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COINTEGRATION APPROACH TO ESTIMATING BILATERAL TRADE ELASTICITIES BETWEEN U.S. AND HER TRADING PARTNERS

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Almost all previous authors who estimated the trade elasticities relied upon aggregate trade data. To avoid the aggregation bias, this paper provides estimates of trade elasticities using bilateral data between the United States and her six largest trading partners. Application of cointegration analysis reveals that in many cases, bilateral trade elasticities are large enough to justify real depreciation of the dollar as a mean of improving U.S. trade balance. [F14]

1. INTRODUCTION

In 1970 total trade for the United States was equivalent to 7% of its GDP. In 1991 that figure increased to 13%, and by 1996 total trade was 20.5% of GDP. This trend is expected to continue into the future, due in part to trade negotiations and trade liberalizations being "fast tracked" in Washington. Therefore, what was once a closed economy has now become quite dependent upon foreign trade. Along with that dependence comes an increased need to understand the dynamic relationship that exists between foreign trade and the exchange rates. The main concern here is whether currency depreciation leads to an improvement in the trade balance of a country. The traditional approach is one of estimating the size of import and export demand elasticities and determining whether their absolute values add up to more than unity, a condition known as the Marshall-Lerner condition (M-L) in the trade literature. If they do, depreciation is said to improve the trade balance.

Previous authors who attempted to estimate the trade elasticities, concentrated on aggregate trade. Examples include Kreinin (1967), Houthakker and Magee (1969), Khan (1974) and Bahmani-Oskooee (1986, 1997). The main shortcoming with these studies is that they all suffer from what is known as the "aggregation bias" problem. To avoid the aggregation bias, in this paper we intend to estimate the trade elasticities on a bilateral basis, namely between the U.S. and each of six of her largest trading

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partners, France, Germany, Italy, Canada, Japan, and the UK. These partners are selected mostly due to availability and reliability of quarterly data on relevant variables.[1]

It should be mentioned that Marquez (1990) has estimated the trade elasticities on a bilateral basis using spectral analysis which employed non-stationary data. In light of recent developments in time-series econometrics, his estimates might not be as efficient and indeed do suffer from the spurious regression problem. To remedy this problem, we use Johansen's cointegration technique which allows for feedback effects among the variables that enter into the import and export demand functions. To this end, we introduce the bilateral trade models in section 2. In section 3 we discuss the empirical results. Section 4 concludes. Finally, the appendix lists the definitions and sources of the data.

2. THE IMPORT AND EXPORT DEMAND MODELS

Aggregate import and export demand models usually include a scale variable and a relative price term. However, since we intend to estimate the trade elasticities on bilateral basis we need import and export prices on a bilateral basis as well. Unfortunately, such indices are not available. Thus, we employ the real bilateral exchange rate as a measure of relative prices. By doing so we measure the sensitivity of import and export demand to movements in the real bilateral exchange rate. Indeed, Dornbush (1980: 58) has used the real exchange rate in formulating the import demand function. Thus, we assume the United States import demand from trading partner *i* takes the following form:

$$Ln\ M_{it}^{U.S.} = \alpha + \beta Ln\ Y_{U.S.t} + \gamma Ln\ REX_{it} + \quad_{t} \tag{1}$$

where $Ln\ M_i^{U.S.}$ = *log* of U.S. real import from trading partner *i*; $Ln\ Y_{U.S.}$ = *log* of U.S. real GDP; and $Ln\ REX_i$ = *log* of real bilateral exchange rate between U.S. and trading partner *i*. As the appendix indicates *REX* is measured in a way such that a decline reflects a real depreciation of the dollar. Thus, if real depreciation is to reduce U.S. imports, we would expect the estimate of $\gamma > 0$. If an increase in U.S. GDP is to stimulate U.S. imports, estimate of β should also be positive.

The U.S. export demand equation (or country *i*'s import demand from the U.S.) can be formulated in a similar fashion as:

[1]It should be indicated that these trading partners account for less than half of U.S. trade. Thus, no strong generalization could be made from the results reported in this paper. However, five of these six countries are part of top 10 countries with which the U.S. has a trade deficit.

$$Ln\ X_{it}^{U.S.} = \alpha' + \beta'\ Ln\ Y_{it} + \gamma'\ Ln\ REX_{it} + \varepsilon'_t \tag{2}$$

where $Ln\ X_i^{U.S.} = log$ of U.S. export to trading partner i (i's imports from the U.S.); $Ln\ Y_i = log$ of trading partner i's real GDP. In equation (2), if real depreciation of the dollar, i.e., a decline in *Ln REX* is to increase U.S. competitiveness and thus her exports, estimate of γ' should be negative. The income elasticity, β', should be positive implying an increase in U.S. exports to country i due to i's economic growth. By selecting i to be Canada, Japan, Germany, U.K., France and Italy, as U.S. trading partners we carry out the empirical analysis in the next section.

3. EMPIRICAL RESULTS

Sine the Marshall-Lerner condition is a long-run condition, the appropriate method of estimation would be cointegration analysis. In applying the cointegration technique, the first task is to determine the order of integration of each variable. To this end, we rely upon a relatively more powerful test by Kwiatkowski, Phillips, Schmidt and Shin (1992) known as KPSS test in which the null hypothesis is stationarity of a variable versus an alternative of a unit root. The KPSS test is formulated in detail in Bahmani-Oskooee (1998) and needs no repeat here. Table 1 reports the results of KPSS test for level stationarity for different values of truncation lag ℓ.

It is clear from Table 1 that regardless of the order of truncation lag, the null of stationarity is rejected for all variables in all trading partners except Ln REX in the case of Germany, U.K. and France. In these three cases, the null is rejected (at least at the 10% level) when the order of truncation lag is small. Similar results (not reported but available upon request) were obtained for the null of trend stationarity. Thus, we proceed by assuming that all variables are non-stationary. Additional testing with the ADF and KPSS revealed that indeed all variables are first difference stationary.

We can now proceed with cointegration tests. Since we are interested in the long run relationship between the variables and in particular the long run estimates of the M-L condition, cointegration analysis is an appropriate method. Specifically, we employ Johansen-Juselius (1990) Full Information Maximum Likelihood (FIML) estimation technique which allows for a feedback effect among the variables. In applying this technique one has to decide the order of the VAR. We use Akaike's Information Criterion (AIC) to select the lag length. However, we also looked at the lag lengths suggested by two other criteria, Schwarz Information Criterion (SIC), and a test based upon the lag associated with the cointegrating vector that yielded the Minimum Mean Square of the Residuals (MMSR). Generally speaking our results were fairly consistent across lag order

Table 1. The KPSS statistics for the null of level stationarity.
(The 5% critical value is 0.463, 10% is .347): 1973I-1996II.

	Lag Truncation Parameter				
Variable	0	1	2	3	4
US					
Ln Y	3.095	2.332	1.876	1.573	1.357
Canada					
Ln Y	3.053	2.303	1.855	1.557	1.345
Ln REX	1.733	1.309	1.058	0.892	0.776
Ln M	2.730	2.074	1.675	1.410	1.219
Ln X	2.724	2.075	1.677	1.413	1.222
Japan					
Ln Y	3.144	2.367	1.902	1.593	1.372
Ln REX	1.919	1.451	1.175	0.993	0.864
Ln M	2.929	2.205	1.771	1.483	1.277
Ln X	2.845	2.150	1.733	1.456	1.259
Germany					
Ln Y	2.963	2.233	1.796	1.506	1.299
Ln REX	0.484	0.367	0.298	0.253	0.221
Ln M	2.532	1.916	1.542	1.295	1.118
Ln X	2.283	1.750	1.430	1.213	1.052
UK					
Ln Y	3.055	2.300	1.848	1.547	1.334
Ln REX	0.708	0.539	0.440	0.376	0.331
Ln M	2.801	2.135	1.728	1.453	1.256
Ln X	2.561	1.955	1.591	1.344	1.165
France					
Ln Y	3.037	2.291	1.846	1.540	1.339
Ln REX	0.424	0.322	0.262	0.223	0.196
Ln M	2.948	2.231	1.796	1.506	1.298
Ln X	2.434	1.848	1.500	1.265	1.094
Italy					
Ln Y	3.062	2.311	1.862	1.563	1.350
Ln REX	1.371	1.037	0.841	0.711	0.620
Ln M	2.669	2.019	1.628	1.368	1.183
Ln X	1.190	0.964	0.817	0.714	0.629

Note: The critical values come from Kwiatkowski et al. (1992), Table 1, p166.
For each country Y = that country's real GDP; REX = real exchange rate; M = that country's imports from the U.S. which is used as U.S. exports to that country; X = that country's export to the U.S. which is used as the U.S. imports from that country.

choices. Johansen-Juselius introduce two statistics for determining the number of cointegrating vectors. These are known as λ-max and trace tests. Table 2 reports these two statistics for all six cases.

Table 2. Cointegration results for import and export demand variables (r = # of cointegrating vectors): 1973I-1996II.

	λ-Max			Trace		
Null	r = 0	r <= 1	r <= 2	r = 0	r <= 1	r <= 2
Alternative	r = 1	r = 2	r = 3	r = 1	r = 2	r = 3
Canada						
Import(2)	21.69	7.23	3.49	32.41	10.72	3.49
Export(1)	58.40	10.49	2.33	71.23	12.89	2.33
Japan						
Import(2)	22.16	12.73	5.90	40.79	18.63	5.90
Export(1)	76.86	15.57	4.80	97.24	20.37	4.80
Germany						
Import(2)	28.58	14.81	7.92	51.31	22.73	7.93
Export(5)	21.27	6.25	2.28	29.80	8.53	2.28
UK						
Import(2)	28.86	16.14	4.01	49.01	20.15	4.01
Export(1)	34.77	21.86	1.82	58.44	23.67	1.82
France						
Import(2)	25.69	16.42	6.88	48.99	23.31	6.88
Export(3)	18.45	11.29	4.55	34.29	15.84	4.55
Italy						
Import(2)	22.35	17.51	11.35	51.19	28.87	11.35
Export(8)	46.85	12.65	6.99	66.49	19.64	6.99
95% Critical Values	22.00	15.67	9.24	34.91	19.96	9.24
90% Critical Values	19.77	13.75	7.53	32.00	17.85	7.53

Note: The lag order for each VAR was selected with AIC, and it appears in parenthesis.

As can be seen the null of no cointegration, i.e., $r = 0$ is rejected for both U.S. import and export demands for all six countries. This is because at least one of the statistics (λ-max or trace) is larger than the critical value at least at the 90% level of significance. Thus, there is at least one cointegrating vector in each case. Further inspection of these statistics reveal that in some cases there are even two vectors. The list includes import and export demand from Japan, the U.K., and Italy as well as the import demand from Germany, and France. King et al (1991) have argued that more than one vector is plausible due to different economic theories dominating different relations among a set of variables. For example in the import demand function one relation can signify the import demand equation and another one an exchange rate equation in which imports and income are the determinants of real exchange rate. In such cases, the choice of one vector over the other is dictated by the theory, i.e., by the expected signs of estimated coefficients. Thus, for each case we only report one vector in which all variables carry their expected signs. Estimates of these vectors appear in Table 3. Note that all vectors are normalized on Ln M and Ln X by setting their coefficients to -1 so that we can easily read the elasticities.

Table 3. Estimates of the Cointegrating Vectors: 1973I-1996II.

Panel A: Import Demand Estimates

Country i	Ln M	Ln $Y_{U.S.}$	Ln REX	Constant
Canada	-1.00	2.26	0.30	-4.76
Japan	-1.00	3.84	0.78	-16.06
Germany	-1.00	2.32	0.42	-6.68
UK	-1.00	2.37	0.68	-6.51
France	-1.00	2.65	0.21	-9.02
Italy	-1.00	4.62	2.77	-37.76

Panel B: Export Demand Estimates

Country i	Ln X	Ln Y_i	Ln REX	Constant
Canada	-1.00	2.02	-0.45	-3.79
Japan	-1.00	1.17	-0.60	2.19
Germany	-1.00	1.22	-0.48	-1.74
UK	-1.00	1.93	-1.02	-5.40
France	-1.00	1.66	-0.88	-2.52
Italy	-1.00	0.06	-1.07	10.33

From table 3 we gather that all variables in all cases carry their expected signs. The income elasticities of import and export demand equations tend to be relatively large, which is consistent with the previous literature. The income elasticities of exports appear to be significantly lower then the income elasticities for imports, suggesting that the US economy can pull other economies out of a recession. However, the reverse impact is not as large. As for the M-L condition, it is clear that the sum of the absolute value of exchange rate elasticities of import and export demands is greater than unity in the cases of Japan, the U.K., France, and Italy but not in the cases of Canada and Germany. Thus, the M-L condition is satisfied for the first four countries implying that real depreciation of the dollar will have a favorable long-run effect on trade between the U.S. and each of the four countries. Four of the countries in this study, i.e., Canada, Japan, Germany and U.K. were also included in Marquez (1990) who estimated bilateral trade elasticities using Band Spectrum analysis. For three of the four countries he overestimated elasticities compared to our estimates. As indicated before, this could be due to the non-stationarity of the data.

How stable are these elasticities over time? Following Pesaran and Pesaran (1997) we try to answer this question by taking into consideration not only the long-run elasticities, but also the short-run adjustment. The task is reduced to forming an error-correction term using the long-run estimates from Table 3. The lagged error-correction term (EC_{t-1}) is then employed in estimating the following error-correction model by OLS.

$$\Delta Ln\, M_t^{U.S.} = a_o + \sum_{j=1}^{n} b_j \Delta Ln\, M_{t-j}^{u.s.} + \sum_{j=1}^{n} c_j \Delta Ln\, Y_{U.S.,\, t-j} + \sum_{j=1}^{n} d_j \Delta REX_{i,\, t-i} + \lambda EC_{t-1} + {}_t \qquad (3)$$

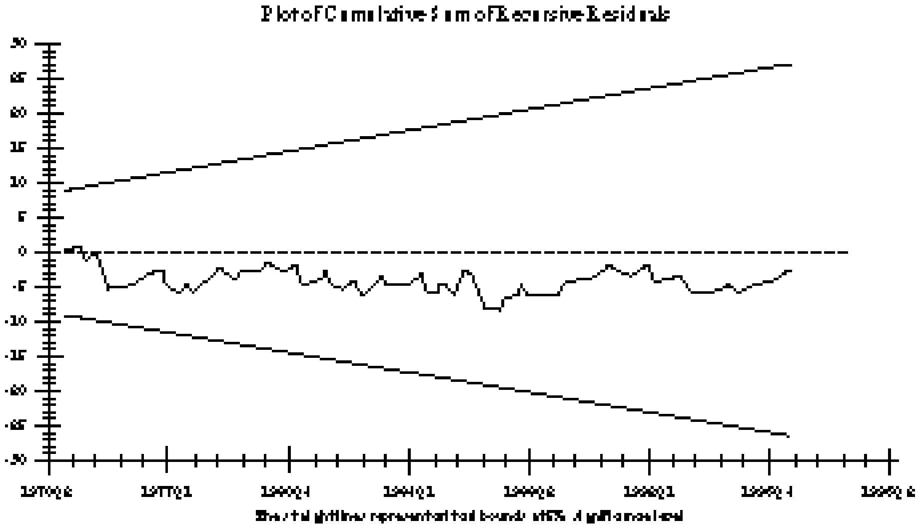
Pesaran and Pesaran (1997) then suggest employing CUSUM or CUSUMSQ tests proposed by Brown, Durbin and Evans (1975). We employ the CUSUM test which is based on the cumulative sum of recursive residuals based on first set of r observations. The CUSUM statistic is updated recursively and is plotted against the break points. If the plot of CUSUM statistic stays within %5 significance level (portrayed by two straight lines whose equations are given in Brown et. al 1975, section 2.3), then the coefficient estimates are said to be stable. A graphical presentation of the test is provided in Figure 1 for the U.S. import and export demand functions from Japan.

It is clear from Figure 1 that in none of the graphs do the plots of CUSUM statistic cross the critical bounds, indicating that indeed all short-run and long-run elasticities are stable. We also carried the same test for other trading partners. All models yielded stable coefficients except the U.S. exports to Canada.

4. SUMMARY AND CONCLUSION

If real depreciation is to have a favorable impact on the trade balance of a country, the sum of the price elasticities of that country's import and export demands must add

Export Demand Equation for Japan



Import Demand Equation for Japan

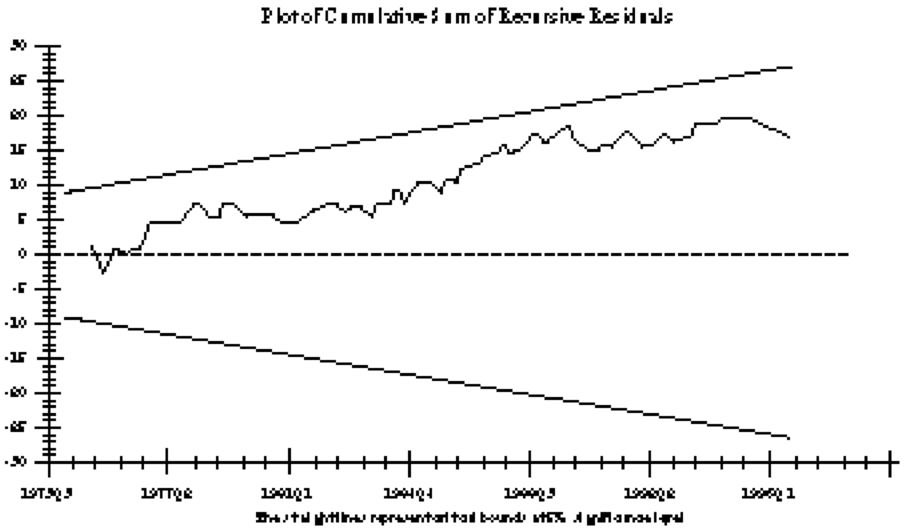


Figure 1. Stability Tests

up to more than unity, a condition known as the Marshall-Lerner condition. In this paper we use Johansen and Juselius' cointegration procedure to test for the existence of a long-run relationship among the variables of import and export demand as well as estimates of the Marshall-Lerner condition. The import and export demand functions are estimated on a bilateral basis between the United States and each of her big trading partners, i. e., Canada, Japan, Germany, the U.K., France and Italy (including the U.S., the G-7). We found evidence that the variables included in the U.S. import and export demand functions were cointegrated, suggesting a long run relationship. The estimates of the real exchange rate elasticities revealed that M-L condition was satisfied in four out of six cases suggesting that in these four cases (Japan, U.K., France, and Italy) real depreciation of the dollar will improve the U.S. bilateral trade balance. Additional testing showed that the elasticities are stable.

APPENDIX

Data Definition and Sources

All data are quarterly over 1973I-1996II period and are collected from the following sources:

a. International Financial Statistics of the International Monetary Fund, CD- ROM.
b. Direction of Trade Statistics of the International Monetary Fund, various issues.
c. Main Economic Indicators of OECD.

Variables:

$M_i^{U.S.}$ = U.S. real imports from country *i*. Nominal import values from source (b) are deflated by the U.S. import price index from source (a) to obtain this variable.

$X_i^{U.S.}$ = U.S. real exports to country *i*. Nominal export values from source (b) are deflated by U.S. export price index from source (a) to obtain this variable.

Y_i = Index of real income in country *i*. Real GDP of country *i* from is set in index form to make it unit free. For all countries data come from source a except for Germany which comes from source *c*.

REX_i = Real bilateral exchange rate between U.S. and each trading partner. It is defined as ($P_{U.S.}\ E/P_i$) where $P_{U.S.}$ is the U.S. GDP deflator (source a); E is the nominal bilateral exchange rate defined as number of *i*'s currency per dollar (source a); and P_i is country *i*'s GDP deflator (source a).

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