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A STRUCTURAL ANALYSIS FOR FORECASTING KOREA'S EXPORT QUANTITY

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Export functions have been empirically estimated by many researchers in order to measure price and income elasticities, which are then used in forming various economic policy measures. However, since the model specification of these researches has not included the exchange risk variable, the estimation results can not be said to represent the real behavioral pattern of exporters. This paper tries to rectify this inappropriateness by explicitly including the exchange risk variable in the estimation process. Estimation result shows that exchange risk affects Korea's export quantity significantly along with those variables such as export unit prices, importing country's income level, etc. In addition, the short-run model with error correction term provided more accurate forecast for the Korean export quantity than the long-run equilibrium model.

JEL Classification: F10, F17
Keywords: Export Quantity, Dynamic Equation, Equilibrium Equation

I. INTRODUCTION

After the market average exchange rate system was introduced in 1990, the exchange rate has been rather unstable as it is determined mainly by the demand and supply forces of foreign exchange. As the result, the participants of the foreign exchange market haveexchange rate system.[1] In this new situation, the behavioral functions of the exporters been exposed to a higher exchange risk than before the introduction of the market average should be obviously different from those under relatively stable foreign exchange rate.

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[1] The market average exchange rate system was replaced by the free floating exchange rate system in December, 1997.

However, the researchers in this field have not taken into account this important change of environments in their empirical analyses of export functions. Export functions have been empirically estimated by many researchers in order to measure price and income elasticities, which are then used in forming various economic policy instruments.

Basically, the model specification of these researches is not complete in the sense that the exchange risk variable is not explicitly included in the estimation process. Therefore, the estimation results can not be said to represent the real behavioral pattern of exporters. The policy measures based upon those estimation results also are inappropriate for the same reason. This paper tries to rectify this inappropriateness of export function estimation by explicitly including the exchange risk variable in the model specification.

Until recently, the effect of foreign exchange risk on the international trade has not received much attention by the researchers in the field of trade function estimation. After major advanced countries had changed their exchange rate systems toward the free floating one in 1973, the effects of the volatility risk of the exchange rate on the international trade began to appear in the literature. Hooper and Kohlhagen(1978), however, could not find a significant evidence that exchange rate volatility significantly decreased international trade volume. They utilized monopolistic framework instead of the traditional perfect competition model to analyze the effect of foreign exchange risk on the trade volume among the advanced countries.

The literature in the 1980s began to argue that foreign exchange risk did significantly affect the trade volume in the negative direction. Akhtar and Hilton(1984) showed that exchange rate volatility significantly decreased the trade volume between Germany and U.S. Cushman(1988) estimated the effect of foreign exchange risk on the U.S. trade volume with six major trading partners(England, Netherland, France, Germany, Canada and Japan) during the free floating exchange rate period of 1974 ~ 1983. In the meantime, Feenstra and Kendall(1991) argued that exchange rate volatility significantly affects the international prices of tradable commodities. Chung(1997) and Kim(1998) also tried to emphasize the significant effect of exchange rate fluctuation on export and import volume using the trade data of Korea.

In addition to incorporating the exchange rate volatility explicitly into the estimation process, for a complete export function estimation, this paper utilizes the error correction model in the estimation process. Traditional regression analysis is applicable for the time-series data only when the series has stationarity over time. If the time-series data turn out to be unstationary, spurious regression results are inevitable.[2]

A great part of existing empirical studies on trade relationships have run

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[2] Most of the time-series data look like they have inter-relationship with each other even though they do not have one.

regressions with data in levels. However, given the possibility that most of the underlying series had non-stationary residuals, the simple application of Ordinary Least Squares(OLS) methodology might have led to spurious regression results. Error correction model deals with this phenomenon and arms at correcting it. In line with this methodology, several studies have been carried out focusing on the long-run relationship[3] between the trade volume and exchange rates and the short-run link[4] between the two variables.

In this study, not only long-run static effects will be inferred but also short-run dynamic effects will be focused on, emphasizing their corresponding elasticities. Then, the estimation results will be utilized to forecast the Korea's export quantity. The long-run equilibrium and short-run dynamic forecasting results derived from the model are compared by calculating the value of MAPE(Mean Absolute Percentage Error). MAPE has been widely used for the comparison of forecasting accuracy of various forecasting methods after the work of Makridakis, Wheelright and McGee (1983).

The remainder of the paper is organized as follows. Section Ⅱ proposes some simple model specifications for the empirical estimation employed in this paper and describes the data set used for the estimation. Our empirical findings are given in Section Ⅲ. Finally, Section Ⅳ concludes the paper.

Ⅱ. THE MODEL

2.1. Error Correction Model

It is often argued that the possibility of spurious regression is high when the regression result turns out to have relatively high adjusted R^2 and, at the same time, relatively low Durbin-Watson(D.W) statistics. In this case, high adjusted coefficient of determination ($\bar{R}^2$) does not reflect the true relationship among the time-series variables. It just shows that the variables have the same trend, upwards or downwards, over time. Meanwhile the low Durbin-Watson statistics represents the unstability of the residual terms. This problem of the spurious regression phenomenon is due to non-stationary tendencies in the time-series data.

However, the regression results can be regarded as consistent and valid ones if the non-stationary time-series data have, so called, cointegration relationship among the variables. In general, cointegration relationship is defined when a linear combination, which produces stationary series, exists among the individual non-stationary variables.

The existence of cointegration relationship has a very significant implication for the regression analysis. Cointegration relationship means that the resulting

[3] See, for example, Bahmani-Oskooee(1991) and Arize(1994).

[4] See, for example, Mahdhavi and Sohravian(1993) and Bahmani-Oskooee and Alse(1994).

error component after the linear combination becomes stationary and its equilibrium has the value of zero. Therefore, even though the economic variables seem not to have any significant relationship among them in the short run, they maintain a consistent relationship in the long run when there exists cointegration relationship among the time-series variables. That is, if the variables in consideration are cointegrated, there is a long-run equilibrium relationship.

The error correction model developed by Engle and Granger(1987) takes care of this problem. The model has the advantage of not only incorporating the stationarity of the time-series and long term equilibrium relationship but also analyzing short-run dynamic aspect of those time-series variables. In other words, the error correction method helps building the model that reflects adjustment process toward long-run equilibrium without ignoring short-run dynamic characteristics of the variables.

Furthermore, the regression method using the difference variables in order to take care of the spurious regression phenomenon has the disadvantage of loosing long-run information contained in the level variables. In this respect, the error correction model is utilized to grasp the short-run dynamic relationship among the variables as the model takes care of the spurious regression problem and overcomes the disadvantage of loosing the long-run information due to differencing the level variables.

The estimation process of the error correction model is as follows. First, we need the cointegration test to find out the existence of long-run equilibrium relationship among the time-series variables. This test is the process of confirming whether the estimated regression equation has the stable residuals or not. Second, short run dynamic equation is estimated by utilizing Ordinary Least Squares(OLS) method after the variables are differenced and the residual components of the previous periods along with lagged dependent variable are added in the estimation process as explanatory variables.

2.2. Model Specification

It can be said that Korea's export quantity is dependent upon export unit prices of Korean products and competing country's products, income and price levels of importing countries, and the exchange risk the exporters are facing. Then estimation equation can be set up in linear logarithmic form as follows.

<u>Long-run equilibrium equation</u>

$$\ln EQ_1 = \beta_0 + \beta_1 \ln EUP_{t-j} + \beta_2 \ln EUC_{t-j} + \beta_3 \ln FY_{t-j} + \beta_4 \ln FP_{t-j} + \beta_5 \ln ER_{t-j} \qquad (1)$$

where, EQ is export quantity of Korea, EUP is export unit price of Korean commoditities, EUC is export unity price of competing country's products, FY

and FP are importing country's real income and price levels respectively, and ER is exchange risk facing the Korean exporters.

Obtaining long-run estimates in equation (1) is the first step to estimating the complete model. The next step is to specify the short-run model in error-correction form, that is to include not only those variables which contain the short-run information but also the cointegration relations(long-run information) obtained from equation (1)

Short-run dynamic equation

$$\Delta \ln EQ_t = \gamma_0 + \gamma_1 \Delta \ln EUP_{t-j} + \gamma_2 \Delta \ln EUC_{t-j} + \gamma_3 \Delta \ln FY_{t-j} + \gamma_4 \Delta \ln FP_{t-j} + \gamma_5 \Delta \ln ER_{t-j} + \gamma_6 \Delta \ln EQ_{t-j} + \gamma_7 ECT_{t-j} \quad (2)$$

where, ECT is the error correction term, the residual compoment obtained from the estimation of the long-run equilibrium equation.

Since the rise of own export unit price decreases export quantity, the co-efficients of the variable (EUP), $\beta_1(\gamma_1)$, are expected to have negative values. On the other hand, the rise of overseas price level (FP) and competing country's export price (EUC) along with the increase of foreign income level (FY) will obviously have positive impact on Korea's export quantities; i.e., $\beta_2(\gamma_2)>0$, $\beta_3(\gamma_3)>0$, $\beta_4(\gamma_4)>0$. But higher exchange risk facing the Korean exporters is expected to decrease export quantity; i.e., $\beta_5(\gamma_5)<0$. And the residual component of the previous periods (ECT) in equation (2) represents the period by period deviation from the long run equilibrium and is expected to have negative coefficient. This implies that export quantity of each period is undergoing the adjustment process toward the long run equilibrium over time.

And the subscript j in the equations (1) and (2) represents the time lag. If a certain period of time is j and the terminal period is t, long run means $t=j$. Short run is defined as the period of time path from j to t, where the long run equilibrium is attained.

2.3. The Data

The data that are utilized in the econometric estimation of the equations (1) and (2) are obtained from various sources as follows. And the data used for the model estimation cover the period from the first quarter of 1983 to the second quarter of 1995. Data from the third quarter of 1995 to the fourth quarter of 1996 are used as a holdout sample to calculate the MAPE.

The Monthly Bulletin of the Bank of Korea gives us the quarterly data for export quantity index and export unit price index, which are used as the proxy variables for export quantity and export unit price variables of Korea in the model. The proxy variable for competing country's export unit price is that of

Taiwan[5], which is a strong competitor of Korea in the world market for almost every manufactured product. *The Monthly Statistics of Export and Imports, Taiwan Area* published by Finance Ministry of Taiwan gives us the data on the export unit price of the competing country in the model specification. The data on the importing countries' real national income and price levels[6] are obtained from the *International Financial Statistics(IFS)* that is published by International Monetary Fund(IMF).

The foreign exchange risk might be measured by the degree of deviation of the real exchange rate away from the expected one. To get this measurement, we obviously need to have expectation values of the future exchange rates. There are, in general, two different methods for forecasting future exchange rates. One is the structural model and the other is the autoregressive model.[7] In this paper, since the forecasting is not the major concern of the study, we obtained the forecasted exchange rates, and thus the foreign exchange risk from the existing literature on this subjects. The related data are obtained mostly from Lee(1995) and Suh(1996), which also give detailed explanation of the forecasting method.

The descriptive statistics for the variables to be used in the estimation of Korea's export function are presented in Table 1.

[Table 1] Distribution of the Variables

Variable	Mean	Std.Dv.
EQ	95.2	72.3
EUP	81.7	75.1
EUC	86.3	62.9
FY	1,158.6	877.2
FP	92.3	56.3
ER	0.08	0.059

Note : Variables in the table are as follows. EQ is the export quantity index, EUP is the export unit price index of competing country, FY is the importing countries' national income in billion dollars, FP is the importing countries' price level and ER is degree of deviation of the exchange rate from the expected one.

[5] The export unit price of Japan along with that of Taiwan was attempted as the proxy variable for competing country's export unit price in the empirical estimation process. But, the export unit price of Japan was excluded in the estimation result along with the average export unit prices of Taiwan and Japan due to unsatisfactory regression results.

[6] Six major countries are selected as importing countries of Korean products. They are U.S., Japan, Germany, France, United Kingdom and Canada. The real national incomes and price levels of these countries are averaged with relevant weights according to their import amounts from Korea.

[7] This model conceives the property of the exchange rate variable having long-run tendency of autoregressive movement and ,in general, has the expression of $\ln S_t = \alpha_0 + \sum \alpha_i \ln S_{t-i} + \varepsilon_t$.

[Table 2] Unit Roots Test Results

Variables	Level	Difference
EUP	-2.307	-3.347*
EUC	-2.511	-3.182*
FY	-2.068	-3.203*
FP	-2.964	-3.321*
ER	-3.105	-3.470*

Note : According to Dickey-Fuller test statistics, the critical value to reject the null hypothesis that a time series datum has unit root is -3.18(sample size=50) at the significant level of 10%.

In addition, ARIMA, X-11 method is utilized to adjust seasonalities for all quarterly time-series data used in the regression analysis. The regression analysis package used in this study is RATS 4.0.

Ⅲ. EMPIRICAL RESULTS

3.1. Tests on Unit Root and Cointegration

In this paper, Dicky and Fuller's (DF) test[8] is utilized to figure out whether the time-series data used in the regression analysis are stationary or not. The test result is shown in Table 2. The table shows that all the level variables (Y_t) turned out to have the unit roots, which means that the time-series data are not stationary over time. However, all of the first difference variables ($Y_t - Y_{t-1}$) do not have the unit roots, hence they become stationary.[9] These tests are executed with the time lag of three periods, which are generally regarded as the most realistic lag structure of Korean export behavior.

Since the unit root test gives us the result that all the level variables are not stationary, hence are not appropriate to apply the ordinary regression method. The next step is, as mentioned earlier, to execute the cointegration test. This test is to figure out whether the unstationary time-series data have a stable linear combination among them or not. If they have it, then there is no problem at all to proceed the regression analysis. This cointegration test utilizes the long run equilibrium equation and has two kinds of statistics. One is Dicky-Fuller(DF) and the other one is Augmented Dick-Fuller(ADF).[10]

The cointegration test result is shown in Table 3. The table says that the export quantity function rejects the null hypothesis that the cointegration

[8] Dicky-Fuller's test is basically to find out whether the coefficient of any variable's own lagged variable has the regression coefficient of unity. If any time series can be expressed as $Y_t = Y_{t-1} + \varepsilon_t$, the DF method tests if the regression coefficient of Y_{t-1} is equal to one. For this reason, this test is usually called unit root test.

[9] The test statistics are obtained from Lee and Lee(1995).

[10] ADF test utilizes the difference variables while DF test uses the level variables.

[Table 3] Cointegration Test Results

	DF-test	ADF-test
export quantity function	-4.459*	-3.972*

Note : According to cointegration test statistics from Engle and Granger(1987), the critical values are 4.42 for DF-test and 3.85 for ADF-test with sample size of 50 and 5 variables at the significance level of 10%.

relationship does not exist among the variables used in the regression analysis at the 10% significance level. This result means that the export quantity function can now be estimated using the error correction model without causing the inconsistency problem of the regression result. Thus, the data generating process examination suggests that the use of cointegration technique will be suitable to proceed with the long-run analysis.

3.2. Estimation Results

Now the error correction model is estimated empirically after the unit root and cointegration tests are executed. The long run equilibrium equation is estimated in the first place and the estimated residual terms of the previous periods are included in the short-run dynamic equation as an explanatory variable. Thus the cointegration technique allows for a useful and meaningful link between the long-run and short-run approach to econometric modeling. With this method, the adjustment process toward the long-run equilibrium is explicitly incorporated in the estimation process.

The estimation results of the error correction model of the export quantity function of Korea are summarized in the following two equations (3) and (4). The regression equation (3) represents the long-run equilibrium equation while the regression result (4) represents the short-run dynamic equation of the Korea's export quantity function. Up to four lags have been tried for each equation, which should provide a sufficient representation of the process generating the data given that we are dealing with quarterly time series.[11]

First of all, these regression results turned out to be statistically significant. All the estimated coefficients have signs consistent with the model and the t-statistics are relatively high enough to make the regression results statistically significant. In the meantime, the adjusted R^2 of the short-run dynamic equation turned out to be lower than that of the long-run equation, which is caused by the fact that some of the relevant information of the level variables are lost when the variables are differenced to get the necessary stationarity.

[11] In general, economic results are quite sensible with a few lags.

long-run equilibrium equation

$$\ln EQ_t = -18.6437 - 1.9678 \ln EUP_{t-3} + 2.7554 \ln EUC_{t-2} + 3.0194 \ln FY_{t-2}$$
(4.7341) (2.9967) (3.1455) (2.2667)

$$+2.3108 \ln FP_{t-3} - 1.0472 \ln ER_{t-2} \quad (3)$$
(1.8975) (1.9472)

$R^2 = 0.9487$ $D.W. = 1.6104$
t-values are in the parentheses

short-run dynamic equation

$$\Delta \ln EQ_t = 0.0596 - 1.2283 \Delta \ln EUP_{t-3} + 1.0337 \Delta \ln EUC_{t-4} + 3.2631 \Delta FY_{t-3}$$
(1.9652) (2.4364) (2.0779) (2.1983)

$$+1.6458 \Delta \ln FP_{t-4} - 0.8994 \Delta \ln ER_{t-3} - 0.2279 \Delta \ln EQ_{t-3} - 0.7526 ECT_{t-1}$$
(1.9077) (1.8865) (1.7438) (4.8751)

$R^2 = 0.9338$ $D.W. = 1.6732$
t-values are in the parentheses

The above regression results show that Korea's export quantities are affected significantly by those variables such as export unit prices of Korean products and competing country's products, income and price levels of Korea's major trading partners, and foreign exchange risk.

It is estimated that a 1% rise of export unit price lowers Korea's export quantity by 1.9678% in the long-run and a 1% point rise of export unit price lowers 1.2283% point of export quantity in the short-run. This result shows that export demand for Korean products is very much sensitive to changes in export price. That is, Korean firms are exporting their commodities to the overseas markets based on price competitiveness rather than product quality and performance competitiveness. Hence, it can be said that the doldrum of Korea's exports to the world market during the mid 1990s had been caused by the production cost increase due to such factors as fast rising wage rate and high interest rates.

Competing country's export price has, as expected, positive impact on Korea's export. A 1% rise of the price increases Korea's export by 2.7554% in the long-run and a 1% point rise of the same variable increases Korea's export by 1.0337% point in the short-run. A 1% rise of importing countries' price level yields 2.3108% increase of Korea's export to those countries in the long-run and a 1% point rise of the same variable increases Korea's export by 1.6458% point in the short-run. These results tell us that Korea's exporting commodities have rather strong competitory relationship against the importing countries' commodities as well as competing country's products.

In addition, a 1% increase of foreign income level generates 3.0194% of Korea's exports to those countries in the long-run and a 1% point rise of the same variable increases Korea's export by 3.2631% point in the short-run. This estimation results show that Korea's exporting goods are very much income elastic in the major overseas markets.

Another important concern of this paper is to figure out empirically the impact of foreign exchange risk on Korea's exports. Estimation results show that a 1% rise of exchange risk decreases 1.0472% of Korea's exports in the long-run and a 1% point rise of the exchange risk lowers Korea's export quantity by 0.8994% point in the short-run. From this result, it can be conjectured that exporting firms tend to raise export price when there exists higher foreign exchange risk, thus decreases export quantities accordingly. Usually, foreign exchange risk is small when the exchange rate itself maintains smaller fluctuation and vice-versa. This aspect has a very important policy implication.

Lastly, the coefficient of the error correction term (ECT) is estimated to have the value of -0.7526 with a very high t-statistics of 4.8751. This implies that the discrepancy between export quantity of the previous period and long-run equilibrium export quantity is adjusted as much as 75.26% in the export quantity of this period.

3.3. Forecasting Results

One quarter ahead forecasts for the holdout sample of 6 periods(from the third quarter of 1995 to the fourth quarter of 1996) are derived with the two models(long-run equilibrium model and short-run dynamic model). And then

[Table 4] Forecast Results of the Model for the Holdout Sample

Year	Quarter	Actual Export Quantity	Forecasted EQ[1]		APE[2]	
			long-run model	short-run model	long-run model	short-run model
1995	3rd	184.2	196.5	187.2	6.7	1.6
	4th	203.4	186.5	199.0	8.3	2.2
1996	1st	188.1	201.6	191.4	7.2	1.8
	2nd	215.5	202.4	212.1	6.1	1.6
	3rd	200.6	211.4	203.2	5.4	1.3
	4th	257.9	237.5	252.7	7.9	2.0
				MAPE	6.9	1.8

Note: 1) one quarter ahead forecast calculated from equations (3) and (4)

2) APE(Absolute Percentage Error)= $\frac{|\text{Forecsated EQ} - \text{Actual EQ}|}{\text{Actual EQ}}$

APE(Absolute Percentage Error) of each model for each period of forecast is calculated. The results are presented in Table 4.

As shown in the table 4, MAPE of the short-run model is only almost one fourth of that of the long-run model. It means that short-run model refines the forecast of Korea's export quantity considerably. The short-run model, in which the error correction term of the last quarter is introduced, refines the forecasting result for the next quarter. The forecasting result derived from the long-run model can be utilized to formulate long term policy regarding the equilibrium level of foreign exchange rate. On the other hand, refined forecasting derived from the short-run model can be utilized to adjust economic policy measures related to supply and demand of foreign exchange, that is, the rate of capacity utilization of industries, the rate of unemployment, etc in the next quarter.

Ⅳ. CONCLUDING REMARKS

This paper utilizes the error correction model, recently developed regression technique to work with non-stationary variables, to empirically estimate Korea's export quantity function. The unit root tests along with cointegration tests were executed in the first place to identify the stationarity and linear combination of the time-series data for the regression analysis. Then, the long-run equilibrium and short-run dynamic equations are set up for empirical estimation.

According to the estimation results, Korea's export quantities are significantly affected by those variables such as export unit prices of Korean and competing country's products, price and income levels of importing countries and the degree of foreign exchange risk facing the Korean exporters. Especially, a 1% rise of exchange risk turned out to decrease Korea's export quantity by 1.0472% in the long-run and a 1% point rise of the variable lowers Korea's export quantity by 0.8994% point in the short- run. Therefore, it can be said that stabilizing exchanges rates is a very important policy concern to maintain stable export activities of Korean firms.

Based upon the estimation results of this paper, a few policy implications can be made as follows. First, higher exchange rate risk leads to the rise of export price, which results in the decline of export volume. Therefore, policy measures should be introduced to stabilize the exchange rate over time. The most important policy measure for the purpose is to establish firmly the forward market for foreign exchange. The current foreign exchange market should be developed and expanded to incorporate more forward transactions of foreign exchange.

In addition, it is well known that the material effect of the government intervention on the foreign exchange rate is rather weak and limited. Hence, the foreign exchange market intervention by the Bank of Korea should be very well designed and just in time. Otherwise, the central bank's intervention policy would aggravate the stability of foreign exchange market.

The short-run model proposed in this paper has considerably refined one-quarter ahead forecasting result than the long-run equilibrium model for the Korea's export quantity. This refined forecasting result will be very useful to the policy maker in charge of foreign exchange related policy measures in the short-run.

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