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A NOTE ON THE S-CURVE DYNAMICS OF COMMODITY TRADE BETWEEN BRAZIL AND THE UNITED STATES

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The S-curve hypothesis postulates that the correlation coefficient between the current exchange rate and past trade balance values may be negative. However, the correlation between the current exchange rate and future values of the trade balance may be positive. Previous research using aggregate trade flows between Brazil and rest of the world find weak support for the curve. When we disaggregate Brazil's trade flows with the U.S. and investigate 95 industries that trade between the two countries, we find support for the S-curve in 51 industries. Small and large industries and durable and non-durable commodities are found to benefit from currency devaluation.

JEL classification: F31

Keywords: S-curve, industry data, Brazil, the United States

1. Introduction

A country that is experiencing a decline in its net exports may adhere to currency devaluation or allow its currency to depreciate, but due to adjustment lags such as recognition, production, delivery, etc. the trade balance may continue to deteriorate, with improvement coming later. This short-run pattern of movement of the trade balance subsequent to devaluation has been tested by two concepts that rely upon two different approaches. The J-curve introduced theoretically by Magee (1973) and tested empirically by Bahmani-Oskooee (1985) mostly relies upon a reduced-form trade balance model and different estimation techniques and regression analysis. The S-curve introduced by Backus *et al.* (1994) relies upon a cross-correlation function between past and future values of the trade balance and the current terms of trade or the real exchange rate. Bahmani-Oskooee and Hagerty (2010) provide a comprehensive review of both concepts, classifying all studies into three categories. The first group uses aggregate trade flows between

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one country and the rest of the world. To reduce aggregation bias, the second group uses trade flows between two countries. To further reduce the aggregation bias, the third group uses trade flows between two countries disaggregated by commodity. The evidence in support of both the S-curve and the J-curve increases with the level of disaggregation.

In this paper we concentrate on the experience of Brazil. Can Brazil enjoy an improvement in its trade balance in the future as a result of currency depreciation? Four studies have tried to answer this question by relying upon the J-curve concept. The results are mixed at best. Bahmani-Oskooee and Malixi (1992), who test the J-curve phenomenon for several developing countries, include Brazil in their sample and find support for the J-curve in Brazil. So do Gomes and Paz (2005), who only consider the case of Brazil. However, Moura and Da Silva (2005), who also use Brazilian data, do not find any support for the J-curve. The three studies use aggregate trade data between Brazil and rest of the world, hence they may suffer from aggregation bias. To reduce the bias and search for further evidence in support of the J-curve, Bahmani-Oskooee *et al.* (2012) concentrate on trade between Brazil and its major trading partner, the United States, and consider the experiences of 92 industries. Using the bounds-testing approach to cointegration and error-correction modeling, which distinguishes the short-run effects of currency depreciation from its long-run effects, they are able to support the J-curve in almost one-third of the industries.

As for Brazil's experience with the S-curve, only two studies have estimated the curve for developing countries. While Senhadji (1998), who tests the curve for 36 developing countries using aggregate trade data, does not include Brazil in his analysis, Parikh and Shibata (2004), testing the curve for 64 developing countries, include Brazil and find weak support for the S-curve there. These studies use aggregate trade flows between each country and rest of the world, the same procedure as Backus *et al.* (1994), who test the curve for 11 OECD countries. In an effort to reduce aggregation bias, Bahmani-Oskooee and Ratha (2007a) disaggregate trade flows by trading partners and provide more support for the S-surve in trade between the U.S. and each of its major trading partners. Unfortunately, they do not include Brazil as a partner.

In this paper, we examine trade between the U.S. and Brazil exclusively and try to find stronger support for the S-curve using bilateral trade flows. To further bolster our results we disaggregate bilateral trade

flows and estimate the curve for each of the 95 industries that trade between the two countries, finding support for the S-curve in 52 cases. To demonstrate how we arrive at our findings, in Section 2 we explain the method of generating the S-curve. The findings are reported in Section 3 and a summary is provided in Section 4.

2. Data and Methodology

As indicated in the previous section, the S-curve is based on the cross-correlation between the current real exchange rate and future as well as past values of the trade balance. Thus, following Bahmani-Oskooee and Ratha (2007b) and the literature, we define the cross-correlation coefficient (COR) between the trade balance (TB) and the real exchange rate (RE) as:

$$COR = \frac{\sum (RE_t - \overline{RE})(TB_{t+k} - \overline{TB})}{\sqrt{\sum (RE_t - \overline{RE})^2 (TB_{t+k} - \overline{TB})^2}} \tag{1}$$

where $\overline{RE}$ and $\overline{TB}$ are the mean of all observations over the study period. By allowing k to take negative values such as -5, -4, -3, -2, and -1, we calculate cross-correlation coefficients between the current exchange rate and past vales of the trade balance. And by allowing k to take positive values such as 1, 2, 3, 4, and 5, we calculate the same correlation between the current exchange rate and future values of the trade balance. The S-curve is then produced by plotting constructed correlation coefficients against corresponding lags and leads.[1]

Before we proceed, it should be mentioned that since the industry-level data are reported by the U.S., we define the TB and RE from the U.S. perspective. Thus, for each industry i, the trade balance is defined as $TB_i = (X_i - M_i)/GDP_{US}$ where X_i is U.S. exports of industry i to Brazil, M_i is U.S. imports of the same industry from Brazil, and $GDPUS$ is U.S. gross domestic product. All variables are measured in nominal U.S. dollars so that the ratio measures the trade balance in terms of domestic output. This definition is followed by all previous research on the S-surve. The real exchange rate between the U.S. dollar

1. It is common practice to detrend the data; the Hodrick-Prescott filter is used for this purpose.

and the Brazilian *real* is defined as $RE = P_{BR}/(P_{US} \cdot E)$ where P_{BR} is the price level in Brazil, PUS is the price level in the U.S., and E is the nominal exchange rate defined as the number of Brazilian *real* per U.S. dollar. Thus, an increase in RE reflects a real depreciation of the dollar, which implies that the contemporaneous correlation coefficient between the two variables is expected to be positive.[2]

3. Results

We are now in a position to plot our constructed COR variable against a number of lags and leads to see if we can provide stronger support for the S-curve at the commodity level. We first summarize our findings in Table 1, which contains information such as industry code, name, their trade share, and an indication of whether the S-curve is supported.

Table 1. Industries studied and their trade shares

Code	Industry name	Trade share	Support
13	Meat in airtight containers n.e.s.	0.001688	
48	Cereal preps. and preps. of flour	0.000634	Yes
51	Fruit, fresh, and nuts excl. oil	0.004393	
53	Fruit, preserved and fruit preparations	0.0068	
61	Sugar and honey	0.006284	
62	Sugar confectionery, sugar preps.	0.000662	Yes
81	Feed stuff for animals	0.000483	
112	Alcoholic beverages	0.000168	
122	Tobacco manufactures	4.13E-05	
211	Hides and skins, excluding fur skins	1.46E-05	
231	Crude rubber including synthetic and recycled	0.005775	Yes
273	Stone, sand and gravel	8.17E-05	Yes
276	Other crude minerals	0.002225	
283	Non-ferrous ores and concentrates	0.00366	
284	Non-ferrous metal scrap	0.000293	
291	Crude animal materials, n.e.s.	0.001894	
292	Crude vegetable materials, n.e.s.	0.000851	Yes

2. The data on price levels (measured by PPI for both countries), the exchange rate, and U.S. GDP are from the International Financial Statistics published by the International Monetary Fund. The industry-level trade data are from World Bank's WITS system (which in turn receives the data from the United Nations' COMTRADE database). All data are annual over the 1971-2010 period.

Table 1. (continued)

Code	Industry name	Trade share	Support
422	Other fixed vegetable oils	0.000139	
431	Animal/vegetable oils and fats, processed	0.000784	
512	Organic chemicals	0.057495	Yes
513	Inorganic chemicals elements, oxides	0.013377	Yes
531	Synthetic organic dyestuffs, natural	0.002277	
532	Dyeing and tanning extracts	9.46E-05	
541	Medicinal & pharmaceutical products	0.02464	Yes
571	Explosives and pyrotechnic products	0.000178	Yes
581	Plastic materials, regenerated	0.032407	Yes
599	Chemical materials and products	0.017733	Yes
611	Leather	0.001583	
612	Manuf. of leather	8.83E-05	Yes
629	Articles of rubber, n.e.s.	0.010798	
631	Veneers, plywood boards and other wood	0.001198	Yes
632	Wood manufactures, n.e.s.	0.003398	Yes
641	Paper and paperboard	0.007375	Yes
642	Articles of paper, pulp, paperboard	0.001065	Yes
651	Textile yarn and thread	0.000954	Yes
652	Cotton fabrics, woven excluding narrow	0.000308	
653	Text fabrics woven excluding narrow	0.000555	Yes
654	Tulle, lace, embroidery, ribbons	4.68E-05	Yes
655	Special textile fabrics and related	0.003323	
656	Made up articles, wholly or chiefly	0.002021	Yes
657	Floor coverings, tapestries, etc.	0.000257	Yes
661	Lime, cement and fabr. bldg.mat.	0.010213	Yes
662	Clay and refractory construction materials	0.001563	Yes
663	Mineral manufactures, n.e.s.	0.00244	
664	Glass	0.00133	Yes
665	Glassware	0.000458	Yes
666	Pottery	3.53E-05	Yes
667	Pearls and precious and semi-precious stones	0.000872	
671	Pig iron, spiegeleisen, sponge iron	0.016903	
672	Ingots and other primary forms of iron	0.007023	
673	Iron and steel bars, rods, angles,	0.002921	
677	Iron and steel wire	0.000471	Yes
678	Tubes, pipes and fittings of iron ore	0.003005	
682	Copper	0.001139	
689	Misc. non-ferrous base metals	0.001535	
692	Metal containers for storage	0.001821	Yes
693	Wire products ex electric and fence	0.000451	

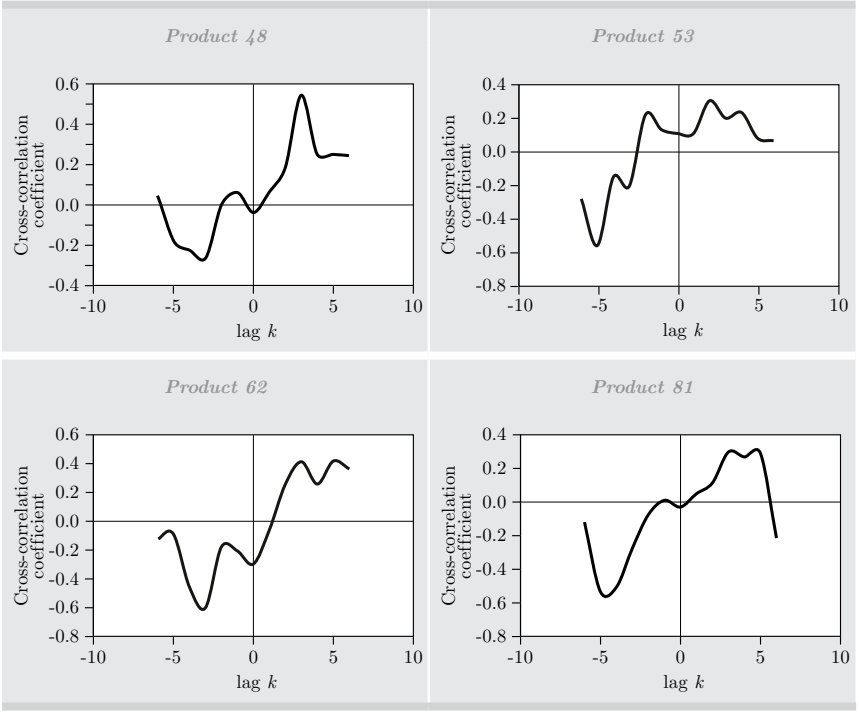
Table 1. (continued)

Code	Industry name	Trade share	Support
694	Nails, screws, nuts, bolts, rivets	0.001425	Yes
695	Tools for use in the hand or in machine	0.002828	
696	Cutlery	0.000824	Yes
697	Household equipment of base metals	0.000612	Yes
698	Manufactures of metal, n.e.s.	0.003871	Yes
711	Power generating machinery	0.02137	
712	Agricultural machinery	0.00546	Yes
714	Office machines	0.016514	Yes
715	Metalworking machinery	0.001971	
717	Textile and leather machinery	0.000671	Yes
718	Machines for special industries	0.032678	Yes
719	Machinery and appliances non electrical	0.059249	Yes
722	Electric power machinery and switch	0.01633	Yes
723	Equipment for distributing electricity	0.002378	Yes
724	Telecommunications apparatus	0.015917	Yes
725	Domestic electrical equipment	0.000535	Yes
729	Other electrical machinery and appliances	0.015454	Yes
731	Railway vehicles	0.003438	
732	Road motor vehicles	0.022861	Yes
734	Aircraft	0.013807	
812	Sanitary, plumbing, heating & light	0.000504	Yes
821	Travel goods, handbags and similar	0.00018	Yes
841	Clothing except fur clothing	0.000653	Yes
851	Footwear	0.006768	
861	Scientific, medical, optical, meas.	0.021344	Yes
862	Photographic and cinematographic su	0.002191	
863	Developed cinematographic film	1.54E-06	
864	Watches and clocks	0.000206	
891	Musical instruments, sound recorder	0.002976	
892	Printed matter	0.002153	
893	Articles of artificial plastic mater.	0.003287	Yes
894	Perambulators, toys, games and sporting	0.001879	Yes
895	Office and stationery supplies, n.e.s.	0.000638	
896	Works of art, collector pieces	0.000601	
897	Jewelry and gold/silver watches	0.001288	Yes
899	Manufactured articles, n.e.s.	0.003152	Yes
931	Special transactions & goods not classified	0.100907	Yes

Source: ??
Note: n.e.s. stands for "not specified elsewhere."

From the last column of the table, we gather that the S-curve is supported in 52 out of 95 industries, which is a much stronger level of support than for the J-curve concept investigated by Bahmani-Oskooee *et al.* (2012), who find that the same data set supports the J-curve in only 31 cases. It appears that neither industry size nor industry classification (e.g., durable versus non-durable) play any role in the outcome.[3] While many of the industries are small as measured by the size of their trade shares, the four largest industries are also among those that support the S-curve. These include industry code 718 with 3.26%, 719 with 5.92%, 732 with 2.28%, and 931 with 10.09%. For brevity, in Figure 1 we report only the plots of the curves for industries that support the S-pattern.

Figure 1. S-curves in industries that support the pattern



3. This finding is consistent with Bahmani-Oskooee and Xu (2013) who conduct a similar analysis for U.S.-Mexico industry-level data. It is also consistent with Bahmani-Oskooee and Ratha (2010) who do the same for U.S.-China trade.

Figure 1. (continued)

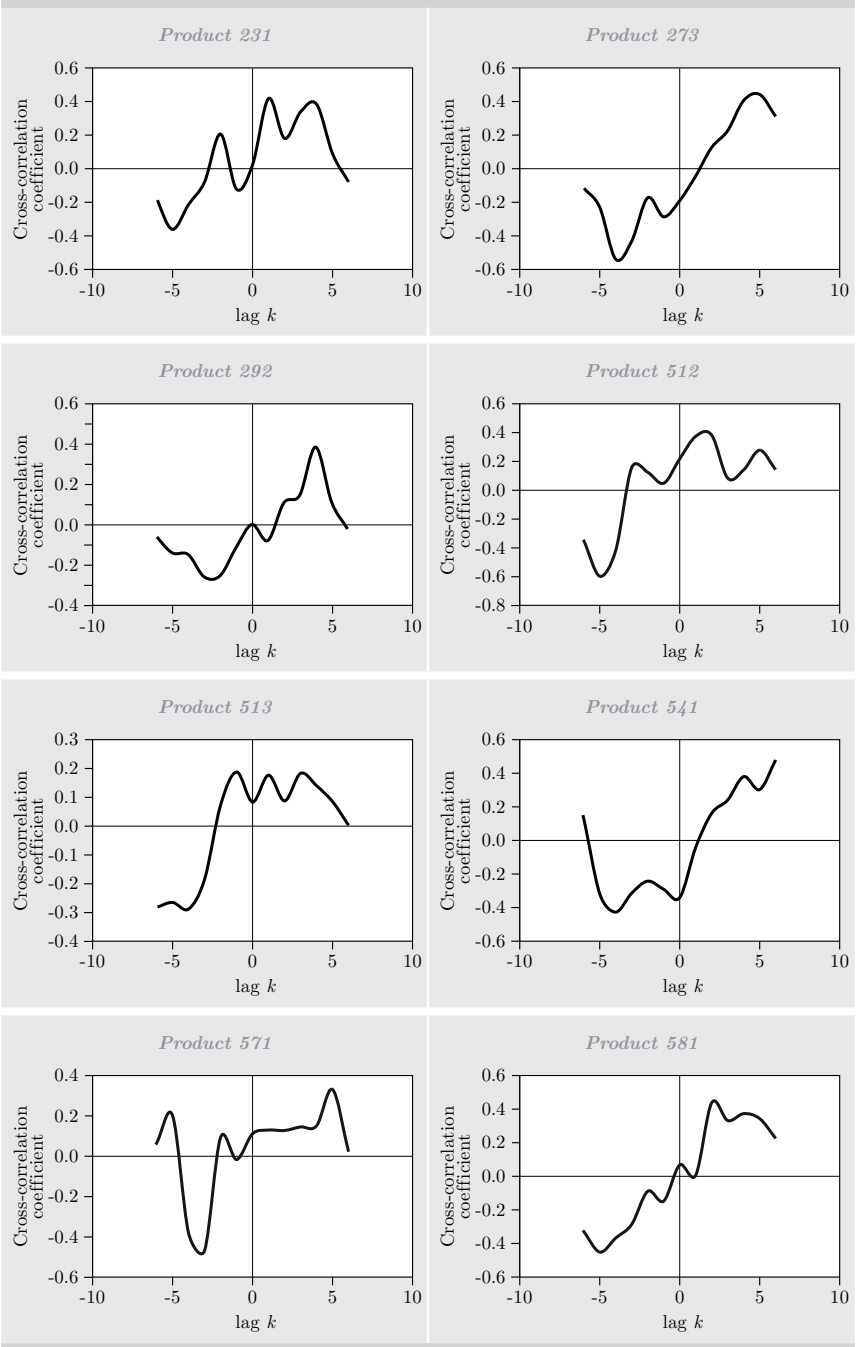


Figure 1. (continued)

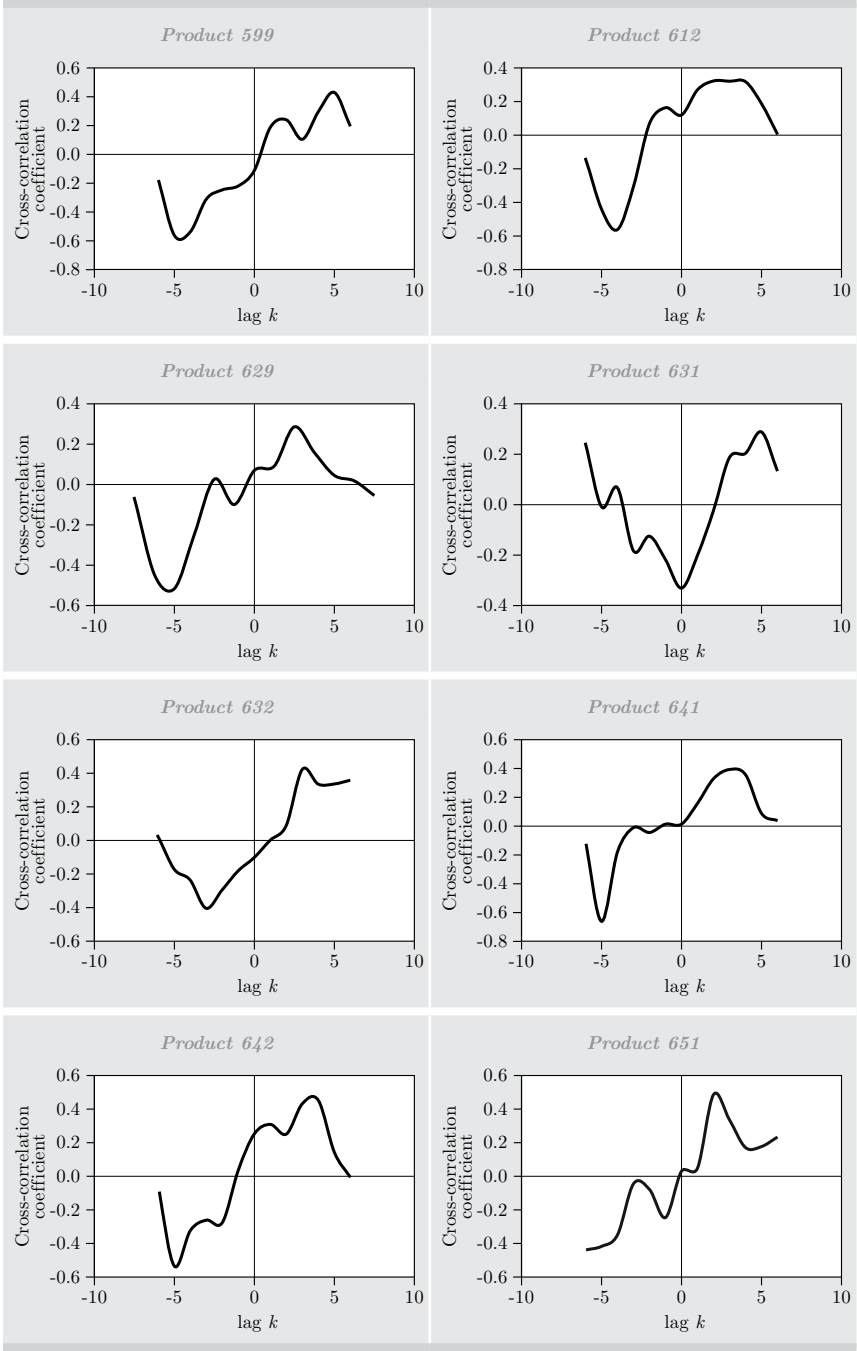


Figure 1. (continued)

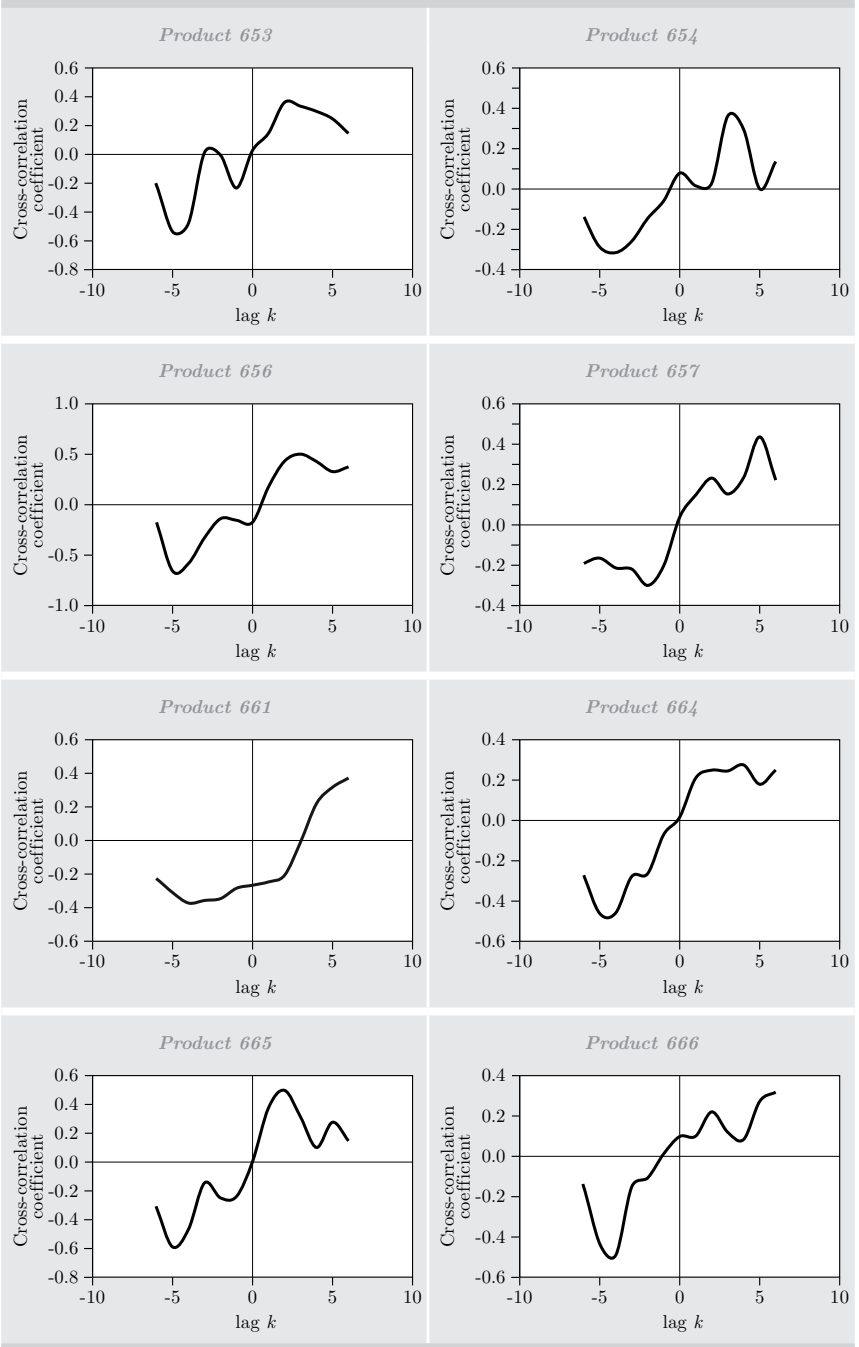


Figure 1. (continued)

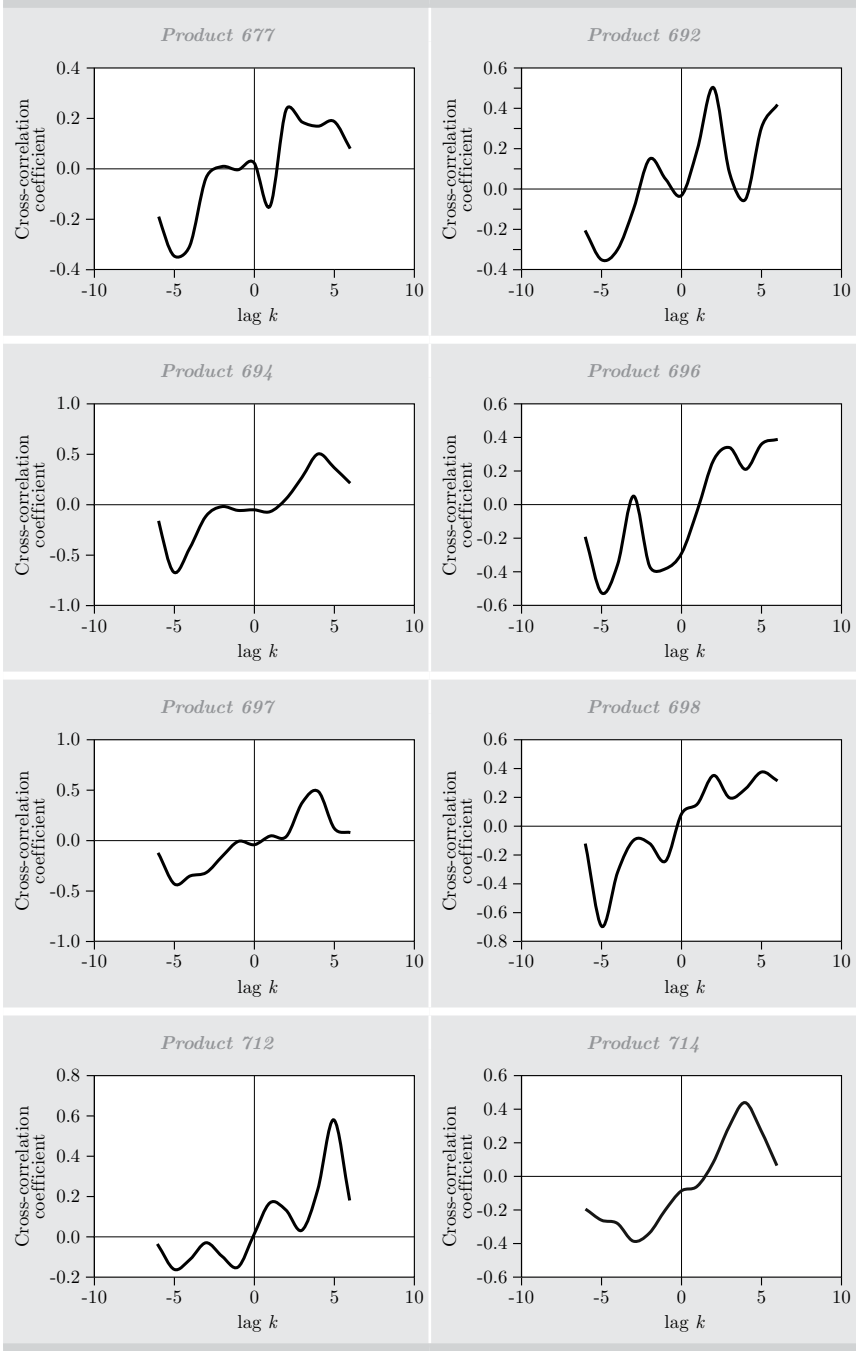


Figure 1. (continued)

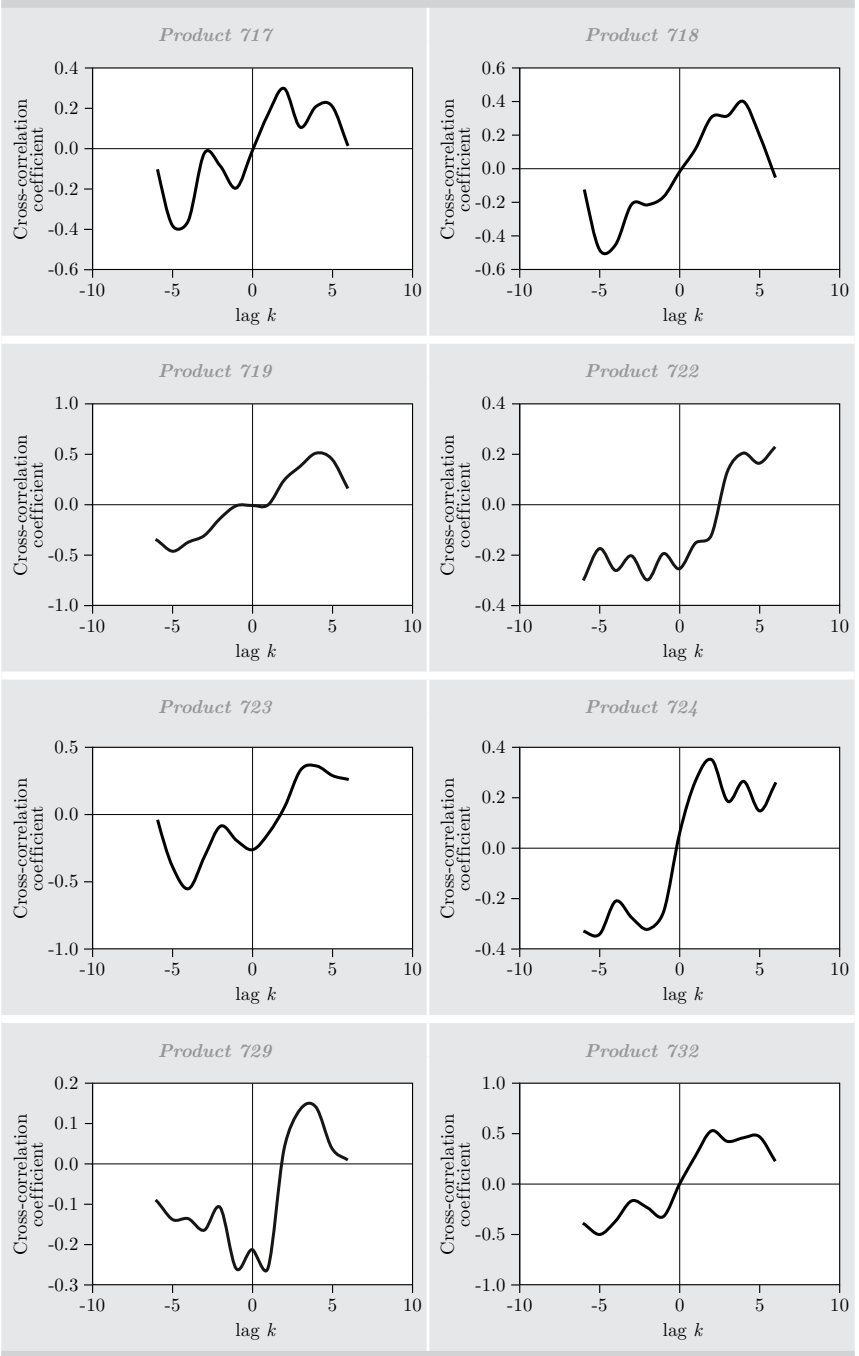


Figure 1. (continued)

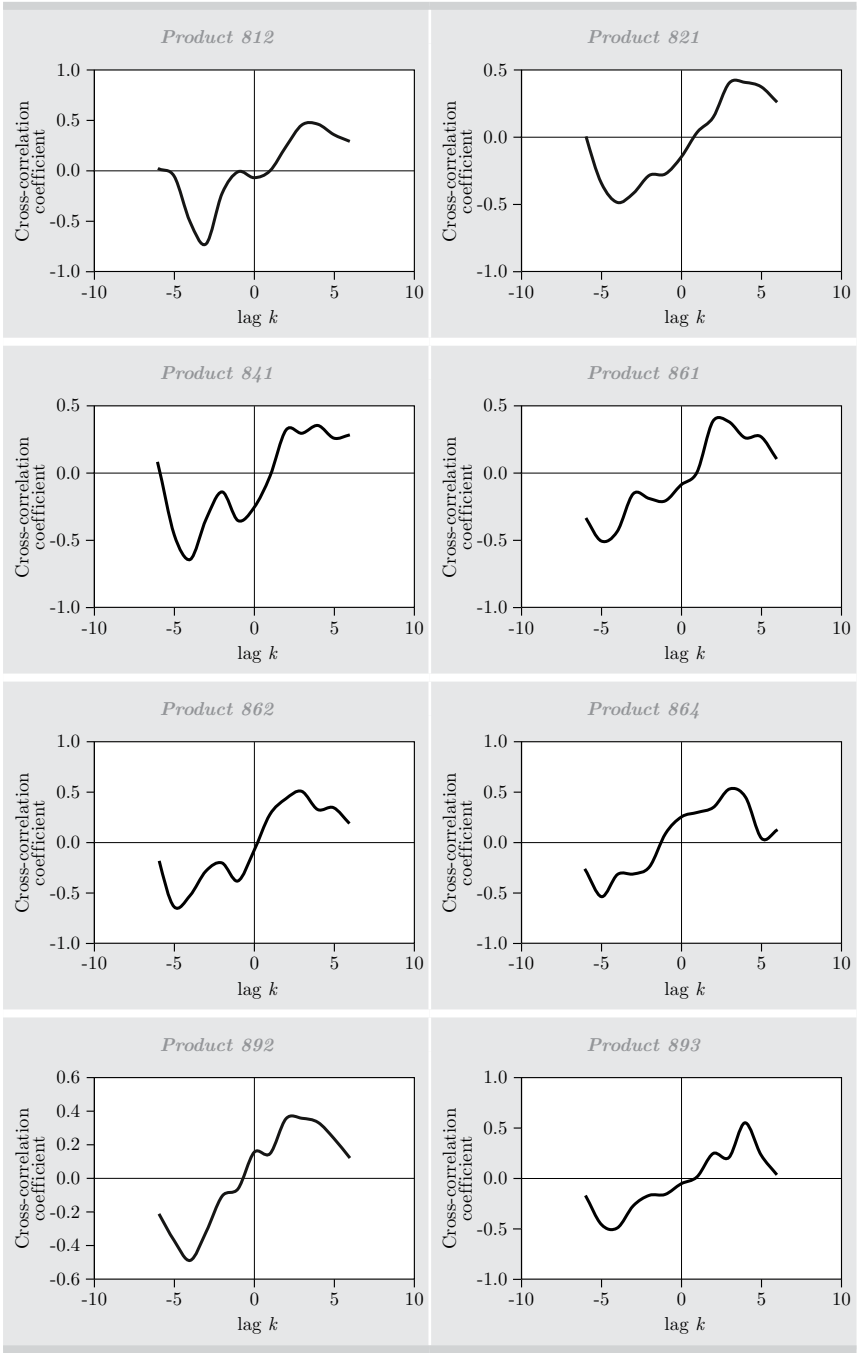
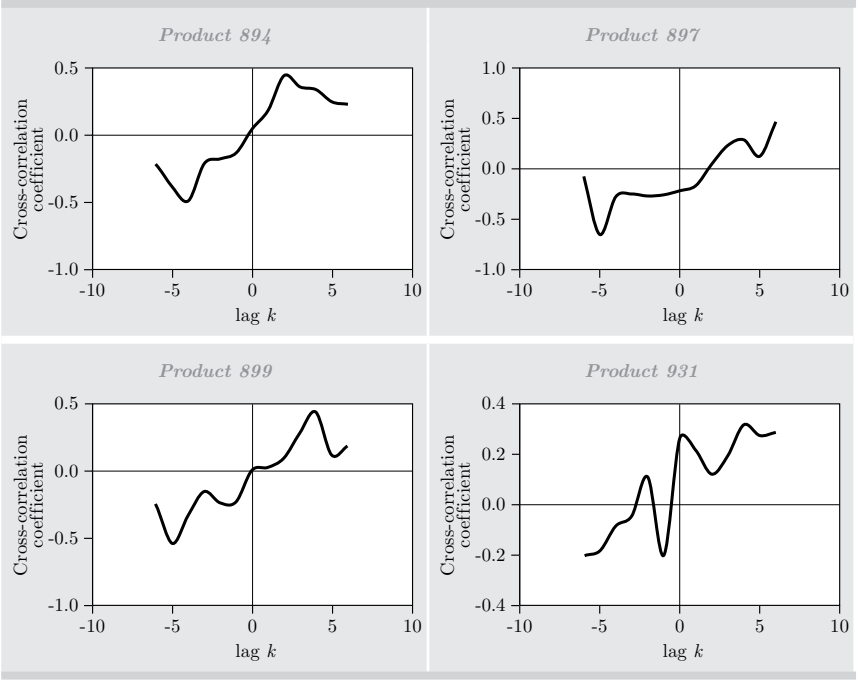


Figure 1. (continued)



Source: Authors' construction.

4. Summary

A country that is experiencing a decline in net exports or deterioration in its trade balance may adhere to currency devaluation or allow its currency to depreciate. Due to lags such as recognition, production, replacement, delivery, etc. the impact of devaluation is not instantaneous. The trade balance continues to deteriorate after devaluation and improvement comes only after the adjustment lags are realized. This short-run deterioration followed by an improvement can be tested using either the J-curve or the S-curve concept.

These curves are tested empirically by using the aggregate trade flows of one country with the rest of the world or between two countries using bilateral trade flows. In this paper we consider the experience of Brazil with the S-curve phenomenon. A previous study that includes Brazil among many other developing countries and tests the S-curve using aggregate trade flows between Brazil with the rest of the world finds weak support for the S-curve. However, in our study, we consider

not only the trade flows between Brazil and one of its major trading partners, the U.S., but we take an additional step to disaggregate the trade flows between the two countries by industry and investigate the experience of each of the 95 industries involved in that trade between the two countries. At this disaggregated level, we find support for the S-curve in 52 cases, a result that had been masked by aggregate data. Further analysis reveals that the S-pattern emerges for small as well as large industries and in durable as well as non-durable commodities, identifying industries that will reap the benefits of currency devaluation.

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