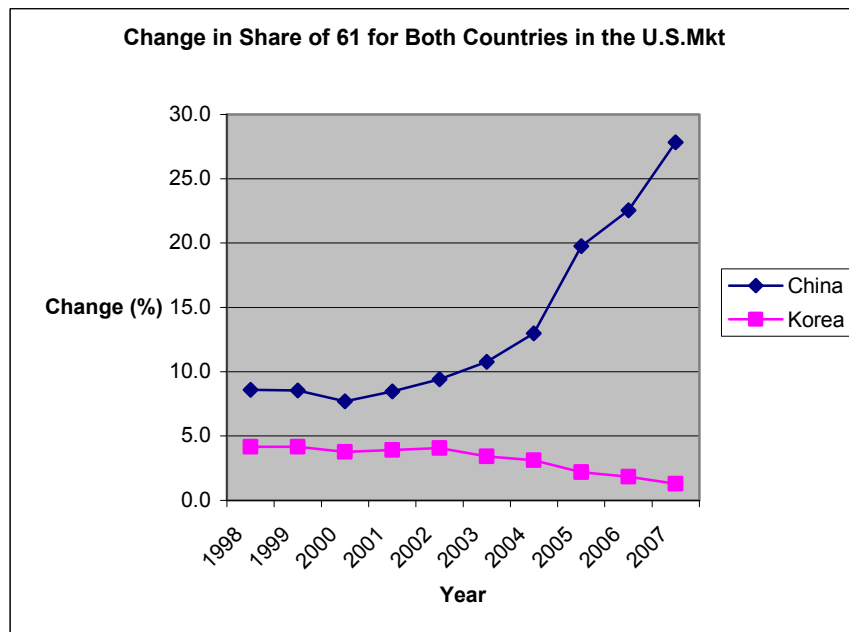
84: Nuclear Reactors, Boilers, Machinery etc, PTS

**Figure 2-9 Change in Share of 27 for Both Countries in the U.S. Mkt**



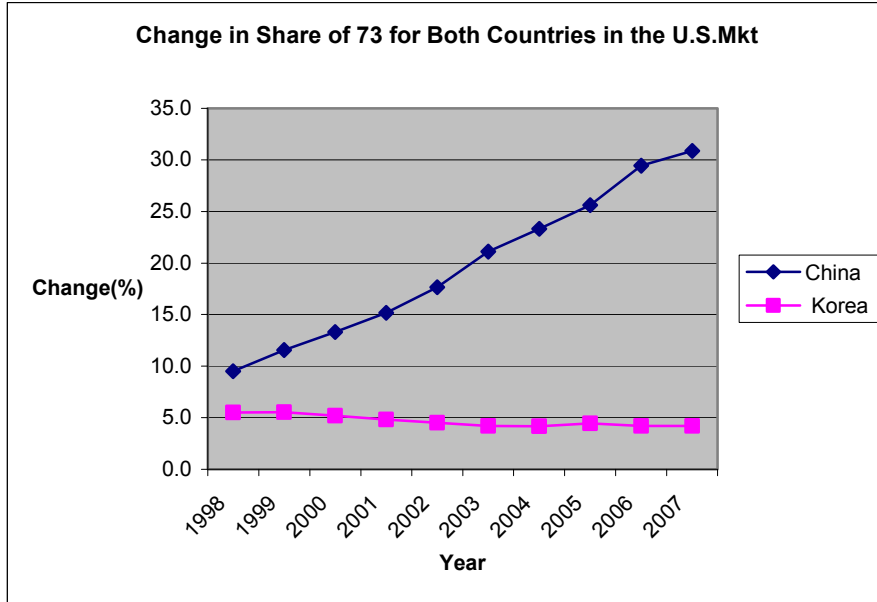
27: Mineral Fuel, Oil etc; Bitumin Subst; Mineral Wax

**Figure 2-10 Change in Share of 61 for Both Countries in the U.S. Mkt**



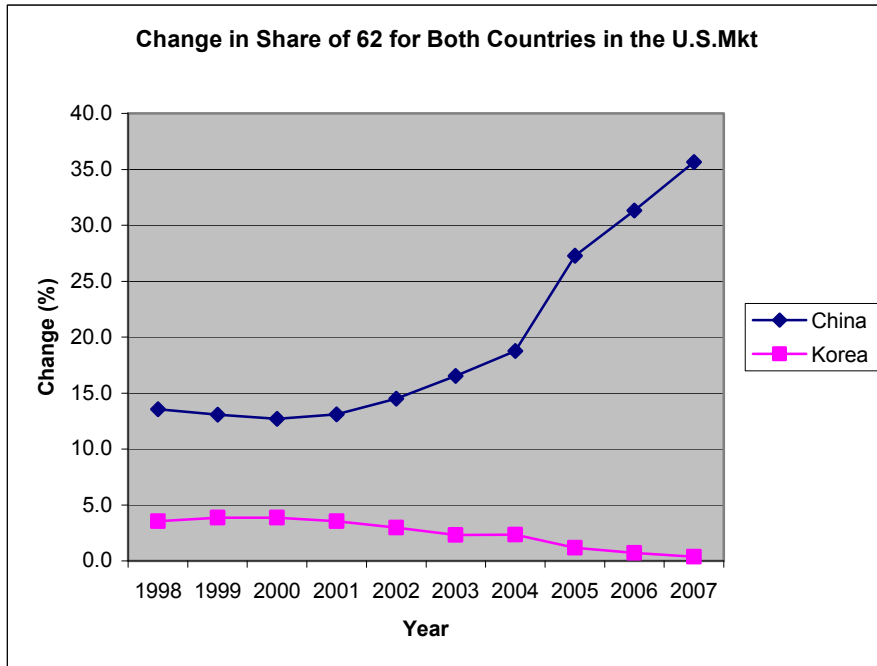
61: Apparel Articles and Accessories, Knit or Crochet

**Figure 2-11 Change in Share of 73 for Both Countries in the U.S. Mkt**



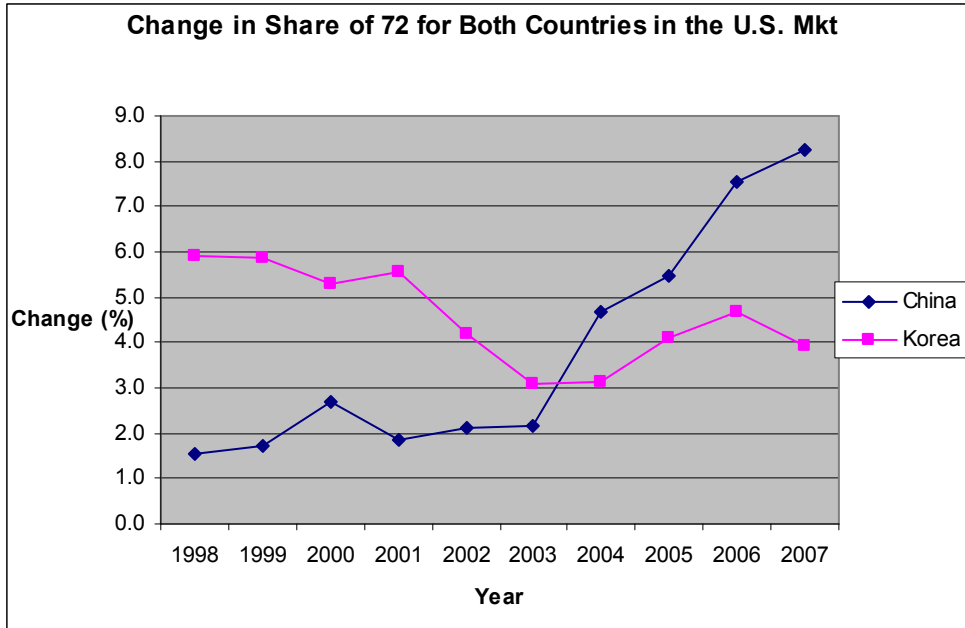
73: Articles of Iron or Steel

**Figure 2-12 Change in Share of 62 for Both Countries in the U.S. Mkt**



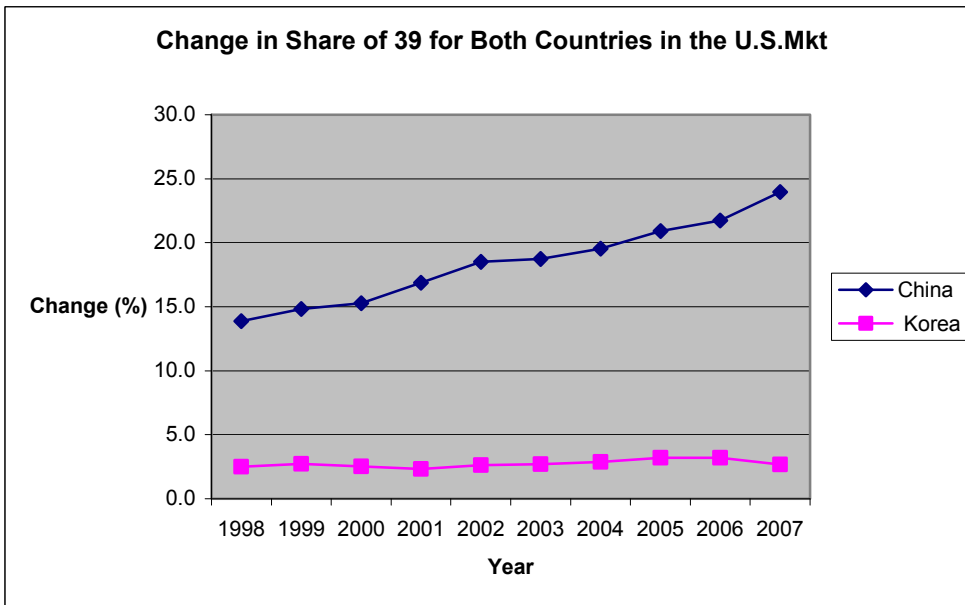
62: Apparel Articles and Accessories, Not Knit etc

**Figure 2-13 Change in Share of 72 for Both Countries in the U.S. Mkt**



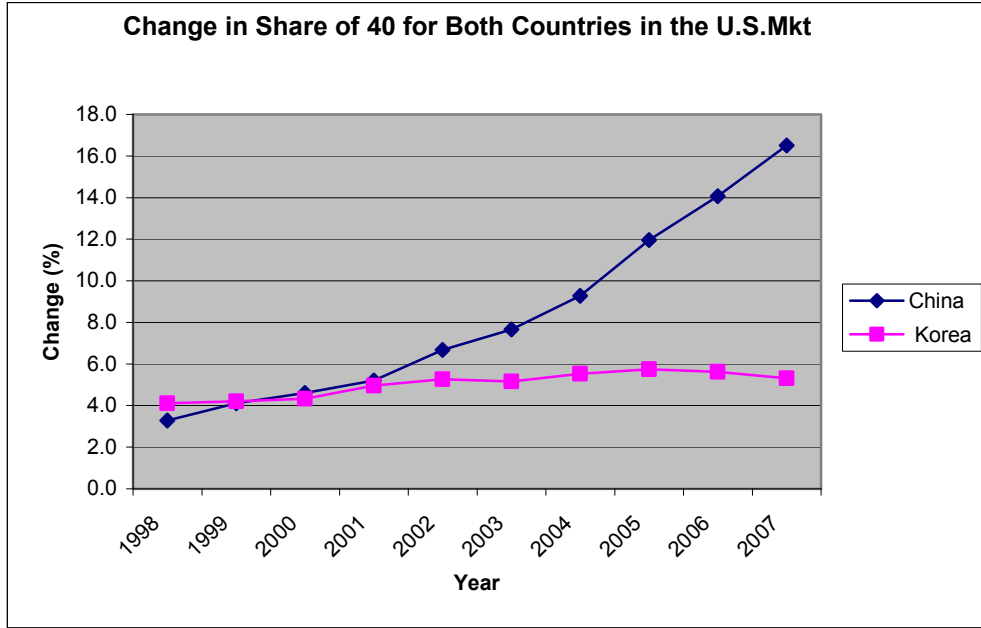
72: Iron and Steel

**Figure 2-14 Change in Share of 39 for Both Countries in the U.S. Mkt**



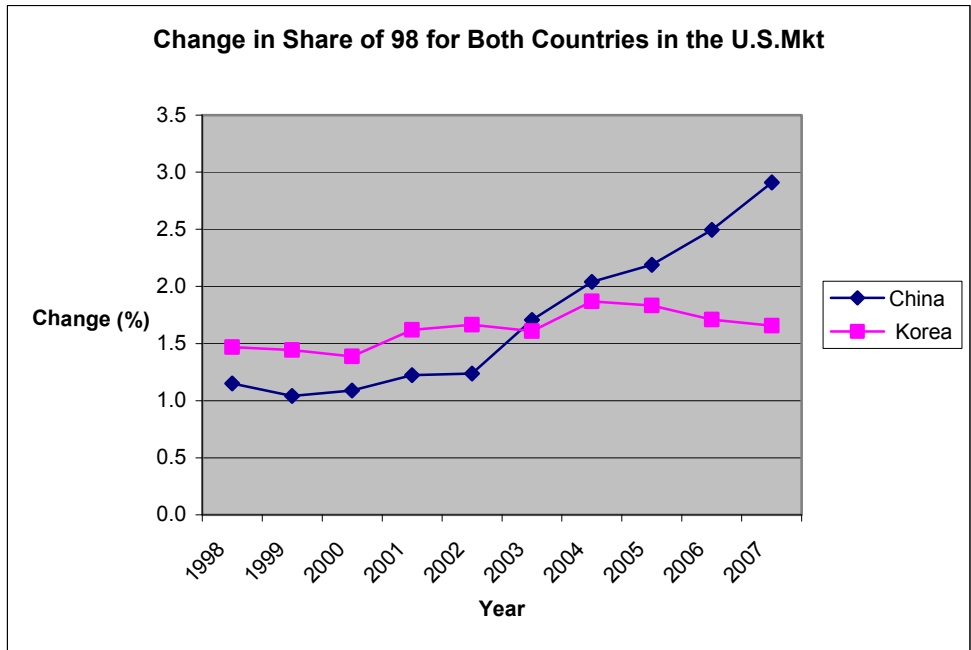
39: Plastics and Articles Thereof

**Figure 2-15 Change in Share of 40 for Both Countries in the U.S. Mkt**



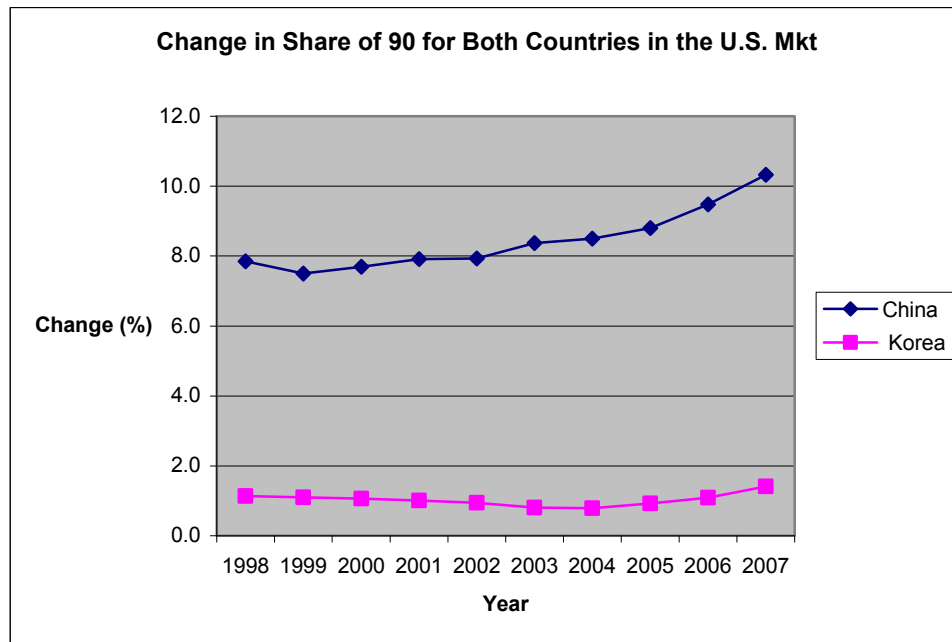
40: Rubber and Articles thereof

**Figure 2-16 Change in Share of 98 for Both Countries in the U.S. Mkt**



98: Special Classification Provisions, Nesoi

**Figure 2-17 Change in Share of 90 for Both Countries in the U.S. Mkt**



90: Optic, Photo etc, Medic or Tramway, and Parts etc

## Appendix B

Armington accounts for U (utility function)<sup>97</sup> with CES under such assumptions.

$$U = \left[ \sum_{i=1}^m \beta_i q_i^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} \quad (i=1, \dots, m) \quad (1)$$

Where  $\sum_i \beta_i = 1$  is used as a normalization,  $q_i$  is the imported good from the  $i$ th source (or market) and  $\alpha$  is constant for  $i$ th source.

How does the demander (importer) treat the demand equation function for imported goods? This question is an essential one given use of the Armington model. To address this problem, we use a utility maximization function subject to expenditure. For solving this problem, a method to find optimal solution is used as follows:

$$\text{Max } U = \left[ \sum_{i=1}^m \beta_i q_i^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} \quad (i=1, \dots, m) \quad (2)$$

Subject to

$$E = \sum_{i=1}^m p_i q_i, \quad (\alpha \neq 1, \quad \sum_i \beta_i = 1, \quad \beta_i \in [0,1] \quad \text{all } i) \quad (3)$$

Where, E = total expenditure on imports in a importer (or a importing country)

$U$ = utility (the demand side of domestic country)

$p_i$ =the price of imported good from source  $i$

$q_i$  = the quantity of imports from source  $i$  (the supply side of foreign countries)

$\beta_i$ = the parameter that gives the weight associated with particular good

$\alpha$  = the elasticity of substitution between the source of imports

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<sup>97</sup> This study uses utility's form and features as same as that of Pishbahar and Huchet-Bourdon (2007).

So, under these conditions, using equation (2) and (3) demand function for  $q_i$ , leads to the equation (4). That is, if the equation (2) is maximized subject to equation (3) it comes out to equation (4).

$$q_i = \left(\frac{1}{p}\right) \left(\frac{p_i}{p}\right)^{1-\alpha} \beta_i^\alpha E \quad \text{where } p = \sum_i (\beta_i^\alpha p_i^{1-\alpha})^{\frac{1}{1-\alpha}} \quad (4)$$

When equation (4) is changed to simplify, the value (equation (5)), and ratio forms (equation (6)) are found.

$$p_i q_i = \beta_i^\alpha E \left(\frac{p_i}{p}\right)^{1-\alpha} \quad (5)$$

These equations are called ‘‘Armington equations’’ (equations (4) and (5)). In particular, here  $\alpha$  is constant in these equations for all import sources.

Finally, to calculate the elasticity of substitution ( $\alpha$ ) between the sources of import, equation (5) can be written into equation (6) by using logarithm form.

$$\ln(p_i q_i) = \alpha \ln(\beta_i) + (1 - \alpha) \ln\left(\frac{p_i}{p}\right) + \ln(E) \quad (6)$$

Equation (7) is the ratio of form. Equation (8) is modified by using logarithm form into the equation (7).

$$\frac{q_i}{q_j} = \left(\frac{\beta_i}{\beta_j}\right)^\alpha \left(\frac{p_i}{p_j}\right)^{-\alpha} \quad (7)$$

$$\ln\left(\frac{q_i}{q_j}\right) = \alpha \ln\left(\frac{\beta_i}{\beta_j}\right) + (-\alpha) \ln\left(\frac{p_i}{p_j}\right) + \ln(E) \quad (8)$$



Derivation of Armington Equations by Using Homothetic-CES Utility Function:

$$\text{Max } U = \left[ \beta_1 q_1^{\frac{\alpha-1}{\alpha}} + \beta_2 q_2^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}}$$

Subject to,

$$E = p_1 q_1 + p_2 q_2$$

Lagrange Equation Form:

$$L = \left[ \beta_1 q_1^{\frac{\alpha-1}{\alpha}} + \beta_2 q_2^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} + \lambda [E - p_1 q_1 - p_2 q_2]$$

F.O.C :

$$\frac{\partial L}{\partial q_1} = \beta_1 \left[ \frac{\alpha-1}{\alpha} \right] q_1^{\frac{\alpha-1}{\alpha}-1} \left[ \beta_1 q_1^{\frac{\alpha-1}{\alpha}} + \beta_2 q_2^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}-1} - \lambda p_1 = 0$$

$$\frac{\partial L}{\partial q_2} = \beta_2 \left[ \frac{\alpha-1}{\alpha} \right] q_2^{\frac{\alpha-1}{\alpha}-1} \left[ \beta_1 q_1^{\frac{\alpha-1}{\alpha}} + \beta_2 q_2^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}-1} - \lambda p_2 = 0$$

$$\frac{p_2}{p_1} = \frac{\beta_2 q_2^{\frac{\alpha-1}{\alpha}}}{\beta_1 q_1^{\frac{\alpha-1}{\alpha}}} \quad \text{is changed into } q_2 = \left[ \frac{\beta_2}{\beta_1} \right]^{\alpha} \left[ \frac{p_2}{p_1} \right]^{-\alpha} q_1$$

$$\begin{aligned}
E &= p_1 q_1 + p_2 q_2 = p_1 q_1 + p_2 q_1 \left[ \frac{\beta_2}{\beta_1} \right]^\alpha \left[ \frac{p_2}{p_1} \right]^{-\alpha} \\
&= p_1 q_1 \left[ 1 + \left[ \frac{\beta_2}{\beta_1} \right]^\alpha \left[ \frac{p_2}{p_1} \right]^{-\alpha} \right] \\
&= p_1 q_1 \left[ \frac{\beta_1^\alpha p_1^{1-\alpha} + \beta_2^\alpha p_2^{1-\alpha}}{\beta_1^\alpha p_1^{1-\alpha}} \right] \\
&= p_1 q_1 \left[ \frac{p^{1-\alpha}}{\beta_1^\alpha p_1^{1-\alpha}} \right]
\end{aligned}$$

Where,  $P^{1-\alpha} = \beta_1^\alpha p_1^{1-\alpha} + \beta_2^\alpha p_2^{1-\alpha}$

Thus,

Armington Equations:

$$p_1 q_1 = E \left[ \frac{\beta_1^\alpha p^{1-\alpha}}{p^{1-\alpha}} \right] \quad \text{Or} \quad q_1 = E \left[ \frac{\beta_1^\alpha p^{1-\alpha}}{p^{1-\alpha}} \right] \left[ \frac{1}{p_1} \right]$$

# **ESSAY 3 - The Recent Behavior of Korea's Export Demand Function by using the Bounds Testing Approach**

## **I. Introduction**

In general, economists in growth and international fields agree that a country's export is vital to perform its economic growth and development because export role usually leads to an increase in output by various pathways, such as expanding knowledge and innovation technology, proffering economies of scale, and navigating toward measure of trade liberalization.

Export is mainly determined by an exchange rate as a ratio of the relative price of goods and income of the foreign country<sup>98</sup>. If we know the movement of change in the exchange rate and foreign income in international trade, we can promptly treat issues such as trade policy and balance of payments in a country. In order to control these issues, economists in international fields usually use the export demand function to measure income and price elasticities.

Specifically, the export demand elasticities are used to represent the extent of demand change on changes in income and price. For example, when income elasticity of export demand is higher, increasing exports can play the role as a catalyst for economic growth<sup>99</sup>. For instance, in order to reach its appropriate economic growth, an export country would need to watch out to change the import country's income to cope with an immediate change in the international trade environment (compared with other factors such as the exchange rate) because a country's exports are principally dependent upon income.

In addition, the competition of export products of a specific country is higher in the international market when the price elasticity is higher. Thus, since the exchange rate and income of foreign countries can play a vital role in determining an increase or decrease of a country's exports, it seems that export performance in a country like Korea, which depends on significant trade to improve its economic growth, is influenced mainly by changes in the exchange rate and foreign countries' income.

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<sup>98</sup> Exports can be fixed by the exchange rate and foreign demand (abroad income). Economic growth of countries with a high degree of dependence on foreign trade relies significantly on exports. Economic growth in such countries are mainly controlled by abroad income (abroad economic growth) and exchange rate.

<sup>99</sup> A variable with high elasticity in a demand model means it has more explanation power to changes in demand. High income elasticity in an export demand model mean that changes in income induces a significant (high) change in export demand.

Recently the rate of increase in Korea's exports has increased significantly since 2000 despite its slow economic growth rate. For instance, the average rate of Korea's export growth was 8.7% in the 1990s, but increased to a rate of 12.4% from 2000 to 2006. The percentage rate of increase of exports raised two digits consecutively since 2003. This was caused by the world economic boom, which has stimulated an increase of Korea's exports in the past few years<sup>100</sup>. Remarkably, there has also been an increase in exports despite the appreciated Korean currency, sluggish investment in the Korean economy, and high oil prices in several years<sup>101</sup>. Specifically, there has been an increase in Korea's exports since its exporters have moved toward diversifying export markets in response to the high world economic growth. In the past, Korea's exports principally relied on developed countries such as the U.S.A. and Japan, but in recent years Korea has been increasing its dependence on other developing countries, such as the Association of South-East Asian Nations (ASEAN) and BRICs<sup>102</sup> to prevent a decrease of its exports from the developed countries' economic recession and to make risk hedge of exports.

According to the Lucky Goldstar Economic Research Institute (LGER)(2007)'s Korea report, the analysis of change in export price by change in exchange rate has illustrated a relative gradual decrease in the explaining power of exchange rate (the Korean currency relative to the U.S. dollar) in an export demand equation<sup>103</sup> by using recent sample observations. Accordingly, the Korean currency has been continuously depreciating since the economic crisis in 1997 but has appreciated<sup>104</sup> from March 2002 to 2007 immediately after the Information Technology (IT) bubble burst in 2002.

In recent years, an increase in Korean exports has not been caused by the exchange rate but by foreign country demand (income), especially developing countries, including BRICs, which have led world economic growth for several years<sup>105</sup>. So, the income factor rather than price (exchange rate) has led to an increase of Korea's exports in recent years. Therefore, this

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<sup>100</sup> According to the International Monetary Fund (IMF), there was an average world economic growth rate of 3.3% in the 1980s and 1990s. Since 2003, the world economic growth rate has increased to an average rate of 5% since 2003.

<sup>101</sup> The increase in oil price is due to the Iraq War, BRIC's high demand of oil, oil speculation, and so on.

<sup>102</sup> BRICs stands for Brazil, Russia, India and China. This word is used finically by Goldman Sachs Group in 2003.

<sup>103</sup> Explained power of exchange rate from estimating an export price equation are -0.662 from 1980:01 to 1989:12, -0.896 from 1990:01 to 1997:12, -0.337 from 1998:01 to 2001:12, -0.377 from 2002:01 to 2007:07, respectively.

<sup>104</sup> Exchange rate (currency of Korea to the U.S. dollar) appreciated by 30.9% in 2006 compared with that in 2002. Currency of Korea to Japan in dollar appreciated by 21%.

<sup>105</sup> An increase in investment and production in these developing countries is evident after the 1990s. For instance, an increase in China's economic growth has been an average rate of about 9-10 % since the early 1990s.

study will estimate the demand function of the Korean exports by using recent sample observations and will then compare income elasticity with price elasticity to see which factor, export or income in Korea's export demand function, has a greater impact (shock) on changes to Korea's exports.

To this end, we will use an econometric methodology of Autogressive Distributed Lag (ARDL); a bounds testing approach to detect long run relationships in variables. By using this method, we will investigate whether a long-run relationship exists among variables and will then find short-run elasticities by using an error correction model if cointegration exists in variables.

In addition, by using the Cumulative Sum (CUSUM) and the Cumulative Sum of Squares (CUSUMSQ) tests, this study will observe whether changes in the structure of Korea's export demand exist or not, and we will add a dummy variable into this export demand model in order to reflect an economic crisis in Korea in 1997 (which may possibly affect the structural change in export demand).

Finally, the organization of this study will be as follows. Section II will review the literature. Section III will provide the framework for the demand function of exports. Section IV will state the results of estimation and the last section, V, will be a summary and conclusions.

## **II. Recent Performance of the Korean exports**

### **1. Exports**

Figure 3-1 shows the change in growth rate of Korea's GDP from 1970 to 2005. Remarkably, the growth rate of Korea's GDP has slowed down since the economic crisis in 1997. Its average growth had continued to decrease from the 1980s and 1990s after its highest growth rate of 11.3% in the 1970s. Specifically, the growth rate of Korea's GDP between 2000 and 2005 fell to an average of 5.8% per year, which indicates that the potential growth of Korea's GDP has weakened. Some Korean economists are concerned about the slowing growth rate because it may portend a slump in the near future.

(Insert)[Figure3-1]

Specifically, Korea's export growth has increased at a double-digit percentage rate since 2003 due to a strong demand for Korean exports in high technology sectors, such as Information Technology (IT) by developing countries as China<sup>106</sup>. These changes have taken place even though there have been appreciating exchange rate of the Korean currency relative to the U.S. dollar, and sluggish domestic demand<sup>107</sup>.

Figure 3-2 reports changes in Korea's exports from 1950 to 2005. The amount of Korea's exports has been increasing since 1950. Recent exports have increased at a double-digit rate since the mid 1980s. Korea's exports reached \$326.0 billion in 2006 (from 150.0 billion in 1996) and Korea has become one of the eleven few countries that attained \$300.0 billion in several countries<sup>108</sup>. Also, an annual average rate of export growth from 2002 to 2006 is 19.3%<sup>109</sup>.

(Insert)[Figure 3-2]

Although there have been surging oil prices and appreciating exchange rates since 2002, the robust export performance of Korea in 2007 (export total amount: 371.5 billion and growth of exports: 14.2%) is comparable to that of the mid-1980s. In the mid-1980s, the Korean economy had advantages from a low interest rate, low oil price, and strong U.S. dollar and Japanese Yen<sup>110</sup> relative to the Korean currency.

Meanwhile, figure 3-3 shows changes in the percentage ratio of exports to GDP. The percentage ratio of exports to the real GDP increased from 29.3% in 1997 to 54.1% in the first quarter of 2004 (Samsung Economic Research Institute, 2004). This percentage export ratio to

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<sup>106</sup> For instance, an average rate of Korea's exports was 8.7% in the 1990s, but increased to a rate of 12.4% from 2000 to 2006.

<sup>107</sup> Although the exchange rate has appreciated and price competition of Korea's exports in product markets is lower, the export boom of Korea has been continuing since 2003. Accordingly, this growth pattern has caused imbalances between service and manufacturing sectors, between small and large firms, and between export and non-export firms. Therefore, there has been an increase in income inequality and aggravating structural weaknesses. Due to these patterns, there is concern that the potential growth of Korea is declining.

<sup>108</sup> Korea's major export commodities are telecommunications, sound recording, office machinery, electronics and electrical machinery, semiconductors, appliances, ships, motor vehicles, and other transport equipment. Chemicals, textiles, iron, and steel are other major export categories. Electronic exports of Korea occupied 40% of the total exports in 2006. Specifically, flash memory products of Korea hold 60% of the share of global sales.

<sup>109</sup> In the same period, an average rate of world's export increment is 16.3%.

<sup>110</sup> Most products between Korea and Japan are competitive in foreign markets and changes in exchange rate between both countries significantly impact the profit of exporters in both countries.

GDP has been steadily augmented since the performance of Korea's export-driving policy in the early 1960s<sup>111</sup>.

(Insert)[Figure 3-3]

## 2. Trade Destination

Figure 3-4 shows the destination of Korea's exports. The composition of Korea's export market shares has changed dramatically. Figure 3-4 shows that Korea's exports to developed countries have declined over time while its exports have increased in developing countries. Specifically, Korea's exports to developed countries have decreased from 74.6% in 1970 to 39.4% in January-November of 2007 (Samsung Economic Research Institute) while its exports to developing countries increased from 25.4% in 1970 to 60% in 2007.

(Insert)[Figure 3-4]

Specifically, Korea's exports to China have increased from a share of about 0% in 1970<sup>112</sup> to 22.1% in 2007 while Korea's export share to the U.S. and Japan have gradually decreased. In recent years, Korea has experienced rapid trade growth with China. Korea's export goods and services to China were valued at \$18.4 billion in 2000 and \$61.9 billion in 2005. Korea is now the second-largest exporter to China while China is the most important export destination for Korea. A significant part of exports from Korea to China consists of capital goods and industrial supplies which are provided for many Korean firms located in China. Meanwhile, Japan also imported many goods from Korea. Korea's exports to Japan have steadily increased from \$31.8 billion in 2000 to \$48.4 billion in 2005<sup>113</sup>. In addition, Korea's exports to the U.S. have increased very little from \$37.6 billion in 2000 to \$41.3 billion in 2005.

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<sup>111</sup> Also, since the 1970s, its ratio of imports to GDP has increased when exports is enlarged.

<sup>112</sup> Official foreign relationship between Korea and China did not exist in 1970s. Formal relationship between both opened in 1992.

<sup>113</sup> Korea's imports from China have grown rapidly from \$12.8 billion in 2000 to \$38.6 billion in 2005.

### 3. Exchange Rate

Although the Korean currency has appreciated more than any other currency in Asia<sup>114</sup> since 2004, Korea's export growth has been in a two-digit percentage increase. According to the bank of Korea (2006), the exchange rate of the Korean currency to the U.S. dollar has steadily fallen since 2002.

Figure 3-5 shows the movement of exchange rate between the Korean currency and the U.S. dollar in the past several years. The drop of the Korean currency (Won) price<sup>115</sup> to the U.S. dollar has been accelerating since 2004. In the first quarter of 2005, Won/\$ fell 12.7% while the export price rose 9.0% and this stimulated a decrease of profits of exporters in Korea who suffered from losses from the falling exchange rate and increasing export prices. The percentage rate of cumulative appreciation of the Korean currency against the U.S. dollar jumped from 12% on December 2004 to 29% on December 2006.

(Insert)[Figure 3-5]

In the past, Korea's exports were very sensitive to exchange rates due to export-driving policies for economic growth. However, in recent years, Korea's exports have not been significantly influenced by the change in the exchange rate as export growth rate has been raised by two digits driving world economic boom within the past few years. This may imply that Korea's export products may have become more competitive as a result of other factors such as design and quality of export goods or the income factor has mainly affect Korea's export growth in recent years, or both.

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<sup>114</sup> The Bush Administration keeps a weak-dollar policy to recover twin deficits.

<sup>115</sup> This means appreciated Korean currency to the U.S. dollar.



### **III. Reviews**

#### **1. Previous studies**

Most previous empirical studies have focused on subjects for time series behavior of export and import goods' quantities and prices. Algiers (2004) describes features of previous studies. For instance, he refers to Prais (1962), who investigated and assessed early estimations of income and price elasticities, Taplin (1973), who searched early world trade models, and Deardoff and Stern (1976), who estimated the price and income elasticities by using the multi-country model. According to Algiers, studies on trade models by Goldstein and Kan (1985), Urbain (1995), Sendhadji and Montenegro (1999), and Neilsen (2001) have received special attention. These main debates demonstrate how the time series behavior of exports and imports should be modeled and how these exports and imports affect the trade model in a given country's international trade. For example, their main subjects are as follows: whether data are annually or quarterly, whether export or import goods are aggregated or disaggregated, whether goods are homogenous or differentiated, and whether export or import goods are a factor of production or final good. After that, the effects of trade are investigated. Algiers (2004) asserts that a slew of literatures have estimated the income and price elasticities in international trade. Most literatures mainly focus on Europe and the U.S. Most econometric estimations have price elasticities ranging from 0 to -4.0 while income elasticities range from 0.17 to 4.5.

There have also been many empirical studies on Korea's export and import demand. However, most previous studies have doubtful results due to the absence of recent time series techniques. For instance, these studies did not consider checking possible non-stationarity of variables to estimate the demand or export demand. Nelson and Plosser (1982) demonstrated that most macro economic variables have been non-stationarity with the exception of the unemployment rate in the U.S. Thus, in recent years, many Korean researchers have tried to use the stationary test for variables to estimate any model and have shown that Korea's case for most macro economic variables follow the same tendency as those of other countries or the U.S.

A representative study of previous work on Korea's export demand model is Yoo's (1995) "Export Demand Function: Comparison between Export Unit Price and Export Price by

Using Engle-Granger Cointegration Test and Use of Efficient Cointegration.”<sup>116</sup> According to Yoo’s study, when based on export unit price, the income elasticity estimate is 3.782 (3.395 when a detrend term is included in the model) and the price elasticity estimate is -0.569 (-0.450 when a detrend term is included in the model). But when based on export price, these give an income elasticity of 4.091 (4.513 when a detrend is included in the model) and a price elasticity of -1.686 (-1.731 when a detrend is included in the model), respectively. Thus, he finds that there are differences between elasticities and which elasticities, based on export price, are larger than those based on export unit price. Using different variables, such as export unit price and export price, into the model may cause this. When based on export price, he also estimates elasticities of income and price by using the Fully Modified (FM) estimator of Phillips and Hansen (1990) and Stock and Watson’s (SW) dynamic OLS technique to avoid a bias problem<sup>117</sup> arising when a small sample is applied to Engle-Granger cointegration. In this case, the income elasticity of FM is 4.091 (4.513 when a detrend term is included) and that of SW is 3.675 (3.966 when a detrend is included). This price elasticity of FM is -1.686 (-1.758 when a detrend term is included), which does not have a big difference when compared with that of Engle and Granger, while that of SW is -1.664 (-1.731 when a detrend term is included), which is larger than that of Engle-Granger. Using an inadequate variable used by the export demand may cause this. Therefore, he suggests that one should be careful in selecting estimation methods to estimate the elasticity of income and price since different methods can lead to different results of the elasticity of income and price.

## **2. Theoretical Framework of Export Determinants**

A basic export model to determine export price and quantity has been provided by Goldstein and Kan (1978, 1985). This export model is an imperfect substitution model and includes export supply side. Many international economists often use this export model to investigate trade performance of a country or the world. An export equation in their model assumes imperfect substitution because export goods in a country can not be completely substituted for foreign goods in export markets since an individual country uses different factor, such as skills and design, to manufacture the same products.

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<sup>116</sup> The efficient cointegration test used by him is a full-modified estimator of Phillips and Hansen (1991) and Stock and Watson’s dynamic OLS. He uses monthly data for his study.

<sup>117</sup> This problem is the degree of freedom.

The imperfect substitution model for exports in a country is derived from equations of export demand and export supply. For instance, according to Goldstein and Kan, export demand of a country and its export supply are represented simply as follows:

$$\text{Export Demand: } M = \alpha_0 - \alpha_1 \left( \frac{P^M}{P^F} \right) + \alpha_2 \text{FI} \quad (1)$$

$$\text{Export Supply: } M = \beta_0 + \beta_1 \left( \frac{P^M}{P^D} \right) + \beta_2 Z \quad (2)$$

Here,  $M$  is the quantity of exports;  $P^M$  is export price (unit price of exports) expressed in foreign currency;  $P^F$  is price of competing goods (world price level) in the import markets (world market) expressed in foreign currency<sup>118</sup>;  $P^D$  is  $(=P^D/e)$ , price of exportable goods in the domestic market expressed in local currency,  $e$  is the nominal exchange rate (local currency per a unit of foreign currency);  $Z$  is domestic production capacity in the tradable sector;  $\text{FI}$  is real income (world real income) in importing countries (the world).

The relative price between exports and competitive goods in the export demand model (1) is a negative sign since exports and competitive goods' prices have an inverse relationship to the demand of the import markets. With all other things equal, the export demand increases if relative price decreases; this means a decrease of the price of exports against a rise of the price of competing goods in import markets. In the export supply equation (2), the firms' decisions of goods exports for foreign markets relies heavily on the relative profit between goods exports and domestic goods sales from firms' production capacity. Thus, the profit of domestic goods sales can be calculated by the price of exportable goods due to the closeness between exportable goods and domestic goods. If the price of exportable goods in the domestic market increases, the supply of exports in firms falls (with other things being equal). This is due to the possibility of more profits in the domestic market. Adversely, the supply of exports increases if export prices and the production capacity of firms increase.

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<sup>118</sup> In general, this competing price is measured by the weighted average of trading partners' export prices in an export country.

According to Goldstein and Kan (1978), both equations (1) and (2) can be rewritten as a single equation (3) to yield an expression for exports' equilibrium volume<sup>119</sup>.

$$M = \chi_0 + \chi_1 \left( \frac{P^F e}{P^D} \right) + \chi_2 FI + \chi_3 Z \quad (3)$$

$$\text{where, } \chi_0 = \frac{\alpha_0 \beta_1 + \alpha_1 \beta_0}{\alpha_1 + \beta_1}, \chi_1 = \frac{\alpha_1 \beta_1}{\alpha_1 + \beta_1}, \chi_2 = \frac{\alpha_1 \beta_2}{\alpha_1 + \beta_1}, \chi_3 = \frac{\alpha_2 \beta_1}{\alpha_1 + \beta_1} \text{ and } \chi_1, \chi_2, \chi_3 > 0.$$

Equation (3) of the equilibrium exports can be rewritten as equation (4) below.

$$M = f(FI, Z, REXR) \quad (4)$$

Where,  $REXR = \left( \frac{P^F e}{P^D} \right)$  is real exchange rate, the relative prices of foreign to domestic goods by using a common currency. Other term definitions are the same as in equations (1) and (2).

## IV. Data and Methodology

### 1. Data and Variable Definitions

The variables and definitions in this study for constructing Autoregressive Distributed Lag (ARDL) bounds testing approach for estimating the export demand function are as follows: real exports (REXPO) is deflated by the unit price index of exports for exports; and nominal exchange rate (NER) is used as a proxy for relative price of export goods against foreign goods price<sup>120</sup>. A sign of this nominal exchange rate in the export demand model is positive since the

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<sup>119</sup> That is, equation (2) is substituted into equation (1) to make equation (3).

<sup>120</sup> There is no real standard exchange rate published by means of government agents such as the department of statistical office in a country. Therefore, most studies make a direct real exchange rate fit their research purpose by such data. Due to these reasons, this study uses just nominal exchange rate, which is published by the Bank of Korea.

depreciation of the exchange rate, which means a relatively low price of domestic currency to foreign currency, stimulates an increase in exports.

The real industrial production index of the Organization for Economic Cooperation and Development (OECD) for world demand is used as a proxy of foreign country (world) income. The domestic real industrial index of Korea is employed for a proxy of domestic output supply. Signs of both variables in the export demand model are positive because an increase of domestic real industrial production and the OECD real industrial production leads to domestic exports by an increase of domestic and foreign countries' export demand.

Since a country's exports are also affected by other special factors, such as political unrest and economic recession (crisis), this study uses a dummy variable to capture its effects in an export demand function. We expect the estimated parameter of the dummy variable to have a negative sign since an economic crisis (recession), for example, can deter export performance of a country to foreign markets.

The monthly time series data are obtained from the Bank of Korea, the OECD, and the International Monetary Fund (IMF). All monthly dates are seasonally adjusted<sup>121</sup> and take a logarithmic transformation from variables to estimate elasticities by using the ARDL bounds testing approach. All variables in our study are in 2000 constant prices and weighted in 2000. The sample period is from 1988:01 to 2006:12.

## **2. Estimation Methodology**

### **2.1 Bounds Testing Approach Procedure**

The Engle-Granger two-step approach and the Johansen's multivariate approach are often used to find a long-run relationship in the level non-stationary variables<sup>122</sup>. However, the Engle-Granger two-step approach has the concept of long-run dynamics of estimated coefficients rather than short-run dynamics. When this is initially developed, the Engle-Granger two-step approach

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<sup>121</sup> Monthly series instead of annual data in this study is used to avoid problems with the degree of freedom for estimation.

<sup>122</sup> There are several econometric methods, such as Stock and Watson's (1988) stochastic common trend system and Park (1990)'s variable addition approach. According to P Aresh K Umar N (2004), in order to test the cointegration between variables, cointegration techniques are Engle-Granger (1987) two-step residual-based procedure, Johansen (1991, 1995)'s based reduced rank regression approach, the variable addition approach of Park (1990), the residual-based procedure for testing the null of cointegration, and the stochastic common trends (system) approach by Stock and Watson (1988).

uses only two variables for the cointegration analysis even though there is a possible cointegration relationship among several variables. So, this method may result in a spurious regression if several non-stationary time series data are cointegrated.

Meanwhile, Johansen's multivariate approach has a problem with the degree of freedom when it is applied to a small sample size for cointegration estimation. Like the Engle-Granger two-step approach, this method is not reliable in testing the cointegration in variables by using small observations<sup>123</sup>. Johansen's multivariate approach has certainty by pre-testing variables before testing the long-run relationship in variables. However, there is also uncertainty due to a possible low statistic value (power) of unit root tests<sup>124</sup> through pre-testing, such as the Augmented Dickey-Fuller (ADF) and Philip-Peron (PP), in order to check the stationary level variables (Pesaran *et.al.*(2001), Cavanagh *et.al.*(1995), and Arayan (2004)).

To avoid the problems suggested above, the bounds testing approach, developed by Pesaran *et.al.* (2001), has often been used for cointegration analysis in variables, especially when small observation time series is used. This bounds testing approach eschews the problem of pre-testing by testing the cointegration in level variables. This method is also called the 'Autoregressive Distributed Lag (ARDL).' According to Pesaran *et.al.* (2001), the ARDL has a few advantages when compared with other methods for testing cointegration in variables. First, this method is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1), or individually (fractionally) cointegrated. Second, short-run and long-run parameters are estimated simultaneously by using the unrestricted ARDL error correction model. Finally, properties of small sample series by using the bounding test are shown and compared with that of the multivariate approach of cointegration, such as Johansen's.

The procedure of the bounds testing approach (Pesaran *et.al.* (2001)) is based on the Unrestricted Error Correction Model (UECM) to find a long-run relationship in variables. In order to estimate a long-run relationship in variables, we can drive equation (5) based on the UECM by variables using this study.

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<sup>123</sup> Toda, *et.al.*(1994) refers to Johansen's multivariate approach which is useful for large samples for cointegration analysis. However, it is not useful for small samples due to low statistic (power) values. They show this problem by using Monte Carlo Methods for the finite sample properties by several tests for cointegration.

<sup>124</sup> Arayan (2004, p 205) refers, "The pre-testing is particularly problematic in the unit-root cointegration literature, in which the power of the unit-root test is typically very low and there is a switch in the distribution function of the test statistics as one or more roots of the  $x_t$  process approach unity (Pesaran, 1997, p 184)."

$$\Delta \ln REXPO = b_0 + \sum_{i=1}^n b_{1i} \Delta \ln LOIP_{t-i} + \sum_{i=1}^n b_{2i} \Delta \ln LIP_{t-i} + \sum_{i=1}^n b_{3i} \Delta \ln LNER_{t-i} + \sum_{i=1}^n b_{4i} \Delta \ln REXPO_{t-i} + b_5 \ln LOIP_{t-1} + b_6 \ln LIPX_{t-1} + b_7 \ln LNER_{t-1} + b_8 \ln REXPO_{t-1} + \mu_t \quad (5)$$

Where  $\ln REXPO$  is the logarithm of real exports,  $\ln LOIP$  is the logarithm of the real industrial production index of the OECD,  $\ln LIPX$  is the logarithm of real industrial production,  $\ln LNER$  is the logarithm of the nominal exchange rate,  $\Delta$  is a first difference operator,  $b_0$  is an intercept, and  $\mu_t$  is a white noise error.

In order to find a long-run relationship in variables, we need to estimate equation (5) by using Ordinary Least Square (OLS) and then all estimated coefficients of lagged level variables are restricted. That is, joint significance of estimated coefficients of lagged levels variables is performed. Here, the null hypothesis with no cointegration in variables is  $H_0: b_5 = b_6 = b_7 = b_8 = 0$ <sup>125</sup>. According to Pesaran *et.al.*(2001), they provide two asymptotic critical value bounds, which relies on independent variables  $I(d)$  with  $0 \leq d \leq 1$ <sup>126</sup>. That is, the lower bound assumes  $I(0)$  for all independents (regressors), and the upper bound is supposed with  $d(1)$  for all them. In this condition, if the calculated F-statistic is larger than the upper critical value bounds at 1%, 5%, and 10% respectively of significance level, then the null hypothesis ( $H_0$ ) with no cointegration is rejected. This means that cointegration exists in variables. While this is not accepted, meaning there is no cointegration in variables, it is smaller than the lower critical value bounds. Lastly, if the calculated F-statistic lies within the critical bound band, inference of cointegration is not conclusive<sup>127</sup>.

## 2.2 Short-run and Long-run Relationship

Once there is existence of a long-run relationship among variables in the ARDL model, we can draw the short-run relationship in variables by using the Error Correction Term (ECM).

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<sup>125</sup> This can also be represented in terms of denotation:  $F_{REXPO}(REXPO | OIP, IP, NER)$ .

<sup>126</sup> Pesaran *et.al.*(2001) have provided the appropriate critical values for different numbers of regressors (explanatory variables) ( $k$ ), and whether the ARDL model contains an intercept or trend or both. They give two sets of critical values. One set assumes that all variables in the ARDL model are  $I(0)$ , and another set supposes that all the variables are  $I(1)$ .

<sup>127</sup> In this case, we need to know the order of integration for the independent (explanatory) variables by using unit root tests such as Augmented Dickey-Fuller (ADF) and Philip and Peron (PP) tests. In this case, we may decide cointegration in variables by using unit root tests.

The long-run and short-run relationships in variables is derived from the UECM that is based on an appropriate ARDL model chosen by employing information criteria such as Schwartz Information Criterion (SIC) and Akaike Information Criterion (AIC).

For a more detailed explanation, we use equations (6) and (7) as follows. If we suppose existence of a long-run relationship in variables, the ARDL ( $r,p,k,q$ ) model is used to find the long-run estimates of variables. The AIC and SIC are employed to select the ARDL ( $r,p,k,q$ ) model before the chosen ARDL ( $r,p,k,q$ ) model is estimated by the OLS<sup>128</sup> in order to obtain the long-run estimates of variables. Equation (6) represents the ARDL ( $r,p,k,q$ ) model to obtain the long-run estimates in this study.

$$\Delta \ln REXPO = b_0 + \sum_{i=1}^r b_{1i} \Delta \ln LOIP_{t-i} + \sum_{i=1}^p b_{2i} \Delta \ln LIP_{t-p} + \sum_{i=1}^k b_{3i} \Delta \ln LNER_{t-k} + \sum_{i=1}^q b_{4i} \Delta \ln REXPO_{t-q} + \mu_t \quad (6)$$

Once we find the long-run relationship among variables, we can construct the short-run relationship model by composing an error correction model from the UECM of equation (5). Equation (7) shows the short-run relationship among variables in this study.

$$\Delta \ln REXPO = \beta_0 + \sum_{i=1}^n \beta_{1i} \Delta \ln LOIP_{t-i} + \sum_{i=1}^n \beta_{2i} \Delta \ln LIP_{t-i} + \sum_{i=1}^n \beta_{3i} \Delta \ln LNER_{t-i} + \sum_{i=1}^n \beta_{4i} \Delta \ln REXPO_{t-i} + \beta_5 D97 + \beta_8 ECM_{t-1} + \varepsilon_t \quad (7)$$

Specifically, a dummy variable, D97 adds into equation (7) to capture a shock of Korea's economic crisis in 1997 to export section. Where  $\Delta$  is a first difference operator,  $\beta_s$  (1 to 4) are coefficients related to short-run dynamics which converge to equilibrium, and  $\beta_8$  measures speed adjustment which is approaching equilibrium. ECM is the error correction term:

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<sup>128</sup> When a small sample size is used, the SIC is more superior to the AIC since the SIC provides parsimonious models compared with the AIC. Pesaran and Shin (1999) recommend lag length of two lags for choosing lag in a model when using annual time series.



$$ECM = \ln REXPO - b_0 - \sum_{i=1}^r b_{1i} \ln LOIP_{t-i} - \sum_{i=1}^p b_{2i} \ln LIP_{p-i} - \sum_{i=1}^k b_{3i} \ln LNER_{k-i} - \sum_{i=1}^q b_{4i} \ln REXPO_{q-i} \quad (8)$$

## V. Estimation Results

In order to estimate the income and price elasticities of the export demand, we need to select an appropriate lag length for equation (5) in order to find a long-run relationship in variables by using the bounding test. We use the Unrestricted Vector Autoregression (UVAR) model with level variables to select an appropriate lag length for equation (5)<sup>129</sup>.

Before we find an appropriate lag length of a model by using the UVAR model, we have to decide whether or not to include a trend term into the UVAR model, including a constant term. We use the Likelihood Ratio (LR) tests to obtain significant statistics for this trend. After the LR test, we find that a trend term should be included into the UVAR model due to obtaining a statistical significance when inserting the trend term into the UVAR model<sup>130</sup>. Therefore, we include the trend term into the UVAR to select a suitable lag length for our model, equation (5).

Table 3-1 reports the results of a selected suitable lag length by using the UVAR model. This study chooses an optimal lag of 3 for our model, equation (5), based on the Akaike Information Criterion (AIC). Afterwards, we perform the bounding test to investigate cointegration in variables in our model.

(Insert)[Table 3-1 VAR Lag Length Order Section Criteria]

Table 3-2 shows the results of the bonding test to find cointegration (long-run relationship) in variables in our model, equation (5). We find a cointegration because a value, 4.7808, of the computed F-statistic at the order of lags of 3 exceeds a critical value, 3.484, of bounds testing at a 10% significance level, respectively. That is, the computed F-statistic is larger than the upper bound in the critical value of band, and the null hypothesis, with no long-

<sup>129</sup> In general, choose an appropriate lag length for a model by using the AIC or SIC.

<sup>130</sup> By using the LR test of deletion of deterministic/exogenous variables in the VAR, unrestricted value of Chi-square with degree of freedom: 34.3787 (0.000 that is p-value) and restricted value of Chi-square with degree of freedom 4 value: 6.1439 (0.189). Critical value of Chi-square with degree of freedom: 9.488 at a 5% level of significance.

run relationship between LOIP, LIP, LNEXR, and LREXPO, is rejected. So, our model takes a long-run relationship between a dependent variable and independent variables. Therefore, since there is a long-run relationship in variables, independent variables as OIP, IP, and NEXR can be handled as factors of impact to the dependent variable, REXPO.

(Insert)[Table 3-2 the Results of F-test for Cointegration]

From the information above, we can estimate the long-run coefficients and the Error Correction Model (ECM) since there is a long-run relationship between the dependent variable and independent variables. We estimate the long-run coefficients by using the ARDL model. Before we estimate long-run estimates, we select an optimal lag for the ARDL model. In order to select an optimal ARDL model, we use the AIC to select a proper lag of order and then we acquire the ARDL (3, 3, 2, 2) model. We estimate long-run coefficients of variables by using this ARDL (3, 3, 2, 2). However, we find that all coefficient estimations of variables in the long run, with the exception of trend, are statistically insignificant. We expect this reason is due to some misspecifications for our model or measurement errors, specifically using monthly data instead of annual or quarterly data as used in previous studies. In addition, we find that all signs of all coefficients are positive, which are consistent with our expectation as referred in an earlier section<sup>131</sup>. Table 3-3 shows these results.

(Insert)[Table 3-3 Estimated Long-run Coefficients by AIC (ARDL 3, 3, 2, 2)]

Meanwhile, in order to see the short-run dynamic effects of variables, we construct the Error Correction Model (ECM) based on the selected ARDL (3, 3, 2, 2) model. In order to obtain efficient estimates, we consider adding a dummy variable to reflect a shock to Korea's export section into the model. We compare results including the dummy variable with those that did not include the dummy variable into the model. Tables 3-4 and 3-5 show the estimated values of the error correction model. Table 3-4 reports the estimated values of the error correction model without a dummy variable, D97, whereas table 3-5 shows those of the error correction model

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<sup>131</sup> Due to using the nominal exchange rate in this study, an increase in the nominal exchange rate (depreciated Korean currency to the U.S. dollar) will motivate to increase Korea's exports into the world market.

with a dummy variable, D97. In table 3-4, all coefficients are statistically significant, with the exception of DLnNEXR (1) and (-1), constant, and trend, but in table 3-5, all coefficients are significantly significant, with the exception of DLnNEXR (-1), constant, trend, and D97, and the statistical significance of these coefficients increased compared with those without a dummy variable. So, we believe that the dummy variable, D97, gave rise to increase the statistical significance of coefficients.

(Insert)[Table 3-4 Error Correction Representation for Selected ARDL Model without D97]

(Insert)[Table 3-5 Error Correction Representation for Selected ARDL Model with D97]

Meanwhile, in tables 3-4 and 3-5, the error correction coefficients (speed adjustment)' estimations are -0.13772 and -0.13688 respectively; which are statistically significant and have the correct sign<sup>132</sup>. There is little difference between these speed adjustment's estimations. In general, the larger speed adjustment coefficients of error correction the faster economy returns to its equilibrium once shocked. So, in this case, we expect that the ECM model without the dummy variable has adjusted faster to the equilibrium but would not cause a big difference due to a rare gap between these speed adjustments' estimations.

Korea became a member of OECD in the mid 1990s. The Korean economy experienced a structural change of economy due to the economic crisis at the end of 1997. Also, this country may have been impacted by the IT bubble of the world economy in 2001. Finally, in recent years, a high oil price and the Iraq War could have affected Korea's export section. To test the structural change in Korea's export demand section in this situation, we test for structural stability.

To test the stability of the regression coefficients, which implies the structural change in export demand section, we use the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) of the recursive residual test for structural stability<sup>133</sup>. Figures 3-6 and 3-7 show that structural instability exists due to the line of computed value, which crosses two lines of

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<sup>132</sup> A low value of ECM means a low speed of convergence to equilibrium.

<sup>133</sup> There are two tests to check a model's structural stability (change). One is the Chow test. This is often used if we know exactly a break point. The other is the CUSUM test of Brown-Durbin-Evans (BDE). This CUSUM test is employed when we don't know an accurate break point. We assume that this study may not know any break point due to some possible break points (events) in the Korean economy.

critical values. Figure 3-6 represents the structural change in Korea's export demand in 1995, 2001, and 2004, while figure 3-7 shows this in 1991 and 2005. However, we do not find that Korea's economic crisis in 1997 affected Korea's export demand. Thus, we find that the structural change in Korea's export demand exists. Specifically, we confirm that the entry of Korea into the OECD in 1995 and the IT bubble in the world economy in 2001 should affect Korea's export demand section due to existing structural break points by using the CUSUM test.

(Insert)[Figure 3-6 Plot of Cumulative Sum of Recursive Residuals for Coefficients Stability of ECM Model]

(Insert)[Figure 3-7 Plot of Cumulative Sum of Squares of Recursive Residuals for Coefficients Stability of ECM Model]

## VI. Summary and Conclusions

In order to catch a recent change in Korea's exports, this study estimates the elasticities of Korea's export demand based on a basic concept of export demand and supply model suggested by Goldstein and Kan (1978, 1985). Specifically, to estimate price and income elasticities of export demand, we used the ARDL bounds testing approach developed by Pesaran, *et. al* (1998). This method has three advantageous characteristics compared with other methods for testing cointegration in variables. First, this method is applicable irrespective of whether the underlying repressors are purely  $I(0)$ , purely  $I(1)$ , or individually (fractionally) cointegrated. Second, the short-run and long-run parameters are estimated simultaneously by using the unrestricted ARDL error correction model. Finally, properties of a small sample series by using the bounding test are shown compared with that of multivariate approach of cointegration, such as Johansen's.

We found a long-run relationship among variables in the export demand model by using the ARDL bounds testing approach. This study estimated the short-run and long-run elasticities on income and price. We found that in the long run all signs of estimated coefficients are corrected, which are consistent with our expectations as referred in an earlier section. However, the values of estimated coefficients on income and price with the exception of a trend term are statistically insignificant. This may be due to misspecifications or measurement errors. These results are different with those of previous literature, which specifically used annual or quarterly data and real exchange rates. However, our study employed monthly data or nominal exchange

rate and different sample periods. In order to avoid misspecifications or measurement errors, we may use appropriate variables and data.

Meanwhile, we used the error correction model to estimate the short-run elasticities of income and price since there is the long-run relationship among variables in our export demand model. Specifically, we added a dummy variable into our export demand model to obtain more right or exact estimations since the dummy variable in our study reflects a shock (Korea's economic crisis in 1997) into the export demand.

In contrast to the results of the long-run elasticity, we found that estimates of the short-run elasticities are nearly statistically significant. Particularly, we found that the estimated dummy variable's value is not statistically valid but increases the statistical significance of elasticities respectively, compared with that of the export demand without the dummy variable. When we use the structural break test to check structural change in Korea's export demand, we found that there is no structural break point of 1997. So, we expect that a shock of Korea's economic crisis in 1997 might not significantly affect Korea's export demand. However, we found that the IT bubble of the world economy in 2001 and the entry of Korea into the OECD triggered the change in Korea's export demand due to existing structural break points.

Meanwhile, we found that the short-run income elasticities are larger than price elasticities in our study. This implies that the change of Korea's exports in the short-run is more sensitive to changes in foreign income (industrial production) compared with that of the price (exchange rate). An interesting result, thus, is that in recent years Korea's exports in the short-run may have a higher export performance on income than that of price (exchange rate). This may be a consequence of the dependence of an increase in foreign income in recent years. As referred in an earlier section, developing countries have increased their economic growth dramatically compared with that of developed countries, and Korea's exports have increased to these developing countries. Thus, in recent years, an increase in Korea's exports is mainly affected by income compared with price, specifically in the short run.

In addition, this study may have limitations. First, we used the nominal exchange rate as a proxy of commodity price ratio between domestic and foreign goods under the assumption of stable change in price. However, in order to obtain a more accurate analysis, this study may use the real exchange rate. However, there is difficulty in obtaining a trustful real exchange rate. Specifically, even though some studies use real exchange rate for their research, there may not be

trustful data since the real exchange rate is usually studied or reported by individual researchers or agents which do not have a public reputation. Also, obtaining trustful real exchange rate may be, in fact, difficult due to getting wide data information such as major trade partners' exports and imports, GDP, consumer price or wholesale price, and exchange rate. For example, it is difficult to obtain trustful and consistent data information about exchange rate or income from a country such as China, which has not managed its macro economic indicators well even though this country has a high ratio of trade to national income. China has tried to collect its economic indicators and data in only recent years.

Second, for our research purpose, we used the OECD industrial production index as a proxy of foreign income, but in fact we may use necessary world income which reflects all trade partner countries' income. However, it is not easy to obtain for any research in economic fields. A proxy variable, as foreign income in Korean international research, related with Korea's international trade, is often used by the U.S. GDP, Japan's GDP, or an average of total weighted GDP of these countries because they have a significant economic relationship with Korea and they also have well arranged macro indicators for research.

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## Appendix

**Table 3-1 VAR Lag Length Order Section Criteria**

Criteria Lag	LogL	AIC	SIC	LR	Adj. LR
0	1318.6	1310.6	1297.1	21119.0(0.000)	1628.5(0.000)
1	2171.8	2147.8	2107.3	412.6969(0.000)	317.1652(0.000)
2	2228.6	2188.6	<b>2121.3**</b>	299.1172(0.000)	229.8771(0.000)
3	2263.3	<b>2207.3**</b>	2112.8	229.7749(0.000)	176.5862(0.000)
4	2278.2	2206.2	2084.7	199.9472(0.000)	153.6631(0.61)
5	2292.1	2204.1	2055.6	172.1672(0.000)	132.3137(0.92)
6	2300.8	2196.8	2021.3	154.7526(0.000)	118.9302(0.56)
7	2312.3	2192.3	1989.8	131.7471(0.000)	101.2501(0.55)
8	2332.7	2196.7	1967.1	90.9912(0.015)	69.9284(0.285)
9	2343.7	2191.7	1935.2	68.8236(0.026)	52.8922(0.291)
10	2354.0	2186.0	1902.5	48.2537(0.033)	37.0838(0.246)
11	2363.0	2179.0	1868.4	30.4071(0.016)	23.3684(0.104)
12	2378.2	2178.2	1840.6	-	

Notes: 1) Level variables are REXPO, NEXR, OIP, IP and exogenous variables are

Constant, and Trend.

2) AIC is Akaike information criterion, SIC is Schwarz information criterion,

3) LR is test statistic of a sequential modified LR test at 5% of significant level.

4) Adj. LR is adjustment LR

5) Two asterisks (\*\*) mean an optimal lag length at absolute value chosen by each criteria.

**Table 3-2 The Results of F-test for Cointegration**

Calculated F-statistics $H_0 : b_5 = b_6 = b_7 = b_8 = 0$	$F_{\text{Rexpo}} (\text{Rexpo}   \text{Nexr, Oip, Ip})$		
Critical Value Bounds	Lower bounds, I (0)	Upper bound, I(1)	
1 %	5.315	6.414	<b>4.7808(0.00)</b>
5 %	4.066	5.119	
<b>10 %</b>	<b>3.484</b>	<b>4.458</b>	

Notes: Intercept and trend for k=3 (explanatory variable), (Pesaran and Pesaran, 1997, p.478)

Parentheses ( ) are p-value.

**Table 3-3 Estimated Long-run Coefficients by AIC (ARDL 3, 3, 2, 2)**

Variables	LnNEXR	LnOIP	LnIP	Constant	Trend
Coefficients	0.12741(0.911)	1.0466(1.342)	0.50721(1.065)	3.0149(1.075)	0.0058149(2.120)
Standard Error	0.13983	0.77980	0.47638	2.8049	0.027424

Notes: Parentheses ( ) are t-value.

**Table 3-4 Error Correction Representation for Selected ARDL Model without D97**

Regressor	Coefficient	Standard Error	t-value (p-value)
DlnREXPO (-1)	-0.43083	0.069235	
DlnREXPO (-2)	-0.17851	0.056120	<b>-3.1809(0.002)***</b>
DlnNEXR	-0.042419	0.083442	-0.50836(0.612)
DlnNEXR(-1)	0.020948	0.094314	0.22211(0.824)
DlnNEXR(-2)	0.27924	0.86256	<b>3.2374(0.001)***</b>
DlnLOIP	1.1569	0.51719	<b>2.2369(0.026)**</b>
DlnLOIP(-1)	0.96573	0.50810	<b>1.9007(0.059)*</b>
DlnLIP	0.64718	0.076954	<b>8.4099(0.000)***</b>
DlnLIP(-1)	0.17223	0.088045	<b>1.9561(0.052)*</b>
constant	0.41521	0.38264	1.0851(0.279)
trend	0.8008E-3	0.5225E-3	1.5326(0.127)
ECM(-1)	-0.13772	0.048155	<b>-2.8599(0.005)***</b>

Notes: \*\*\*, \*\*, and \* means significant at 1%, 5%, and 10 % level

R-Squared .55670 R-Bar-Squared .52714  
 S.E. of Regression .032845 F-stat. F( 11, 213) 23.9743[.000]  
 Residual Sum of Squares .22655 Equation Log-likelihood 457.0876  
 Akaike Info. Criterion 442.0876 Schwarz Bayesian Criterion 416.4668  
 DW-statistic 2.0230

**ECM= LREXPO -0.12741\*LNEXR -1.0466\*LOIP -0.50721\*LIP -3.0149\*INPT -0.0058149\*T**

**Table 3-5 Error Correction Representation for Selected ARDL Model with D97**

Regressor	Coefficient	Standard Error	t-value (p-value)
DlnREXPO (-1)	-0.43463	0.069387	<b>-6.2638(0.000)***</b>
DlnREXPO (-2)	-0.17917	0.056147	<b>-3.1911(0.002)***</b>
DlnNEXR	-0.060509	0.085788	<b>-0.70533(0.481)*</b>
DlnNEXR(-1)	0.032517	0.095196	0.34158(0.733)
DlnNEXR(-2)	0.27388	0.086489	<b>3.1667(0.002)***</b>
DlnLOIP	1.1651	0.51747	<b>2.2516(0.025)**</b>
DlnLOIP(-1)	0.93971	0.50910	<b>1.8458(0.066)*</b>
DlnLIP	0.65503	0.077462	<b>8.4562(0.000)***</b>
DlnLIP(-1)	0.17728	0.088253	<b>2.0088(0.046)**</b>
constant	0.42339	0.38289	1.1058(0.270)
trend	0.7860E-3	0.5230E-3	1.5029(0.134)
D97	0.031424	0.034375	0.91415(0.362)
ECM(-1)	-0.13688	0.048182	<b>-2.8410(0.005)**</b>

Notes: \*\*\*, \*\*, and \* means significant at 1%, 5%, and 10 % level

R-Squared .55846 R-Bar-Squared .52677  
 S.E. of Regression .032858 F-stat. F( 12, 212) 22.0289[.000]  
 Akaike Info. Criterion 441.5365 Schwarz Bayesian Criterion 414.2077  
 DW-statistic 2.0358

**ECM = LREXPO -.13022\*LNEXR -1.0056\*LOIP -.52921\*LIP -.22957\*D97 -3.0931\*INPT -.0057423\*T**

Figure 3-1

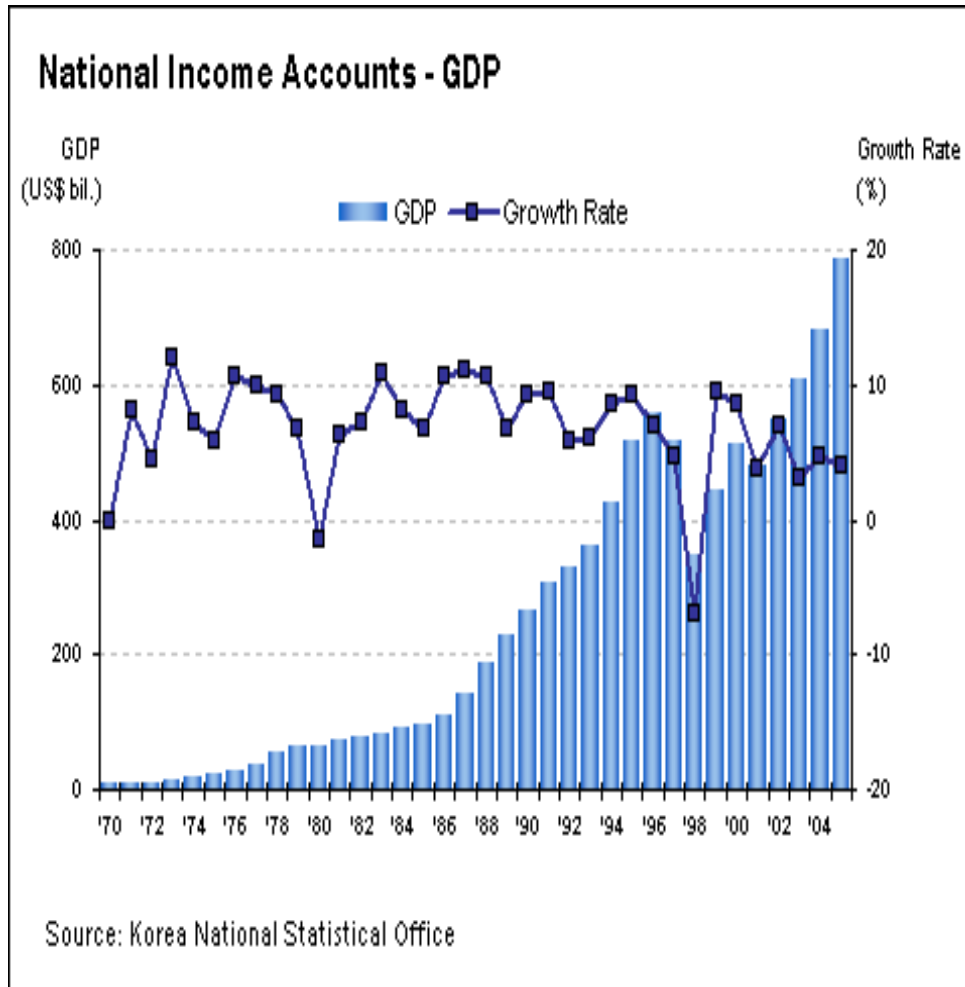
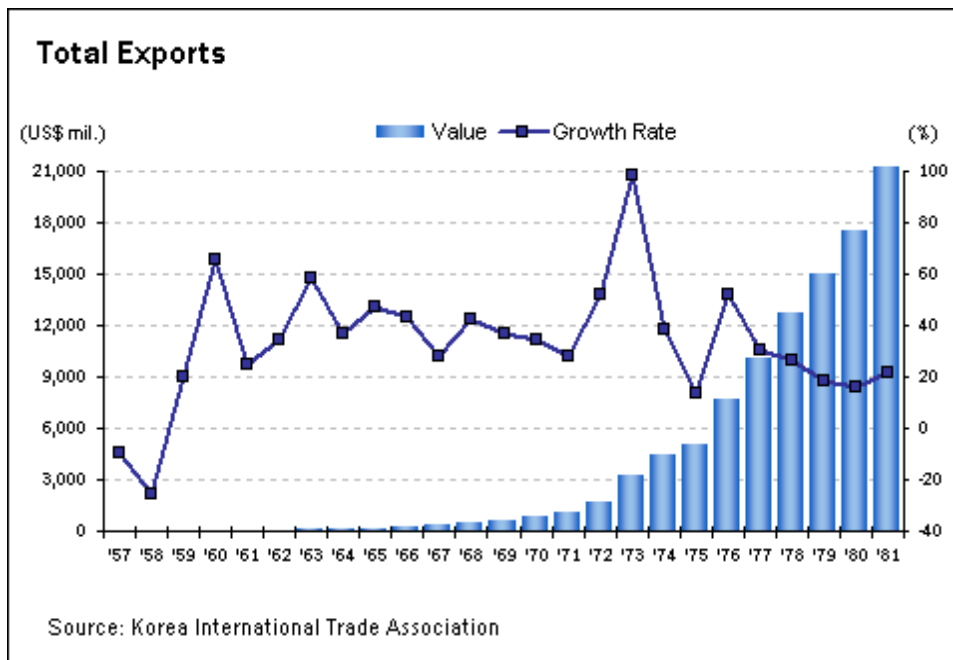
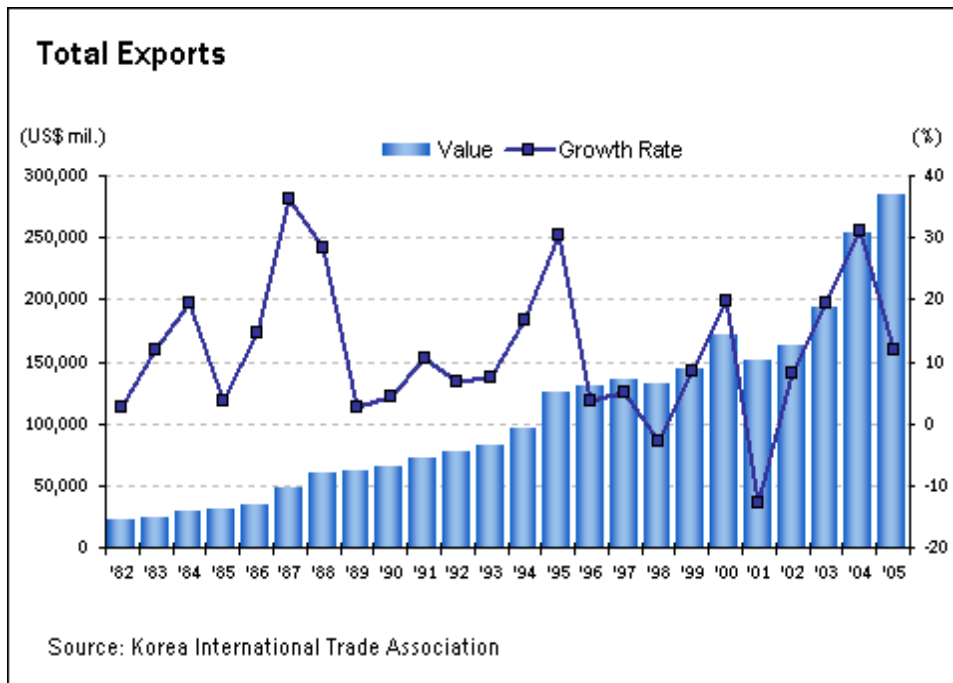
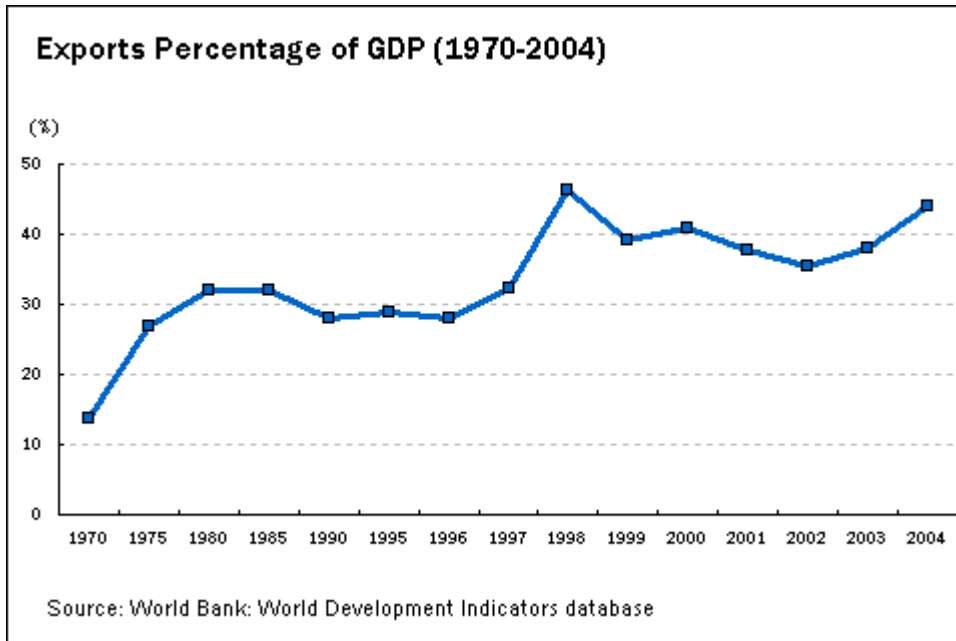


Figure 3-2

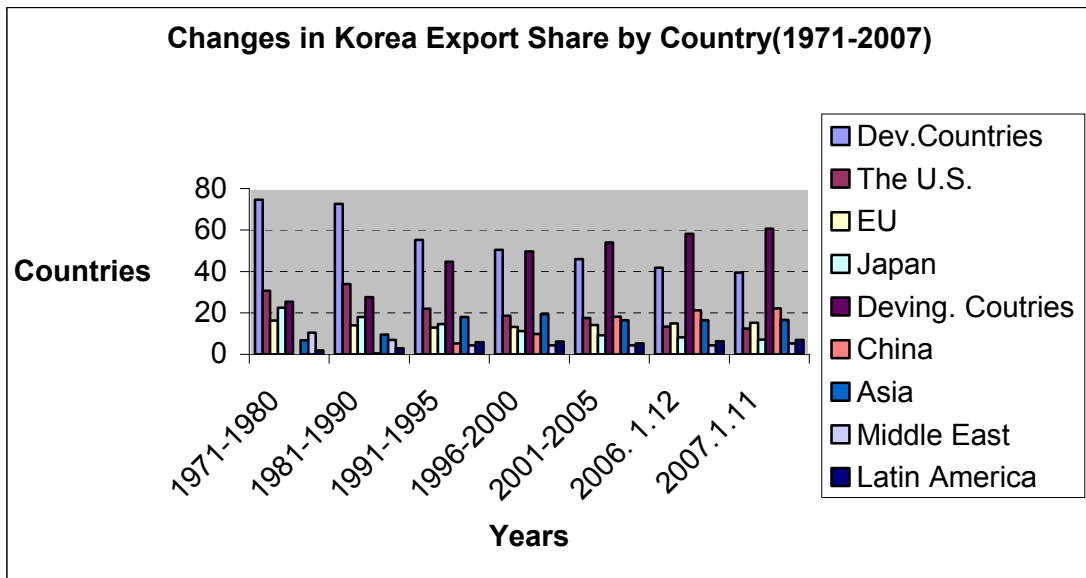


Note: due to 1997 of economic crisis, 2001 of IT bubble exports of Korea was decreased.

**Figure 3-3**



**Figure 3-4**



Source: Samsung Economic Research Institute (2007)

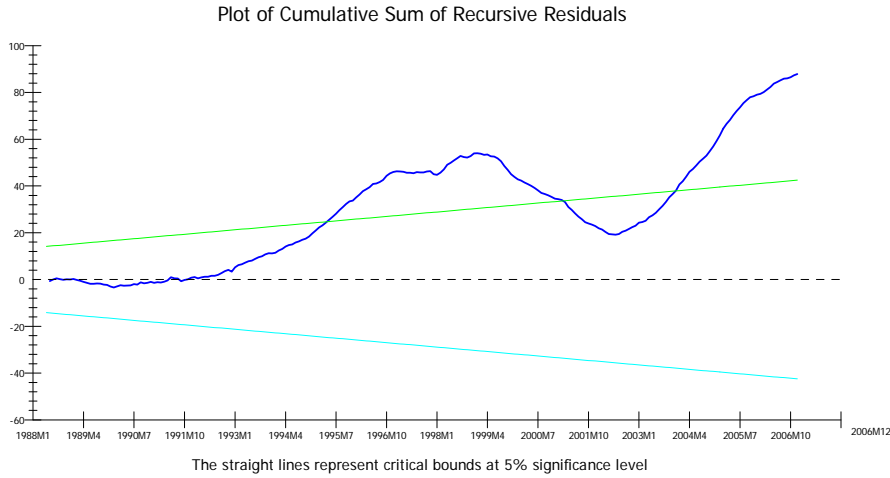
**Figure 3-5**



Source: Bank of Korea, Economic Statistics System.

Available: [http://ecos.bok.or.kr/EIndex\\_en.jsp](http://ecos.bok.or.kr/EIndex_en.jsp), downloaded on February 6<sup>th</sup> in 2007.

**Figure 3-6 Plot of Cumulative Sum of Recursive Residuals for Coefficients Stability of ECM Model**



**Figure 3-7 Plot of Cumulative Sum of Squares of Recursive Residuals for Coefficients Stability of ECM Model**

