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Korean Trade Flows and the S-Curve*

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Over the last few decades Korea has relied upon export promotion policies and has enjoyed substantial increase in its trade with the rest of the world including China which has replaced the U.S. as major trading partner of Korea. Is Korea's trade sensitive to changes in the value of won? The S-Curve hypothesis is used to answer this question. At bilateral level the answer was in the affirmative only in limited number of countries which excluded China. At commodity level between Korea and China, only 32 out of 96 industries seemed to benefit from won depreciation. The 32 industries were all small.

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1. INTRODUCTION

Two closely related concepts in economics are used to assess the response of the trade balance to currency depreciation in the short run. The first known as the J-Curve hypothesis introduced originally by Magee in 1973 and the second known as the S-Curve hypothesis introduced by Backus *et al*. in 1994. Both hypotheses rely upon a notion that once a currency is devalued or is depreciated, the trade balance does not adjust instantaneously. Indeed, due to adjustment lags, trade balance improves only down the road and in the future. Bahmani-Oskooee and Hegerty (2010) review both concepts in detail. Basically, while testing the J-Curve hypothesis is based on estimating a reduced form trade balance model through regression analysis, testing the S-Curve is based upon correlation analysis between the past and future values of the trade balance and the current exchange rate.[1)]

Since this paper deals only with the S-Curve, a very brief introduction to concept is in order. As mentioned, the concept was originally introduced by Backus *et al*. (1994) when they based the relation between the trade balance and the terms of trade or real exchange rate on cross-correlation analysis. They demonstrated that since currency depreciation today affects the trade balance favorably tomorrow (due to adjustment lags), we expect cross-correlation between the current exchange rate and future values of the trade balance to be positive. However, the same cross-correlation between current exchange rate and past values of the trade balance is expected to be negative. Intuitively, this is because an increase in the past trade balances (i.e., surpluses) is expected to cause currency appreciation today.[2)]

Backus *et al.* (1994) provided mixed results when they used aggregate trade flows of each of the 11 OECD countries with the rest of the world to empirically test the S-Curve. Subsequent studies that followed Backus *et al*. (1994) and used aggregate trade flows of one country with the rest of the world also provide mixed support for the S-Curve. They include Senhadji

[1)] For J-Curve effect in Korea see Buyangerel and Kim (2013).
[2)] Note that it is assumed that an increase in the exchange rate reflects depreciation.

(1998) who tested the S-Curve for 30 developing countries; Parikh and Shibata (2004) who tested the phenomenon for 14 Asian countries, 25 African countries, and 20 Latin American countries, and Bahmani-Oskooee, Kutan, and Ratha (2008) who tested the phenomenon for 10 emerging countries of Bulgaria, Croatia, Cyprus, Czeck Republic, Hungary, Poland, Romania, Russia, Slovak, and Turkey.

As mentioned, all of the above studies used aggregate trade flows of one country with the rest of the world. Bahmani-Oskooee and Ratha (2007a) then pointed out that the failure to support the S-Curve could be due to aggregation bias. They concentrated on the U.S. trade with the rest of the world and disaggregated the U.S. data by trading partners and empirically tested the S-Curve between the U.S. and each of her 24 major trading partners. This approach provided more support for the S-Curve at bilateral level. Additional support at bilateral level was provided for the S-Curve when Bahmani-Oskooee and Ratha (2007b) tested the curve between Japan and her trading partners and by Bahmani-Oskooee and Zhang (2013) between China and her major trading partners.

Since this paper is concerned with Korea's experience, it should be mentioned that Korea was included in Senhadji (1998) and Parikh and Shibatha (2004) who provided support for the S-Curve between Korea and rest of the world. The question we ask in this paper, do all major trading partners of Korea conform to the S-Curve, i.e., does Korea enjoy an improvement in her trade balance with all of its trading partners or are there partners that do not contribute to Korea's trade balance improvement. To get some idea about major trading partners of Korea, we identify them in table 1 using share of Korea's exports and imports. The ranking that is based on Korea's export shares reveal China as the major partner.

Section 2 of the paper introduces the method of generating the S-Curve. The results are then reported in section 3 with a summary and conclusion in section 4. Data definition and sources are discussed in an Appendix.

Table 1 Korean Exports to & Imports from Major Partners in 2011 (Billions of Dollars)

Rank	Partner	Exports	Imports
1	China	134.205	86.426
2	U.S.	56.417	44.816
3	Japan	39.712	68.302
4	Hong Kong	30.974	2.315
5	Singapore	20.855	8.965
6	Indonesia	13.563	17.216
7	India	12.685	7.893
8	Vietnam	13.550	5.084
9	Brazil	11.824	6.340
10	Mexico	9.728	2.314
11	Germany	9.508	16.959
12	Thailand	8.468	5.411
13	Australia	8.163	26.322
14	Liberia	7.346	1.2 m. $
15	Philippines	7.343	3.571
16	U.A.E.	7.266	14.759
17	Saudi Arabia	6.965	36.975
18	Malaysia	6.276	10.464
19	Iran, I.R.	6.078	11.333
20	France	5.759	6.317
21	U.K.	5.480	3.812
22	Turkey	5.086	0.804
23	Canada	4.930	6.609
24	Netherlands	4.628	4.424
25	Italy	4.109	4.371

2. THE METHOD

Backus *et al*. (1994) who first introduced the S-Curve concept showed that while cross-correlations between past values of the trade balance and current exchange rate are negative, the same correlations between future values of the trade balance and current exchange rate are positive. Therefore, the task of producing the S-Curve is reduced to one of calculating cross-correlation coefficients and plotting them against the lags and leads used to generate these cross-correlation coefficients. However, the trade balance and the exchange rate must define in a manner that if exchange rate depreciation is to improve the trade balance, contemporaneous correlation must be positive. To this end, we follow all previous studies and define Korea's trade balance with trading partner J as $TB_J = (X_J - M_J)/GDP)$ where X_J is Korea's exports to trading partner J and M_J is Korea's imports from the same partner, and GDP is Korea's Gross Domestic Product. All variables are in U.S. nominal dollars. The real bilateral exchange rate is defined as $REX = (P_J \cdot NEX)/P_K)$ where *NEX* is the nominal bilateral exchange rate defined as number of Korean won per country *J*'s currency; P_K is Korean price level, and P_J is the price level in trading partner *J*. Clearly the definition of *REX* is dominated by the definition of *NEX* and both definitions reflect won depreciation by an increase in either *NEX* or *REX*.

Given the two variables *TB* and *REX*, we next define cross-correlation coefficients between the past and future values of *TB* and current *REX* by:

$$\rho_k = \frac{\sum (REX - \overline{REX})(TB_{t+k} - \overline{TB})}{\sqrt{\sum (REX_t - \overline{REX})^2 (TB_{t+k} - \overline{TB})^2}}. \qquad (1)$$

In (1) $\overline{REX}$ and $\overline{TB}$ are the mean values of the two variables over the sample period. By allowing k to take negative values such as –5, –4, –3, –2, –1, we calculate cross-correlation coefficients between past trade balances and the current real exchange rate and by allowing k to take positive values such as 1, 2, 3, 4, 5, we calculate cross-correlation coefficients between

current exchange rate and future trade balances. Plot of these cross-correlation coefficients against the values of *k* will produce the S-Curve which we do this in the next section. Note that in order to avoid spurious correlation, we use de-trended data that is generated Hodrich-Prescott (HP) filter.

3. THE RESULTS

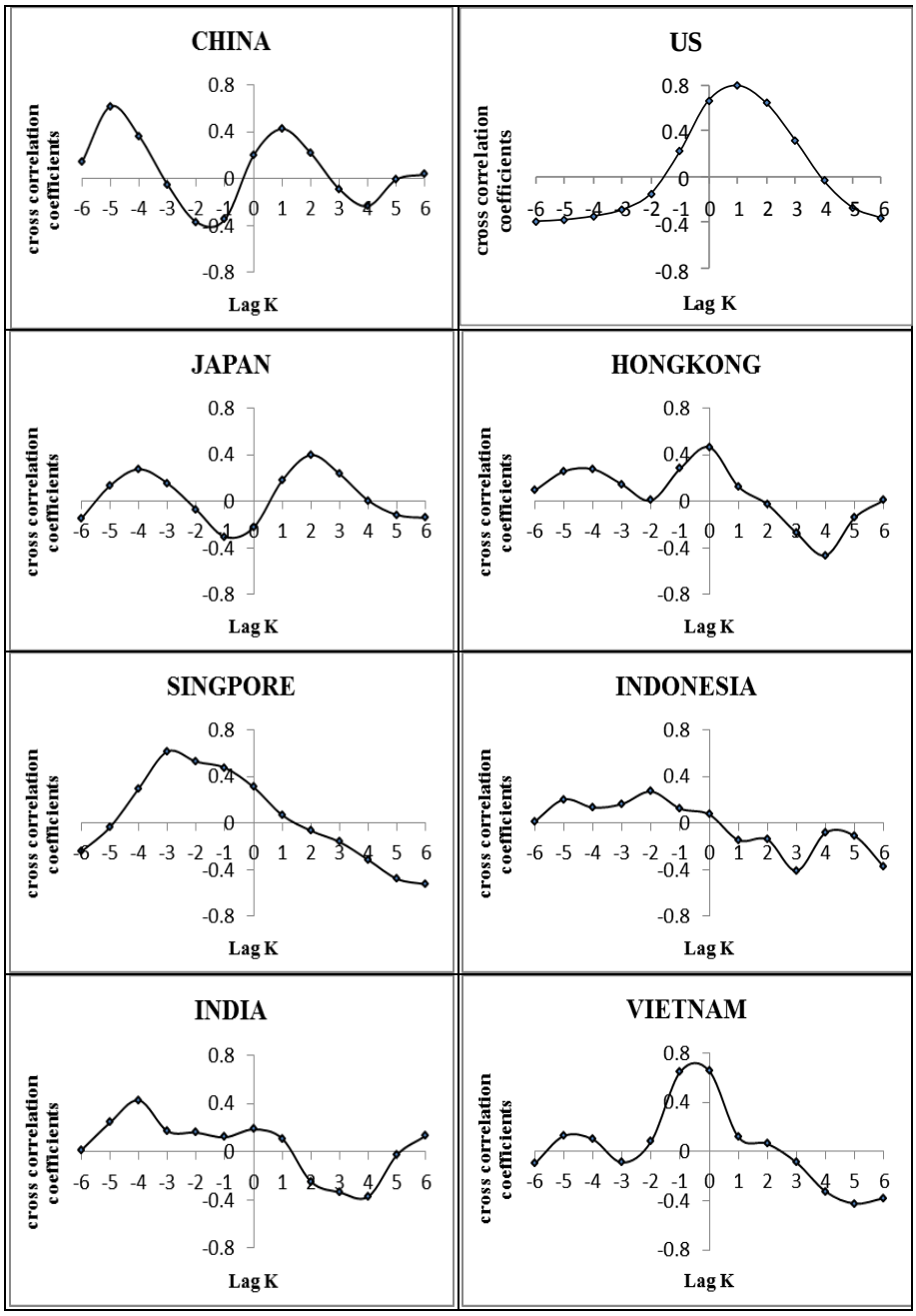
We are now in a position to produce the S-Curve between Korea and each of its trading partners. In measuring cross-correlation coefficients we use annual data over the period 1980-2011. The bilateral S-Curves are reported in figure 1.

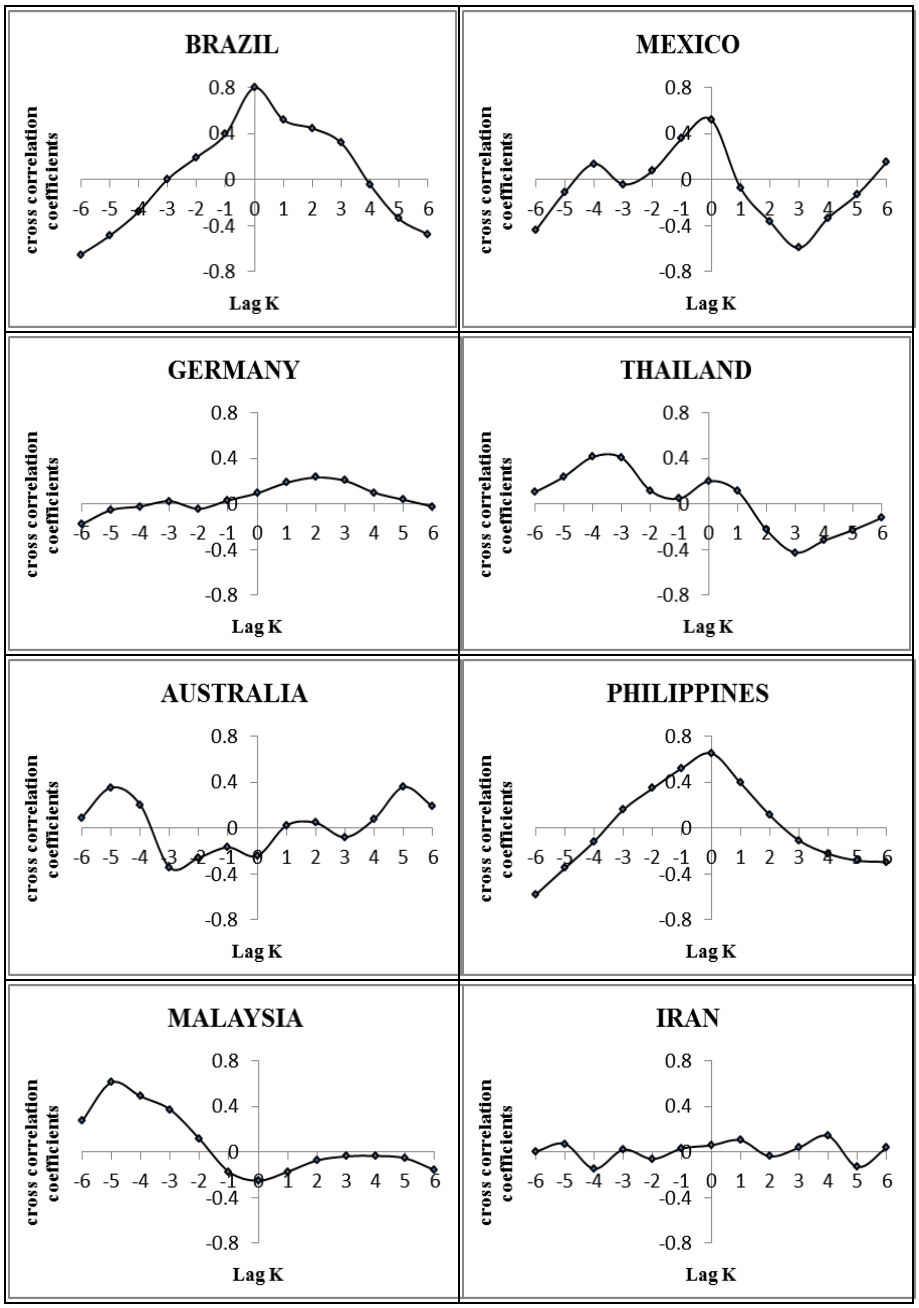
As can be seen from figure 1, the S-Curve is supported in seven cases that include trade between Korea and the U.S., Brazil, Germany, Australia, Italy, Canada, and Saudi Arabia, implying that real depreciation of won against currencies of these countries will improve the trade balance between Korea and each of these partners.

As mentioned before and shown in table 1, Korea's major trading partner is China. The next question we investigate is: Is failure to find support for the S-Curve between Korea and China due to another aggregation bias? To answer this question, we disaggregate the trade flows between the two countries by industry and consider the experience of 96 industries that trade between the two countries. Due to volume of the results we first summarize them in table 2 which shows whether an industry's trade balance conform to the S-Curve pattern.

As can be seen from table 2, the S-Curve hypothesis is supported in 38 out of 96 industries. In order to determine whether size of an industry plays any role, we have also reported in table 2 each industry's trade share and have identified large industries by an * next to its trade share. Clearly, almost all industries which support the S-Curve happen to be small and together engage in 17% of the trade between Korea and China. This is in contrast to

Figure 1 S-Curves between Korea and Its Trading Partners




BRAZIL
MEXICO
GERMANY
THAILAND
AUSTRALIA
PHILIPPINES
MALAYSIA
IRAN
cross correlation coefficients
Lag K
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6

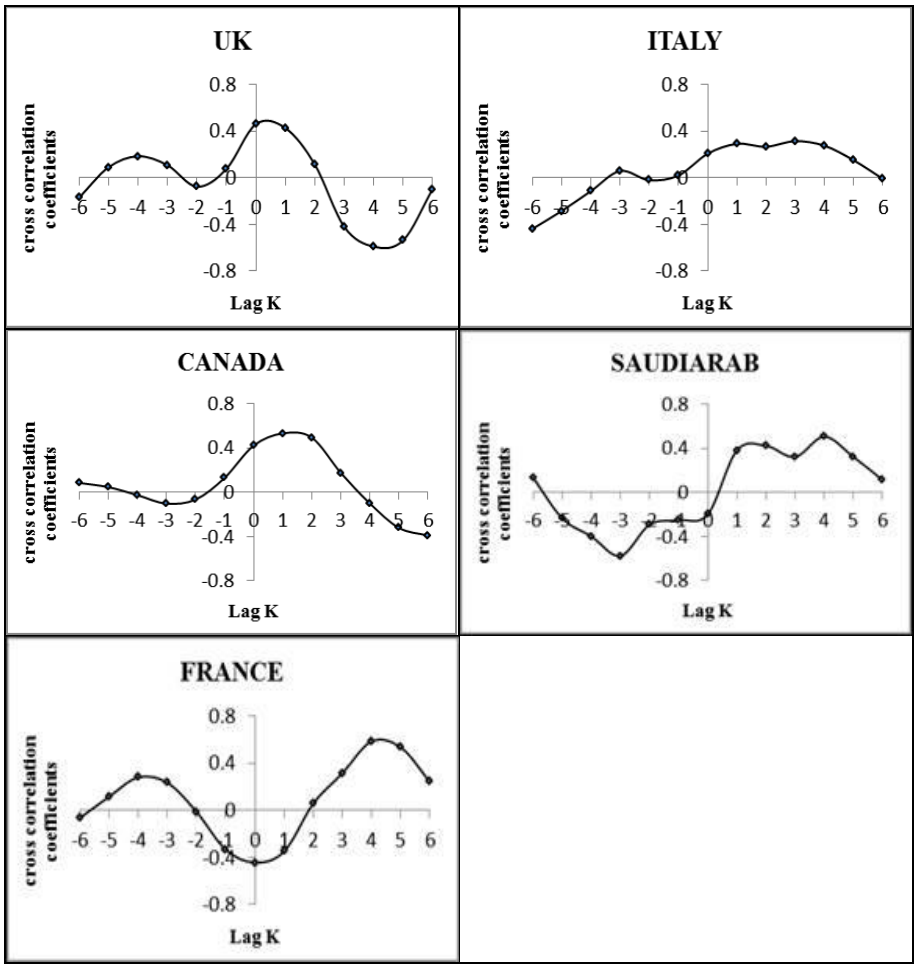

UK
cross correlation coefficients
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Lag K
ITALY
cross correlation coefficients
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Lag K
CANADA
cross correlation coefficients
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Lag K
SAUDIARAB
cross correlation coefficients
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Lag K
FRANCE
cross correlation coefficients
0.8
0.4
0
-0.4
-0.8
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Lag K

Table 2 Korea-China S-Curves at Industry Level

Code	Product Name	Trade Shares in 2011	Support
31	Fish, fresh & simply preserved	0.67	
32	Fish, in airtight containers, n.e.s	0.06	Yes
48	Cereal preps & preps of flour	0.09	Yes
62	Sugar confectionery, sugar preps.	0.02	
81	Feed stuff for animals	0.15	
99	Food preparations, n.e.s.	0.12	Yes
112	Alcoholic beverages	0.01	
231	Crude rubber incl. synthetic	0.52	
266	Synthetic and regenerated artificial	0.10	
276	Other crude minerals	0.16	Yes
284	Non-ferrous metal scrap	0.12	
291	Crude animal materials, n.e.s.	0.05	
292	Crude vegetable materials, n.e.s.	0.10	
332	Petroleum products	5.25*	
512	Organic chemicals	7.04*	
513	Inorganic chemicals	1.09	Yes
514	Other inorganic chemicals	0.42	Yes
531	Synthetic organic dyestuffs, natural	0.13	Yes
533	Pigments, paints, varnishes	0.31	
541	Medicinal & pharmaceutical products	0.18	Yes
553	Perfumery, cosmetics, dentifrices,	0.11	Yes
554	Soaps, cleansing & polishing preparations	0.06	
581	Plastic materials	4.41*	
599	Chemical materials and products, n.e.s.	0.93	
611	Leather	0.15	
612	Manufacturers of leather	0.13	
621	Materials of rubber	0.09	
629	Articles of rubber, n.e.s.	0.16	
631	Veneers, plywood boards & other wood	0.13	Yes
632	Wood manufactures, n.e.s.	0.05	
641	Paper and paperboard	0.25	
642	Articles of paper, pulp, paperboard	0.13	Yes
651	Textile yarn and thread	0.64	
652	Cotton fabrics, woven	0.19	
653	Text fabrics woven	0.91	
654	Tulle, lace, embroidery, ribbons,	0.04	
655	Special textile fabrics and related	0.32	
656	Made up articles, wholly or chiefly	0.16	Yes
657	Floor coverings, tapestries, etc.	0.03	Yes

661	Lime, cement & fabricated building materials	0.35	
663	Mineral manufactures, n.e.s.	0.14	
664	Glass	0.29	
665	Glassware	0.07	
666	Pottery	0.03	Yes
667	Pearls and precious and semi-precious stones	0.02	
672	Ingots & other primary forms of iron	1.03	
673	Iron and steel bars, rods, angles	1.15	Yes
674	Universals, plates and sheets of iron	3.17*	Yes
677	Iron and steel wire	0.16	Yes
678	Tubes, pipes and fittings of iron ore	0.50	
679	Iron steel castings	0.09	Yes
682	Copper	1.08	
684	Aluminum	0.62	Yes
685	Lead	0.02	Yes
686	Zinc	0.06	
689	Miscellaneous non-ferrous base metals	0.37	Yes
691	Finished structural parts	0.79	
692	Metal containers for storage and transport	0.09	Yes
693	Wire products	0.16	Yes
694	Nails, screws, nuts, bolts, rivets	0.13	Yes
695	Tools for use in the hand or in machine	0.20	
696	Cutlery	0.03	
697	Household equipment of base metals	0.08	Yes
698	Manufactures of metal, n.e.s.	0.68	Yes
711	Power generating machinery	1.68	Yes
712	Agricultural machinery and implements	0.03	
714	Office machines	4.29*	
715	Metalworking machinery	0.39	
717	Textile and leather machinery	0.16	
718	Machines for special industries	1.52	Yes
719	Machinery and appliances, non-electronics	4.18*	
722	Electric power machinery and switch	4.64*	
723	Equipment for distributing electric	1.52	
724	Telecommunications apparatus	5.44*	
725	Domestic electrical equipment	0.30	Yes
726	Electric apparatus for medicine purpose	0.06	Yes
729	Other electrical machinery and apparatus	14.47*	
731	Railway vehicles	0.02	

732	Road motor vehicles	3.51*	
733	Road vehicles other than motor vehicles	0.09	
735	Ships and boats	0.45	
812	Sanitary, plumbing, heating & light	0.21	Yes
821	Furniture	0.60	Yes
831	Travel goods, handbags and similar	0.31	Yes
841	Clothing except fur clothing	1.76	Yes
842	Fur clothing	0.03	
851	Footwear	0.44	Yes
861	Scientific, medical, optical means	11.90*	
864	Watches and clocks	0.06	Yes
891	Musical instruments, sound recorders	0.48	
892	Printed matter	0.23	
893	Articles of artificial plastic mate	0.58	
894	Perambulators ,toys, games and sporting goods	0.34	
895	Office and stationery supplies, n.e.s.	0.03	Yes
897	Jewellery and gold/silver smiths watches	0.03	Yes
899	Manufactured articles, n.e.s.	0.18	

Notes: Total trade share is defined as the ratio of sum of each industry's exports to and imports from China divided by sum of Korea's exports to and imports from China. Large industries are identified by an *. n.e.s. = not elsewhere specified.

Korea-U.S. commodity trade flows where Bahmani-Oskooee and Xu (2013) constructed the S-Curves for 74 industries that conduct almost 80% of the trade between Korea and the U.S. They found support for the S-curve in 39 industries which all together engage in 45% of the trade. Included among 39 industries were the three largest industries coded 719 (Machinery and appliances), 724 (Telecommunications apparatus) and 732 (Road motor vehicles) which three together conduct 31% of the trade.[3] The findings in this paper are also in contrast to those of Bahmani-Oskooee and Ratha (2010) who investigated the S-Curve for 104 industries that trade between China and the U.S. The S-curve was supported in 42 industries including many of the large industries.[4]

[3] The graphs at industry level are available from corresponding author upon request.
[4] For some other issues related to China-Korea trade see Baak (2011) and Han and Lee (2012).

4. SUMMARY AND CONCLUSION

The S-Curve is a hypothesis that is used to assess the short-run response of the trade balance to exchange rate changes. It basically asserts that while the cross-correlation coefficients between past values of the trade balance and current exchange rate could be negative, the same cross-correlations between future values of the trade balance and current exchange rate could be positive, hence the S-Curve pattern between cross-correlation coefficients and number of lags and leads used in constructing the S-Curve.

Studies which have tried to test the curve fall into three categories. The first category includes those which have used aggregate trade flows of one country with the rest of the world and have provided limited support. Suspecting some aggregation bias in the first group, the second group has disaggregated trade flows by trading partners and have tested the curve at bilateral level and provided relatively more support for the curve. In case the S-Curve is not supported at bilateral level, the third group has engaged in further disaggregation of the bilateral trade flows by industry and has provided more support for the S-Curve at commodity level.

Previous research which has investigated the S-Curve using Korea's aggregate trade flows with the rest of the world has provided empirical support for the curve. In an effort to identify trading partners that contribute to the S-pattern, in this paper we disaggregated Korea's trade flows by trading partners and tested the S-Curve at bilateral level. Support for the S-Curve was found in the trade between Korea and the U.S., Brazil, Germany, Australia, Italy, Canada, and Saudi Arabia.

The curve was not supported between Korea and its major trading partner, China. We, therefore, took an additional step and tested the S-Curve between Korea and China at industry level. Support for the curve was found in 38 of the 96 industries that trade between the two countries. These 38 industries were all small and together conduct 17% of the trade.

APPENDIX

A1. Data Definition and Sources

All data are annual over the period 1980-2011 and are collected from the following sources:

a. International Financial Statistics of IMF
b. Direction of Trade Statistics (from IMF)
c. World Bank
d. DataMarket: http://datamarket.com/data/set/19vw/euroecu-exchange-rates-annual-data#!display=table

A2. Variables

$\boldsymbol{TB_J}$ = net exports defined as Korea's exports to trading partner *J* minus its imports from the same partner deflated by Korea's GDP. Trade flows between Korea and each partners in terms of the U.S. dollar come from source b. Korea's GDP in also U.S. dollars come from source c. When this variable is defined at industry level, industry level data come from source c.

$\boldsymbol{REX_J}$ = bilateral real exchange rate between Won and each partner's currency is defined as $(P_J \cdot NEX / P_K)$ where NEX is the nominal bilateral exchange rate defined as number of Won per country *J*'s currency; P_K is the Korean price level, and P_J is the price level in trading partner *J*. The price levels are all measured by GDP deflators and the data come from source a. Bilateral exchange rates are calculated using the rates against the U.S. dollar and they all come from source a. The dollar-euro rate to be used for euro zone countries come from source d.

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