On the Structural Change in the Import Demand Behavior : the Korean Experience, 1971 – 1988**

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CONTENTS

1. Introduction

In the area of international trade, there have been a number of studies designed to explain the determinants of international trade flows. Especially, the question of magnitudes of the import demand to changes in the income and the price level is of eminent importance. Some studies such as Khan(1975), Bahmani-Oskooee(1986), Sarmad(1989) and Tegene (1989) have already applied this issue to developing countries. However, these studies dealing with the developing economies have ignored examining the structural stability of the import demand equations. Since Korean economy has recorded fast economic growth since early 1970s, its economic structure is open to the question of the structural stability.

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The purposes of this paper are ; first, to provide estimates of import demand functions for Korea using quarterly data with the optimal lag length selection through Akaike's final prediction error criterion, second, to check the stability of coefficients using a procecdure developed by Brown, Durbin and Evans(1975) that lets the data determine if and when structural change may have occurred, and, third, to perform some diagnostic tests (Ljung−Box(1978) test, Breusch−Pagan(1979) test and Shapiro−Wilk (1965) test).

The plan of the paper is in the following way. In section 2, we report the results of our estimating equations for Korean imports. We report in section 3 the results of structural change. Conclusions are given in section 4. Finally, the results based on the yearly data are appended for the purpose of comparison.

2. Estimates of Korean Import Demand

In this section, we present the empirical results of the Korean import demand function, based upon the quarterly data for the period 1971 : I−1988 : IV. Following earlier literature, we assume that real import demand is determined by domestic income and the relative price. Specification of the import demand function is the following :

$$\ln M(t)=a+\sum_{i=0}^{m} b(t-i)\ln Y(t-i)+\sum_{j=0}^{n} c(t-j)\ln(PM/PD)\ (t-j)+u(t)$$

where M is the volume of imports (import value divided by the import price index), Y is the real GNP for Korea, PM is the import price index including tariff rates, PD is the Korean wholesale price index, and u represents the normally distributed stochastic error term, which is assumed to have constant variance and to be serially uncorrelated. Considering that the import volume does not respond instantaneously to change in the explanatory variables, lags are included in the above equation.

In the above equation, $\sum_{i=0}^{m} b(t-i)$ and $\sum_{j=0}^{n} c(t-j)$ denote the long run income and

price elasticities, respectively. It is expected that the income elasticity and the price elasticity show positive[1] and negative signs, respectively.

Akaike's final prediction error (FPE) criterion[2] is adopted to find the optimal lag lengths, FPEs from the third order polynomial distributed lags are compared up to 8 quarters lags. The result showing the minimun FPE during the period of 1971 : I−1988 : IV is recorded in table 1. Long run income (.658) and price elasticities (−1.029) show the expected signs and are significantly different from zero. Unlike the assumption made in Wilson and Takacs (1979) or in Bahmani−Oskooee (1986), Korean experience in table 1 checked through FPE criterion shows that the response of import with respect to income is fairly long, i. e. 6 quarters.

3. Structural Change Test Results

In the results mentioned in the previous section, low value of the Durbin−Watson statistic (0.943) shows the existence of positive first order serial correlation. One of the plausible reasons might be structural change in the parameters. Given that we do not have any clear a priori knowledge of when change may have occurred, we employed the procedures, the cusum and the cusum of squares tests, designed by Brown, Durbin and Evans (1975) to determine directly from the data if and when structural change has occurred. These tests are based on the idea that the data says when the structural change occurred. Though a few studies dealing with the Brown, Durbin and Evans test have been made by some previous authors (Stern, Baum and Greene, (1979) and Deyak, Sawyer and Sprinkle (1989)), researches have not been tried with regard to any developing country. Considering the rapid growth of some developing economies, structural change seems to occur more often

1) See Magee (1975) for the case of negative income elasticity.

2) FPE criterion is well explained in Judge et. al. (1985), pp. 243−44. As for the application of the FPE criterion, see Tegene (1989) among others.

in a rapidly growing country such as Korea. Test results can be summarized in the following manner.

First, the cusum test provides strong evidence of instability in the Korean import sector, suggesting a breakpoint in our sample period at 1981 : I at the 1% level of significance.

Second, the cusum of squares test which is known to be generally more reliable than the cusum test (Kramer et. al. (1985)) was also performed, plotting the cumulated sum of squares of the recursive residuals over time. The result provides strong evidence of structural changes. Based on the cusum of squares test results, we can split the sample period into 3 subperiods at the 5% level of significance ; lst subperiod, running through 1979 : I, 2nd subperiod covering 1979 : II−1980 : IV and 3rd subperiod covering 1981 : I−1988 : IV.[3)]

Acknowledging the evidence of structural instability, we estimated the import demand equations again, depending on the division of subperiods. Estimation results in the period of 1981 : I−1988 : IV are reported in table 2. Results can be summarized in the following way. First, as seen in table 2, the degree of the first order serial correlation is not significant, unlike the result in table 1 where positive first order serial correlation was apparently revealed. Second, the response of import to income change is fairly long, i. e. 7 quarters. Significant responses of import to income are found at 4 to 6 quarters lags. Third, the long run income and price elasticities, 1.246 and −3.046, show the expected signs respectively. In addition, comparing the whole period (1971−1988) with the 1980s data period (1981−1988), the Korean imports have become more responsive to income or relative price changes over time.

After the parameters of the model have been estimated, diagnostic tests are performed on the residuals for the presence of serial correlation, heteroscedasticity and non-normality. The Ljung−Box (1978) test statistic for up to 10th order serial correlation in the residuals take the value $Q^*(10)=15.276$, which is not significant at the 5% level as

3) In case of using annual data without lag for the same data period, cusum of squares test also showed evidence (at the 10% level of significance) of structural change at 1981. See the Appendix for further details.

shown in table 3. That is, residuals are approximately uncorrelated over time. Normality of the regression residuals is also checked through Shapiro−Wilk (1965) test. The Shapiro−Wilk test statistic W is calculated as 0.938, which indicates no rejection of the hypothesized normality at any reasonable level of significance. Testing for the heteroscedasticity through Breusch−Pagan (1979) test, the chi−squared statistic is shown as 0.916, which indicates no rejection of the hypothesized homoscedasticity.

4. Conclusion

Adopting the elasticity approach, we estimated the import demand equation for Korea using quarterly data for the period of 1971 : I−1988 : IV. The result showed positive first order serial correlation. To check the structural stability, we performed structural change test suggested by Brown, Durbin and Evans (1975). The cusum and the cusum of squares tests showed constancy of the parameters to be broken at 1981. Acknowledging the structural break, the new estimation result using data after the break showed that the income and the price elasticities become more responsive over time. Finally, Ljung−Box (1978) test, Shapiro−Wilk (1965) test and Breusch−Pagan (1979) test results show that the regression residuals are approximately uncorrelated, normally distributed and homoscedastic.

〈Appendix〉

In this Appendix, we present the empirical results of the Korean import demand function, based upon yearly data for the period 1971−1988.[4] Following earlier authors, we assume that real import demand is determined by domestic income and the relative price. The

4) This Appendix is abridged from part of Mah (1991).

specification of the import demand function is as follows :

$$\ln M(t) = a_0 + a_1 \ln Y(t) + a_2 \ln(PM/PD)\ (t) + u(t)$$

where M is the volume of imports (import value divided by the import price index), Y is the real GNP for Korea, PM is the import price index including tariff rates (TR), IPI is the import price index without TR, i. e., PM = IPI × (1+TR), PD is the Korean whosesale price index, and u represents a stochastic error term, which is assumed to have constant variance and to be serially uncorrelated. In deriving M, PM is used as the denominator.

In the above equation, a_1 and a_2 denote the income and price elasticities, respectively. It is expected that the income elasticity (a_1) and the price elasticity (a_2) show positive and negative signs, respectively.

Employing a Cochrane−Orcutt iterative procedure in estimatig the equations, we report the estimation results based upon yearly data for 1971−1988 in the following :

$$\ln M(t) = -9.172 + 1.352 \ln Y(t) - 0.066 \ln(PM/PD)\ (t)$$
$$(-5.558)\ (12.494) \qquad (-0.320)$$
$$\bar{R}^2 = 0.946,\ D.\ W. = 1.472,\ rho = 0.678$$

where t ratios are in parentheses.

Income and price elasticities show the expected signs. Income elasticity is high and significantly different from zero. However, price elasticity is low in absolute value and not significant ; that is, relative prices do not exercise a significant influence on Korean imports. This is generally in line with a priori expectation that LDCs have a price−inelastic demand for imported goods.

The following is the estimation result in the case of separating tariff rate (TR) from the import price.

$$\ln M(t) = -20.793 + 1.331 \ln Y(t) + 0.014 \ln(IPI/PD)\ (t) + 1.235 \ln TR(t)$$
$$(-0.673)\ (11.749) \qquad (0.046) \qquad (0.038)$$
$$\bar{R}^2 = 0.939,\ D.\ W. = 1.404,\ rho = 0.642$$

In the above, estimated coefficients for the relative price and the tariff rate are not so satisfactory. It also suggests that raising tariffs would not be effective in reducing imports. Considering that inclusion of the tariff rate as additional independent variable does not ameliorate the results, we use the import price including the tariff rate, i. e. PM.

In the results mentioned in the above, high level of rhos shows the existence of positive first order serial correlation. One of the plausible reasons might be structural change in the parameters. Given that we do not have any clear a priori knowledge of when change may have occurred, we employed the procedures, the cusum and the cusum of squares tests, designed by Brown, Durbin and Evans (1975) to determine directly from the data if and when structural change has occurred.

First, the cusum test provides strong evidence of instability in the Korean import sector, suggesting a breakpoint in our sample period at 1986 at the 5% level of significance and at 1988 at the 1% level of significance.

Second, the cusum of squares test which is known to be generally more reliable than the cusum test was performed, plotting the cumulated sum of squares of the recursive residuals over time. The result provides evidence (10% significance level) of structural change at 1981.

Third, based on the cusum of squares test results, we split the sample period into 2 subperiods ; lst subperiod, covering 1971－1980 and 2nd subperiod, covering 1981－1988. We performed the conventional Chow (1960) test and the result shows the F value of 13. 307 at (3, 14) degrees of freedom, which indicates evidence of structural change even at the 1% level of significance. Though Chow test has been adopted by many researchers interested in the test for the stability, it is based on a strict assumption of equality of disturbance variances between the first and the second subperiod. Relaxing this assumption, we adopted Honda (1982) test which relies on the chi－square statistic. The calculated chi－square statistic was 174.279 with 3 d. f., which rejects the null hypothesis of no structural change at the 1% level of significance.

Acknowledging the evidence of structural instability, we estimated the import demand equations, splitting the data period into 2 subperiods. As seen in table 4, the degrees of the first order serial correlations are not significant in any of the 2 subperiods, unlike the result in the previous section where high degrees of serial correlations were revealed. Adjusted R^2 s are higher than one using the whole data period. Comparing the lst (1971−1980) with the 2nd subperiod (1981−1988), the Korean import over time may be less responsive to income change. Though sign of price elasticity shows unexpected one in the 2nd subperiod, it is not significantly different from zero and, consequently, the price competitiveness does not seem to play an evident role in changing the Korean import.

REFERENCES

Bahmani−Oskooee, M. (1986). "Determinants of International Trade Flows", *Journal of Development Economics,* Vol. 20, pp. 107−23.

Bank of Korea, 「Monthly Bulletin」, various issues.

Breusch, T. S. and A. R. Pagan (1979). "A Simple Test for Heteroscedasticity and Random Coefficient Variation", *Econometrica,* Vol. 47, pp. 1287−94.

Brown, R. L., Durbin, J. and J. M. Evans (1975). "Techniques for Testing the Constancy of Regression Relationships over Time", *Journal of Royal Statistical Society,* series B, Vol. 337, pp. 149−92.

Deyak, T. A., Sawyer, W. C. and R. L. Sprinkle (1989). "An Empirical Examination of the Structural Stability of Disaggregated U. S. Import Demand", *Review of Economics and Statistics,* Vol. 71, pp. 337−41.

Goldstein, M. and M. Khan (1985). "Income and price effects in foreign trade", In R. W. Jones and P. B. Kenen, eds., 「Handbook of International Economics」, Vol. 2, Amsterdam, North−Holland.

Honda, Y(1982). "On tests of Equality between sets of Coefficients in Two Linear Regres-

sions when Disturbance Variances are unequal", *The Manchester School,* Vol. 50, pp. 116－125.

Judge, G. G., Griffiths, W. E., Hill, R. C., Lutkepohl, H. and T. Lee (1985). 「The Theory and Practice of Econometrics」, 2nd ed., New York, John Wiley and Sons.

Khan, M. (1975). "The Structure and Behavior of Imports of Venezuela", *Review of Economics and Statistics,* Vol. 57, pp. 221－24.

Kramer, W., Sonnberger, H., Maurer, J. and P. Havlik (1985). "Diagnostic Checking in Practice", *Review of Economics and Statistics,* Vol. 67, pp. 118－23.

Ljung, G. M. and G. E. P. Box (1978). "On a measure of lack of fit in time series models", *Biometrika,* Vol. 65, pp. 297－303.

Magee, S. P. (1975). "Prices, income and foreign trade : A Survey of recent economic studies", In P. B. Kenen, ed., 「International Trade and Finance : Frontiers for Research」, Cambridge, Cambridge University Press.

Mah, J. (1991). "On the Behavior of Import Demand of Korea", *Asian Economic Journal,* forthcoming.

Sarmad, K. (1989). "The Determinants of Import Demand in Pakistan", *World Development,* Vol. 17, pp. 1619－1625.

Shapiro, S. S. and M. B. Wilk (1965). "An analysis of variance test for normality", *Biometrika,* Vol. 52, pp. 591－611.

Stern, R. M., Baum, C. F. and M. N. Greene (1979). "Evidence on Structural Change in the Demand for Aggregate U. S. Imports and Exports", *Journal of Political Economy,* Vol. 87, pp. 179－92.

Tegene, A. (1989). "On the effects of relative prices and effective exchange rates on trade flows of LDCs", *Applied Economics,* Vol. 21, pp. 1447－63.

Table 1. Real Import Demand Equation for Korea, 1971 : I—1988 : IV

Variables \ lags	0	1	2	3	4	5	6	long run elasticity
constant	−.739							
	(−.787)							
lnY	−.123	−.458	−.156	.154	.394	.489	.359	.658
	(−1.403)	(−4.118)	(−1.925)	(3.264)	(5.301)	(4.750)	(4.241)	
ln(PM/PD)	−.923	.561	−.350	.333	−.649			−1.029
	(−2.608)	(1.136)	(−.704)	(.680)	(−2.050)			

Notes : $\overline{R}^2$ = .964, D. W. = .943, t values are in parentheses. The estimated results are based on the third order Almon distributed lags. Lags are selected based on Akaike's final prediction error criterion.

Table 2. Real Import Demand Equation for Korea, 1981 : I—1988 : IV

Variables \ lags	0	1	2	3	4	5	6	7	long run elasticity
constant	−1.118								
	(−.650)								
lnY	.227	−.122	.013	.164	.287	.340	.278	.059	1.246
	(1.765)	(−.898)	(.082)	(1.120)	(2.710)	(3.244)	(2.109)	(.404)	
ln(PM/PD)	−1.549	1.353	.523	.289	−3.662				−3.046
	(−2.308)	(1.649)	(.655)	(.361)	(−5.496)				

Notes : $\overline{R}^2$ = .968, D. W. = 2.213, t values are in parentheses. The estimated results are based on the third order Almon distributed lags. Lags are selected based on Akaike's final prediction error criterion.

Table 3. Diagnostic Checking Results, 1981 : I－1988 : IV

Test	Statistic	Result
Ljung－Box (1978)	Q*(10) = 15.276	H_0 of no serial correlation up to 10th order is not rejected.*)
Shapiro－Wilk (1965)	W(24) = .938	H_0 of normal distribution is not rejected.*)
Breusch－Pagan (1979)	$X^2(2)$ = .916	H_0 of homoscedasticity is not rejected.*)

Note : *denotes the 5% level of significance.

Table 4. Real Import Demand Equation for Korea

Periods	Estimates				
	lnY	ln (PM/PD)	$\overline{R}^2$	D.W.	rho
1971－1980	1.885	－0.020	0.973	1.828	0.087
	(18.766)	(－0.131)			
1981－1988	0.981	0.450	0.971	1.930	0.060
	(17.610)	(1.077)			

Notes : T ratios are in parentheses. Following the cusum of squares test result, we divided our data period into the above－mentioned 2 subperiods. Yearly data are used in this table.

국 문 요 약

이 논문은 먼저 1971년 ~ 1988년중 한국 수입수요함수의 추정을 의도한다. 다음으로, 개발도상국 경제에서 흔히 발생하기 쉬운 구조변화의 가능성을 고려하여, 추정된 계수의 안정성을 검증하고자 한다. 브라운, 더빈과 에반스에 의한 큐점과 큐점자승 검증을 행해본 결과 파라미터의 불변성은 1981년경 깨지는 것으로 보여진다. 구조변화 이후의 자료에만 근거한 추정결과는 소득탄력성과 가격탄력성 모두가 시간 경과에 따라 보다 탄력적으로 바뀌어감을 알 수 있다. 최종적으로, 회귀잔차들은 룽-박스 검증, 브루쉬-페이건 검증과 샤피로-윌크 검증을 모두 통과하는 것으로 나타나 80년대의 수입수요함수는 진단 검증에 있어서 문제가 없는 것으로 보인다.

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