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The Marshall-Lerner condition at commodity level: Evidence from Korean-U.S. trade

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Abstract

The Marshall-Lerner condition asserts that a devaluation or depreciation will improve the trade balance if sum of price elasticities of import and export demand exceeds unity. Almost all previous studies estimated the condition using aggregate trade data. A new group is now emerging which uses data at commodity level to reduce aggregation bias. We add to this latter group by estimating the Marshall-Lerner condition using commodity prices from 10 single digit industries that trade between Korea and the U.S. We find support for the Marshall-Lerner condition in four industries. These four industries engage in almost 65% of the trade between the two countries.

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1. Introduction

A devaluation, or currency depreciation, is said to improve a country's trade balance in the long run only if the sum of the price elasticities of import and export demand is greater than one. This condition, known as the Marshall-Lerner condition, has been the subject of analysis and estimation by many researchers. Since import and export price indexes are available between one country and the rest of the world, researchers find it more convenient to estimate the relative price elasticities between one country and the rest of the world and establish the validity of the Marshall-Lerner condition. The sample includes Kreinin (1967), Houthakker and Magee (1969), Khan (1974), Goldstein and Khan (1978), Warner and Kreinin (1983), Gylfason and Risager (1984), Bahmani-Oskooee (1986, 1998), Rose (1991), Bahmani-Oskooee and Niroomand (1998), Marquez (1999), Caporale and Chui (1999), and Bahmani-Oskooee and Kara (2005).

Some of the above studies have included our country of interest, Korea, in their sample. Gylfason and Risager (1984) report price elasticities of -2.5 for Korean exports and -0.8 for Korean imports, supporting the Marshall-Lerner condition. However, when Bahmani-Oskooee (1986) estimated the price elasticities using data from the current float, his estimates failed to support the condition for Korea. These findings could be spurious since no unit root and no cointegration analysis were performed on the variables individually and all together. Bahmani-Oskooee (1998) then used Johansen's cointegration technique to verify cointegration and reported price elasticities for Korea that added to more than unity, supporting the Marshall-Lerner condition. The same was verified by Bahmani-Oskooee and Niroomand (1998) and Bahmani-Oskooee and Kara (2005), with updated data and a different estimation method.

The findings from the above studies are mixed for many countries including Korea. One contributing factor is said to be aggregation bias, i.e., a significant price elasticity with one trading partner could be more than offset by an insignificant price elasticity with another partner. To reduce the bias, one should estimate these elasticities between two countries. However, since import and export price indexes are not available between two countries, no study has attempted to do so. Another option is to again concentrate on the trade between two countries and disaggregate their trade flows by commodity. It is then important to estimate the price elasticities for each commodity or industry that trade between the two countries, provided prices are available. Some studies of this approach of disaggregation was originally introduced by Kreinin (1967) and Houthakker and Magee (1969). Kreinin (1967) estimated import demand elasticities for several industrial countries for three groups of manufactures: chemicals, machinery and transport equipments and other manufactures using panel data. There are two shortcomings associated with Kreinin's study. First, since he used panel data, his estimates also suffer from aggregation bias in that whatever is true for one country may not be true for another country. Second, since he did not estimate export demand, we cannot judge the validity of the Marshall-Lerner condition. Houthakker and Magee (1969), however, who estimated both import and export demand elasticities for 29 countries, also estimated import demand elasticites of the U.S. for five industries. While the Marshall-Lerner condition was satisfied for the U.S. using aggregate trade flows, we cannot judge it for each of the five industries since no estimates of export demand were provided for the same industries.

Those who come across import and export price data at the commodity level are joining this later group and Bahmani-Oskooee and Hosny (2013, 2014) are two recent additions. Bahmani-Oskooee and Hosny (2013) estimated import and export demand elasticities, for each of the 59 industries that trade between Egypt and the European Union using the most recent data and showed that the Marshall-Lerner condition holds in 39 cases. Among the 39 industries there were both small and large industries. Bahmani-Oskooee and Hosny (2014) carried out the same analysis and estimated the import and export demand elasticities for 36 industries that trade between Egypt and the U.S. Support for the Marshall-Lerner condition was reported in 28 cases.

It is clear that there is much room to expand the latter group of studies at the industry level whenever commodity prices become available. We have come across import and export prices for 10 single digit industries that trade between Korea and the U.S. and intend to estimate import and export demand price elasticities to determine if the Marshall-Lerner condition holds at industry level. To that end, we outline the models and explain the estimation method in Section II. We report the results in Section III with a summary in Section IV. Definition of variables and sources of data are provided in an Appendix.

2. The Model and the Method[1]

Following Bahmani-Oskooee and Hosny (2013), we assume that the Korean demand for goods imported by industry i from the U.S. takes the following form:

$$\ln M_t^i = \alpha + \beta \ln Y_{KOR,\ t} + \lambda \ln \left(\frac{PM_i}{PD_{KOR}}\right)_t + \varepsilon_t \quad (1)$$

Where M^i is the volume of commodity i imported by Korea from the U.S. It is assumed that Korean income, Y_{KOR}, and import price of the commodity i, PM_i, relative to domestic price level in Korea, PD_{KOR}, are the two main determinants of Korean imports. The Korean domestic price level is included in the specification to account for some degree of substitution between imports of commodity i and close substitutes produced in Korea. We expect an estimate of β to be positive and that of λ to be negative.[2]

In order to obtain relatively more stable coefficient estimates, it is now recommended that in estimating (1), the short-run dynamic adjustment mechanism be incorporated into the estimation procedure. This goal usually is achieved by specifying (1) as an error-correction model. Again, we follow Pesaran *et al.* (2001) and Bahmani-Oskooee and Hosny (2013) and rely upon the following specification:

$$\Delta \ln M_t^i = a + \sum_{j=0}^{n} b_j \Delta \ln Y_{KOR,t-j} + \sum_{j=0}^{n} c_j \Delta \ln\left(\frac{PM_i}{PD_{KOR}}\right)_{t-j} + \sum_{j=1}^{n} d_j \Delta \ln M_{t-j}^i$$
$$+ \sigma_0 LnM_{t-1}^i + \sigma_1 \ln Y_{KOR,t-1} + \sigma_2 \ln\left(\frac{PM}{PD_{KOR}}\right)_{t-1} + u_t \quad (2)$$

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[1] The models and the method in this paper closely follow Bahmani-Oskooee and Hosny (2013).

[2] As argued by Bahmani-Oskooee (1986) and others, it is possible for income elasticity to be negative. As the Korean economy grows, Korea may produce more substitute goods, hence reducing her imports of commodity i.

In (2) Pesaran *et al.* (2001) recommend applying the F-test to establish the joint significance of the lagged level variables as a sign of cointegration.[3] They also provide new critical values that account for the degree of integration of the variables. Indeed, variables could be I(0) or I(1), which are characteristics of almost all macro variables. Hence, there is no need for pre unit-root testing. Once (2) is estimated, the coefficient estimates of the first-differenced variables reflect short-run effects. The long-run effects, i.e., the income and price elasticities in (2) are obtained by the estimates of σ_1 and σ_2 that are normalized on σ_0.[4]

Next, we formulate the U.S. demand for Korean exports of commodity i (X^i) as a function of U.S. income (Y_{US}) and the relative price of exports (PX_i) over U.S. domestic price level (PD_{US}) as in (3):

$$\ln X_t^i = \alpha' + \beta' \ln Y_{US,t} + \lambda' \ln \left(\frac{PX_i}{PD_{US}}\right)_t + \varepsilon'_t \quad (3)$$

Once again, we expect an estimate of β' to be positive and that of λ' to be negative. Furthermore, the error-correction model associated with (3) takes the following form:

$$\Delta \ln X_t^i = \mu + \sum_{j=0}^{m} \varphi_j \Delta \ln Y_{US,t-j} + \sum_{j=0}^{m} \psi_j \Delta \ln\left(\frac{PX_i}{PD_{US}}\right)_{t-j} + \sum_{j=1}^{m} \phi_j \Delta \ln X_{t-j}^i + \theta_0 \ln X_{t-1}^i + \theta_1 \ln Y_{US,t-1} + \theta_2 \ln\left(\frac{PX_i}{PD_{US}}\right)_{t-1} + v_t \quad (4)$$

Again, once (4) is estimated, the short-run effects are inferred by the estimates of coefficients attached to first-differenced variables and the long-run effects are judged by the estimates of θ_1 and θ_2 normalized on θ_0. The Marshall-Lerner condition will be satisfied if the normalized relative price elasticities are negative in both models (2) and (4) and their absolute values add up to more than one.[5]

3. The Results

We are now in a position to estimate error-correction models (2) and (4) for each of the 10 industries that trade between Korea and the U.S. using quarterly data over the 1991Q1-2012Q4 period.[6] Following Bahmani-Oskooee and Hosny (2013), a maximum of six lags is imposed on each first differenced variable and Akaike's AIC criterion is used to select the

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[3] Note that the lagged level variables are equal to the lagged error term from (1) in an Engle-Granger (1987) set up.
[4] For details of normalization see Bahmani-Oskooee and Tanku (2008) and for some other application of this approach see Bahmani-Oskooee and Hegerty (2007, 2013), Halicioglu, F., (2007), Narayan et al. (2007), Tang (2007), Mohammadi et al. (2008), Wong and Tang (2008), De Vita and Kyaw (2008), Payne (2008), Bahmani-Oskooee and Gelan (2009), Dell'Anno, R. and Halicioglu, F. (2010), Chen and Chen (2012),Wong (2013), and Tayebi, S. K., and M. Yazdani, (2014).

[5] Others have used traditional approaches to estimate import and export demand models. Examples include King (1993), Alse and Bahmani-Oskooee (1995), Charos et al. (1996),Truett and Truett (2000), Du and Zhu (2001), Love and Chandra (2005), Agbola and Damoense (2005), Narayan and Narayan (2005), and Narayan et al. (2007)..
[6] As mentioned in the previous section, variables could be a combination of I(0) and I(1). We, therefore, applied the ADF test to all second-differenced variables and made sure that the second-differenced variables are stationary. These results are available from the authors upon request.

optimum lags. All reported results are, therefore, for each optimum model. Since the Marshall-Lerner condition is a long-run condition, we only report the long-run coefficient estimates and make the short-run results available upon request. While Table 1 reports the estimates of the import demand model, Table 2 does the same for the export demand model.

Noting that a significant estimate is denoted by at least one *, we gather from Table 1 that the relative import price term carries a negative and significant coefficient in industries coded SITC7, SITC8, and SITC9. These three industries engage in more than 64% of Korean trade, as reflected by their trade shares. All three industries seem to be price elastic since the price elasticities are greater than one. Korean income carries a significant coefficient in four different industries. While in SITC5 and SITC8 the income elasticity is positive, in SITC1 and SITC4 it is negative. The negative elasticity in these latter two industries imply that as the Korean economy grows, Korea produces more of close substitute goods that belong to these two industries, which reduces her imports. The results of the F test reveal that these long-run estimates are meaningful in industries SITC1, SITC4, and SITC6. In industries SITC7 and SITC8 in which at least income or relative prices carried significant coefficient, following the literature we use an alternative test. Using normalized coefficients and equation (1) we generate the error term and call it ECM. We then replace the linear combination of lagged level variables in (2) by ECM_{t-1} and estimate the new model after imposing the same optimum lags. A significantly negative coefficient signifies convergence toward long-run equilibrium, which is indeed the case in all industries.

Four other diagnostics are reported in Table 1. The Lagrange Multiplier (LM) statistic is reported to check for autocorrelation. Since data are quarterly, it is distributed as χ^2 with four degrees of freedom with a critical value of 9.48. Apparently, none of the optimum models suffer from serial correlation since there is no significant LM statistic in any model. Ramsey's RESET statistic is also reported. It also has a χ^2 distribution but with one degree of freedom. It appears that only in models belonging to SITC2 and SITC9 the RESET statistic is significant, supporting misspecification. However, since these two industries together engage in less than 5% of the trade, the issue cannot be too serious. We have also applied the CUSUM and CUSUMSQ tests to determine stability of the short-run and long-run coefficient estimates. Stable coefficients are denoted by "S" and unstable ones by "U". It is clear that almost all estimates are stable. Finally, we have reported the size of adjusted R^2 to judge the fitness of the models.[7]

We now shift to Table 2 and consider the estimates of the demand by the U.S. for Korean exports. It appears that as one of Korea's major partners, U.S. income is a main long-run determinant of Korean exports in all industries, since it carries a positive and significant coefficient. The exception is SITC8. The relative price term carries a negative and significant coefficient in SITC7, SITC8, and SITC9. These three industries engage in more than 64% of trade and that makes the relative price term a significant player. Since in every industry at least either income or the relative prices is significant, we expect the F test to be significant in all industries for cointegration. This is the case in all industries, except in SITC1 and SITC9. In these latter two industries, cointegration is supported by $ECM_{t-1.}$ Furthermore, since there is no significant LM nor RESET statistic, all models are autocorrelation free and correctly specified. Estimated coefficients are stable, as reflected by the CUSUM and CUSUMSQ tests and the models enjoy good fit, reflected by the size of the adjusted R^2.

[7] For a graphical presentation of the CUSUM and CUSUMSQ tests see Bahmani-Oskooee *et al.* (2005).

From Tables 1 and 2 we gather that the Marshall-Lerner condition is satisfied in four industries coded SITC1, SITC7, SITC8, and SITC9, i.e., the sum of the absolute values of import and export price elasticities exceed unity. Although price elasticities are individually significant, their sum is also significant as evidenced by the significance levels provided in Table 3. Since these four industries have more than 64% of the market share, the depreciation of the Korean won should improve the Korean trade balance in the long run.[8]

4. Summary and Conclusion

If the sum of the price elasticities of import and export demands of a country adds up to more than one, a devaluation by the government or currency depreciation due to market forces, is expected to improve the trade balance in the long run. This condition, known as the Marshall-Lerner condition, now has its own literature and has been subjected to empirical tests by many. The majority of the studies found it convenient to estimate the import and export demands between one country and the rest of the world, mostly because the import and export price indexes are available for aggregate trade flows of each country with the rest of the world. These studies are said to suffer from aggregation bias.

To reduce the bias, there is now a second group of studies that concentrate on trade flows between two countries and use disaggregated data at the commodity level. This group, that has just emerged recently, includes two studies by Bahmani-Oskooee and Hosny (2013, 2014). While Bahmani-Oskooee and Hosny (2013) estimated the price elasticities for each of the 59 industries that trade between Egypt and the European Union, Bahmani-Oskooee and Hosny (2014) did the same for each of the 36 industries that trade between Egypt and the U.S. The first study provided support for the Marshall-Lerner condition in 39 industries and the second study in 28 industries.

Now that we have come across commodity prices for 10 single digit industries that trade between Korea and the U.S., we try to add to the latter group by estimating the Marshall-Lerner condition. The estimates reveal that the condition is met in four out of 10 industries. The four industries engage in almost 64% of the trade between the two countries. We can then conclude that depreciation of the Korean won will help these four large industries.

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[8] Note that industries in which the Marshall-Lerner condition is not met and currency depreciation is not effective, import and export prices could be subject to "pricing to the market" by foreign supplies where foreign suppliers adjust the prices that they charge to maintain their market share and therefore, offset the effects of exchange rate changes. Krugman (1986) provides alternative models addressing "pricing to market" but concludes that the evidence is not sufficient to distinguish one model from the other.

Appendix
Data Definition and Sources

Quarterly data over the 1991Q1-2012Q4 period are used to carry out the empirical analysis. The data sources are as follows:

a. Korea Trade Statistics, Korea International Trade Association (KITA).
b. Organization for Economic and Cooperation Development (OECD).
c. Korea Statistical Information Service, Republic of Korea.

Variables:

*M*i = For each commodity i, *M* is the volume of Korean imports from the United States. It is defined as the ratio of the value of Korean imports from the United States (US) over the respective import price of commodity i. The imports value data for 10 industries come from source a and import prices from source c.

*X*i = For each commodity i, *X* is the volume of Korean exports to the United States. It is defined as the ratio of Korean exports to the United States (US) over the respective export price of commodity i. The exports value data for 10 industries come from source a and export prices from source c.

Y^{US} = United States real GDP. The data come from source b.

Y^{KOR} = Korean real GDP. The data come from source b.

PM_i = For each commodity i, *PM* is import price of commodity i , source c.

PD = domestic price level in Korea. CPI data are used as a proxy for *PD* come from source b.

PX_i = For each commodity i, *PX* is defined as export price of commodity i, source c.

P^{US} = the price level in US. CPI data (used as a proxy for P^{US}) come from source b.

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Table 1: Coefficient estimates and diagnostic tests – *Import demand model*

	SITC Description (Trade Share)	ln Y_{KR}	ln PM/PD	Constant	F	ECM_{t-1}	LM	RESET	CUSUM (SQ)	Adj R^2
0	**Food and live animals (5.14%)**	0.42	0.11	7.12***	4.55*	-0.30***	1.50	0.01	S(S)	0.29
1	**Beverage and tobacco (0.20%)**	-0.92**	-1.12*	10.10***	14.22***	-0.64***	2.71	1.98	S(S)	0.38
2	**Crude material, inedible, except fuels (4.59%)**	-0.49	-0.32	11.31***	3.81	-0.21***	1.28	7.00***	S(U)	0.40
3	**Mineral fuels, lubricants and related materials (5.26%)**	-1.61	0.25	15.12	4.35*	-0.57***	1.80	0.00	S(S)	0.17
4	**Animal and vegetable oils, fats and waxes (0.03%)**	-0.98**	0.01	9.44***	7.81***	-0.45***	0.01	0.15	S(U)	0.20
5	**Chemicals and related products (9.27%)**	1.84*	-1.11	1.39	2.32	-0.11*	0.61	1.53	S(S)	0.53
6	**Manufactured goods classified chiefly by material (11.32%)**	0.47	-0.36	6.36**	4.19*	-0.18***	0.01	0.72	S(S)	0.59
7	**Machinery and transport equipment (56.11%)**	0.37	-1.17**	9.52***	1.74	-0.15**	0.03	0.02	S(S)	0.55
8	**Miscellaneous manufactured articles (8.02%)**	1.24***	-2.39***	5.23***	3.08	-0.25***	0.20	0.07	U(S)	0.73
9	**Commodities and transactions not classified elsewhere (0.06%)**	-6.60	1.00	34.97*	1.71	-0.15**	0.24	4.93**	S(S)	0.19

Notes:

a. *** Significant at the 1% significance level, ** at 5%, * at 10%.
b. Trade share next to the name of each industry is defined as sum of imports and exports of that industry as a percent of total Korean imports and exports.
c. The upper bound critical value for the F-test at the 10% (5% and 1%) significance level is 4.14 (4.85 and 6.36). These come from Pesaran *et al.* (2001).

Table 2: Coefficient estimates and diagnostic tests – *Export demand model*

	SITC Description	*ln Y_{US}*	*ln PX/P_{US}*	*Constant*	*F*	*ECM_{t-1}*	*LM*	*RESET*	*CUSUM (SQ)*	*Adj R^2*
0	**Food and live animals**	3.70**	-0.39	-9.31	5.30**	-0.09*	0.44	3.46	S(S)	0.80
1	**Beverage and tobacco**	3.17**	-0.39	-9.10	2.42	-0.49*	1.06	0.15	S(S)	0.64
2	**Crude material, inedible, except fuels**	2.04***	-0.01	-2.69**	8.88***	-0.43***	0.28	2.86	S(S)	0.29
3	**Mineral fuels, lubricants and related materials**	3.15*	0.04	-5.77	5.62**	-0.59***	1.31	1.38	S(S)	0.40
5	**Chemicals and related products, nes**	2.64***	0.14	-3.58***	9.55***	-0.83***	0.00	0.10	S(S)	0.63
6	**Manufactured goods classified chiefly by material**	1.66***	0.18	1.90	6.00**	-0.25**	0.05	1.26	S(S)	0.51
7	**Machinery and transport equipment**	2.33***	-1.05***	1.06	9.80***	-0.52***	0.05	0.22	S(S)	0.57
8	**Miscellaneous manufactured articles**	-1.09***	-1.07***	14.38***	6.28**	-0.35***	0.48	2.07	S(S)	0.47
9	**Commodities and transactions not classified elsewhere**	10.79***	-2.12*	-45.06**	4.10	-0.27***	0.26	0.05	S(U)	0.11

Notes:

a. *** Significant at the 1% significance level, ** at 5%, * at 10%.
b. Trade share next to the name of each industry is defined as sum of imports and exports of each industry as a percent of toal Korean imports and exports.
c. The upper bound critical value for the F-test at the 10% (5% and 1%) significance level is 4.14 (4.85 and 6.36). These come from Pesaran *et al.* (2001).
d. SITC4 in the export model is excluded due to lack of export price index for this industry.

Table 3: Estimates of 90% Confidence Bands for Four Industries

	SITC Description (Trade Share)	$\lvert\lambda\rvert + \lvert\lambda'\rvert$	**90% confidence band**
1	**Beverage and tobacco (0.20%)**	1.12 (1.67)*	(0.01, 2.25)
7	**Machinery and transport equipment (56.11%)**	2.22 (3.03)***	(0.05, 2.39)
8	**Miscellaneous manufactured articles (8.02%)**	3.46 (5.63)***	(1.37, 3.41)
9	**Commodities and transactions not classified elsewhere (0.06%)**	2.12 (1.86)*	(0.89, 2.89)

Notes:

a. *** Significant at the 1% significance level, ** at 5%, * at 10%.

b. Following Bahmani-Oskooee and Ardalani (2006, footnote 10), we calculate the standard error of the sum of import and export price elasticity ($\lvert\lambda\rvert + \lvert\lambda'\rvert$) for which the ML is satisfied. We then use these standard error to calculate the *t*-ratio and confidence bands for the sum.