An empirical study of the effects that variations in Exchange Rates might have on the bilateral import volumes of the US and three of its trading partners-Japan, Germany, and the UK

Introduction

Foreign exchange has become one of the most important, and at the same time one of the most confounding markets in the modern world dominated by foreign trade, especially since the advent of the floating exchange rate systems in the early 1970s. People and governments primarily wish to purchase foreign currency so that they can buy goods and services from the foreign country, although some do it for speculative reasons. The price one must pay to receive the foreign currency in exchange for the local currency is known as the exchange rate between the two currencies. Because of their "floating" nature, people do a lot of speculation in the foreign exchange market, buying and selling foreign currencies within minutes to rip a fortune or to loose it all. Like all other prices in a free market, prices for foreign exchange are determined by the continuous interaction of the demand for and supply of foreign currencies. To say this, says Robert Carbaugh, is to say "at once everything and to say nothing"(Carbaugh 395). What he means is that a lot of market fundamentals and expectations come into play while determining the exchange rates between different currencies, like bilateral trade balances, real interest rates, inflation rates, government trade policies, consumer taste and preferences, and also speculative opinions and actions regarding foreign exchange rates (Carbaugh 395).

In turn, changes in the real exchange rates lead to the heightening or lowering of prices of foreign goods in local currency terms around the world. The Economic Research Service of the USDA, for example, suggests that the steady appreciations of the US Dollar during the 1997-99 international financial crisis resulted in lower agricultural exports, from a peak of nearly $60 billion in fiscal 1995 to $49 billion in 1999 and that this appreciation also led to a 2 percent decline in global share of all US agricultural exports between 1992 and 1998. ("Economic Research Service", USDA) The logic behind their claim is that an appreciation of the dollar with respect to say, the Deutche Mark, requires more Deutche Marks from the Germans to buy the same amount of Dollars, with which to import goods and services from the United States. American goods look more expensive simply because of the depreciation of their own currency, and demand for imports go down.

A considerable amount of research has been done in an attempt to identify problems associated with floating exchange rates. In 1980, a study by Dennis Warner and Mordechai E. Kreinin indicated that the introduction of floating exchange rates did affect the volume of imports in several major countries, but that the direction of change varied between them. It also concluded that the exchange rate and the export price of competing countries are powerful determinants of a country's exports (Warner and Kreinin 103). Frank D. Graham and Charles R. Whittlesey, in their 1934 paper ***Exchange Rates, Foreign Trade, and Price Level***, argued that currency depreciation will make price of imports seem high to purchasers, but at the same time, the prices of exports will appear high to sellers in this country, who want to supply more at that higher price. It is impossible to say which effect will dominate, but as total exports and imports must balance in the long run, the effect of exchange rate variation cannot influence the two categories of international trade in opposite ways (Graham and Whittlesey 405). In another study pertaining to the Bretton-Woods period of fixed exchange rates, John Wilson and Wendy T. Takacs conclude that the initial impact of exchange rate changes on trade flows tended to be greater than that of price changes. (Wilson and Takacs 267)

Using Vector Auto Regression, Kim Yoonbai suggests through his paper that the exchange rate is an important transmission channel of influence on prices, and with longer lags, on income and trade balance and also that the dollar/yen exchange rate is a much less significant cause for US-Japan bilateral trade than the effective exchange rate or the dollar/mark rate is for multilateral or US-German trade.(Kim 179) Another area of research in this field has been those regarding the effects of exchange rate volatility and uncertainty in the volume of international trade. Kenen and Rodrik in 1984 suggested that volatility appeared to depress the volume of international trade and the result was found to be consistent with previous results from David Kushman and Akhtar & Hilton (Kenen and Rodrik 311).

When these studies were performed, they were usually done across a fairly large number of countries and using trade weighted exchange rates. Trade weighted exchange rate is a weighted-average index of bilateral exchange rates between trade partners using trade volumes as weights. ("Economic Research Service", USDA). The Atlanta Federal Reserve's Economic Review of 1987 says that bilateral weights may be more useful in analyzing the short-run impact of exchange rate changes on a nation's import prices.

Model

The purpose of this paper is to try to assess the veracity of the above mentioned logic that asserts that changes in exchange rates do have an impact on the volume of bilateral trade between nations using a multivariate regression model. Demand for imports are primarily dependent on National Income of the importing country, price of the imported goods, price of domestic goods, and the rate of exchange between the two countries' currencies.

The expected directions of their impact are:

$$\overset{}{M} = M(\overset{+}{Y}, \overset{+}{Pd}, \overset{-}{Pm}, \overset{-}{R})$$

The equations estimated for each country are:

$$\mathbf{lnM_i = \beta_0 + \beta_1\, lnY_i + \beta_2\, lnPd_{i,} + \beta_3\, lnPm_{j,} + \beta_4\, lnR_{ij,} + \varepsilon_i\,,\ \&}$$

$$\mathbf{lnM_i = \beta_0 + \beta_1\, lnY_i + \beta_2\, lnPd_{i,t-1} + \beta_3\, lnPm_{j,t-1} + \beta_4\, lnR_{ij,t-1} + \varepsilon_i}$$

where, M_i = Volume of Imports to the i^{th} country in 1995 dollars (billions)

Y_i = Real (1995)Gross Domestic Product of the i^{th} importing nation (billions)

Pd_i = Price of domestic goods in the i^{th} nation (proxied by the CPI of the i^{th} importing nation(1995=100))

Pm_j = Price of imported goods in the j^{th} nation (proxied by the export price index of the j^{th} exporting nation(1995=100)), and

R_{ij} = Quarterly average of the exchange rate between the i^{th} and j^{th} trading nations, e.g. R with regards to US imports from Japan means $/Y.

Data & Methodology

I chose to study individually the effect of exchange rate changes in US imports from Japan, Germany and the UK an also US exports to these countries, as Japanese, German and British imports from the US. Equations were first estimated without any lags, and then estimated with the price and exchange rate variables lagged by one quarter to study the lagged effects of the exchange rate variable in particular. Since exports are just the other sides of imports, only the import equations were estimated, but from both trading sides. Thus, a total of twelve equations were estimated by the method Ordinary Least Squares.

Quarterly data for all variables was obtained from various sources. I obtained the nominal import and export data by adding the monthly data from the U.S. Census Bureau, Foreign Trade Division, and converted into constant 1995 dollars by using the US import and export price indices (1995=100). One can convert any price/amount to a new base year by dividing the nominal dollars by the corresponding period's price index (or import or export index) and multiplying the product by 100. Real Gross Domestic Product (RGDP), uniform consumer prices, exchange rates, and export and import price indices data were obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Differences in units do not matter in terms of regression analysis except in interpreting the scale of the co-efficient, and all conclusions about signs, significance and economic theory are independent of units of measurement. (Studenmund, 69)

Results

The estimated equations are listed below in the standard form.

i) US imports from Japan

Without lags

$$\ln(M) = -15.248 + 4.024*\ln(Y) - 2.589*\ln(Pd) - 1.585*\ln(Pf) - 0.446*\ln(R)$$

(4.24) (3.29) (0.487) (.206)

t= 0.948 -0.786 -3.249 -2.163

$\check{R}^2 = 0.836$ n=36 d=1.07 F= 45.82

With lags

$$\ln(M) = -35.34 + 8.165*\ln(Y) - 5.868*\ln(Pd(-1)) - 2.414*\ln(Pf(-1)) - 0.90*\ln(R(-1))$$

(5.076) (3.833) (0.507) (0.221)

t = 1.608 -1.531 -4.755 -4.072

$\check{R}^2 = 0.848$ n=35 d=1.48 F= 48.34

ii) Japanese imports from US

Without lags

$$\ln(M) = 11.79 - 2.197*\ln(Y) + 1.184*\ln(Pd) + 3.04*\ln(Pf) - 2.15*\ln(R)$$

	(0.739)	(0.429)	(.253)	(0.785)
t =	-2.97	2.758	12.005	-2.74

$\check{R}^2 = 0.939$ n=36 d=2.39 F= 136.756

With lags

$$\ln(M) = -14.222 + 0.172*\ln(Y) - 0.399*\ln(Pd(-1)) + 3.554*\ln(Pf(-1)) + 0.229*\ln(R(-1))$$

	(0.102)	(0.292)	(0.259)	(0.114)
t =	1.684	-1.368	13.705	2.017

$\check{R}^2 = 0.919$ n=35 d=1.565 F= 98.67

iii) US imports from UK

Without lags

$$\ln(M) = 89.947 - 18.582*\ln(Y) + 17.771*\ln(Pd) - 0.895*\ln(Pf) - 0.518*\ln(R)$$

	(6.513)	(5.067)	(0.328)	(0.294)
t=	-2.854	3.507	-2.731	-1.765

$\check{R}^2 = 0.895$ n=36 d=0.986 F= 75.73

With lags

$$\ln(M) = 27.37 - 6.731*\ln(Y) + 8.406*\ln(Pd(-1)) - 0.862*\ln(Pf(-1)) - 0.425*\ln(R(-1))$$

	(9.489)	(7.114)	(0.402)	(0.334)
t =	-0.709	1.182	-2.146	-1.27

$\check{R}^2 = 0.863$ n=35 d=1.245 F= 54.59

iv) UK imports from US

Without lags

$$\ln(M) = -2.161 - 1.308*\ln(Y) + 3.399*\ln(Pd) - 0.99*\ln(Pf) - 1.029*\ln(R)$$

	(2.703)	(2.751)	(0.949)	(2.563)
t=	-0.484	1.236	-1.043	-0.401

$\check{R}^2 = 0.59$ n=36 d=1.299 F= 13.67

With lags

$$\ln(M) = -5.501 - 0.115*\ln(Y) + 2.243*\ln(Pd(-1)) - 0.477*\ln(Pf(-1)) - 0.132*\ln(R(-1))$$

(0.466)	(0.605)	(0.994)	(0.453)

t = -0.246 3.71 -0.479 -0.292

$\check{R}^2$ = 0.587 n=35 d=1.392 F= 13.06

v) US imports from Germany

Without lags

ln (M) = 99.186 – 22.209*ln(Y) + 19.302*ln(Pd) + 2.569*ln (Pf) – 0.379*ln(R)
(7.203) (5.676) (3.227) (0.223)
t= -3.084 3.4 0.796 -1.699

$\check{R}^2$ = 0.81 n=36 d=1.075 F= 38.392

With lags

ln (M) = 36.116 – 13.337*ln(Y) + 10.813*ln(Pd(-1)) + 7.613*ln(Pf(-1)) - 0.386*ln(R(-1))
(7.993) (6.252) (3.148) (0.206)
t = -1.669 1.729 2.419 -1.875

$\check{R}^2$ = 0.84 n=35 d=1.119 F= 48.117

vi) German imports from US

Without lags

ln (M) = -4.343 + 0.037*ln(Y) + 0.082*ln(Pd) + 1.135*ln (Pf) + 0624*ln(R)
(0.049) (0.584) (1.09) (0.328)
t= 0.759 0.141 1.04 1.906

$\check{R}^2$ = 0.18 n=36 d=0.886 F= 2.977

With lags

ln(M) = -6.733 + 0.043*ln(Y) – 0.309*ln(Pd(-1)) + 2.045*ln(Pf(-1)) + 0.608*ln(R(-1))
(0.056) (0.648) (1.208) (0.35)
t = 0.766 -0.477 1.693 1.734

$\check{R}^2$ = 0.068 n=35 d=1.079 F= 2.716

Once the regression coefficients were estimated, they were put through a series of tests, to test the statistical significance of the coefficient of the exchange rate (R) variable using the t-test, to test for overall fit using the F-test, and to detect serial correlation if any.

The t-tests

The t-test is generally used to test hypotheses about individual regression slope coefficients. In all cases, our null and alternative hypotheses are the same, and as follows:

$H_0 = \beta_4 \geq 0$

$H_A = \beta_4 < 0$

Similarly, number of observations (n) = 36, and number of independent variables (k) = 4. Thus it follows that the degrees of freedom = n-k = 32. For a 5% level of significance, the critical t-value, i.e. $t_c = 1.695$

The rule in using the t-test is that we reject H_0 if $|t_k| > t_c$, and if t_k also has the sign implied by H_A. In this case, if $|t_4| > 1.695$, we reject the null hypothesis, since we are measuring the statistical significance of the coefficient of the exchange rate variable. The results of the t-tests of the exchange rate variable in each of the twelve equations are listed below.

i) **US imports from Japan**

Without lags

$|t_4| = 2.163 > 1.695$ and 2.163 is negative.

Therefore we can reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 0.44% decrease in the volume of imports.

With lags

$|t_4| = 4.07 > 1.695$ and 4.07 is negative.

Therefore we reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 0.9%

decrease in the volume of imports.

ii) **Japan imports from US**

<u>Without lags</u>

$|t_4| = 2.74 > 1.695$ and 2.74 is negative.

Therefore we can reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 2.15% decrease in the volume of imports.

<u>With lags</u>

$|t_4| = 2.01 > 1.695$ but 2.01 is positive.

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

iii) **US imports from UK**

<u>Without lags</u>

$|t_4| = 1.765 > 1.695$ and 1.765 is negative)

Therefore we can reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 0.52% decrease in the volume of imports.

<u>With lags</u>

$|t_4| = 1.27 < 1.695$ (even though 1.27 is negative)

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

iv) **UK imports from US**

<u>Without lags</u>

$|t_4| = 0.4 < 1.695$ even though 0.4 is negative.

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

<u>With lags</u>

$|t_4| = 0.29 < 1.695$ even though 0.29 is positive.

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

v) **US imports from Germany**

<u>Without lags</u>

$|t_4| = 1.698 > 1.695$ and 1.698 is negative.

Therefore we can reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 0.38% decrease in the volume of imports.

<u>With lag</u>

$|t_4| = 1.87 > 1.695$ and 1.877 is negative

Therefore we can reject the null hypothesis and say that the coefficient is statistically significant. This suggests that a 1% increase in the exchange rate would lead to a 0.38% decrease in the volume of imports.

vi) **German imports from US**

<u>Without lags</u>

$|t_4| = 1.906 > 1.695$ but 1.906 is positive

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

With lags

$|t_4| = 1.75 > 1.695$ and 1.75 is positive.

Therefore we cannot reject the null hypothesis. Thus we cannot say that our coefficient is statistically significant.

Only in six equations were the coefficients of the exchange rate variable found to be statistically significant with a 5% level of significance. But the t-test does not test the theoretical validity, does not test importance and is not intended for tests of the entire population (Studenmund 142).

F- Tests of overall significance

The F-test is a method of testing null hypothesis that includes more than one coefficient. It was used during this project to test the overall significance of a regression equation. In our case,

$H0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

HA : H0 is not true

The formula for calculating the F-statistic is as follows:

$F = (ESS/K) / (RSS/(n-K-1))$, where ESS = Explained Sum of Squares, RSS = Residual Sum of Squares, n= number of observations and k = number of explanatory variables.

For a 5% level of significance, with degrees of freedom for the numerator, K = 4, and degrees of freedom of the denominator, n-K-1 = 31, our critical F value, FC = 2.69. We reject H0 if our F statistic is greater than the critical F value. E-views provided the F-statistics for each regression and almost all of them are significantly greater than 2.69

(Please see estimates above). Only trade with Germany showed really low F-statistic and the t-statistics earlier weren't very favorable either. We can conclude fairly certainly that all of the equations have a significant overall fit, even though there is suspicion of serial correlation in the German trade data.

Serial Correlation

Serial correlation is the violation of classical assumption IV which says that observations of the error term are uncorrelated with each other. Since it is much more prevalent with time-series data, I decided to perform the Durbin-Watson d-test to detect any serial correlation in the estimated equations. Even though it does not cause bias in the estimated coefficients, serial correlation increases the variances of the distributions for the estimated beta coefficients. This causes OLS to underestimate the standard errors of the coefficients and in turn increases the t-statistic, which makes one more likely to reject a true null hypothesis, i.e. probability of committing a Type I error is increased.

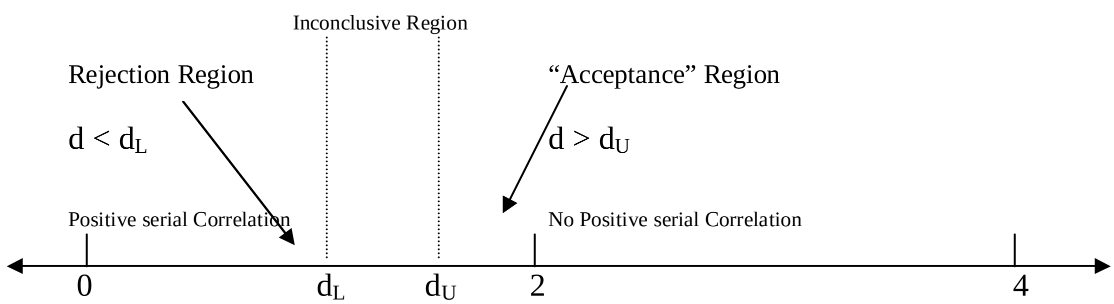

Fig 1: Acceptance and rejection regions for a One-Sided Durbin-Watson ***d*** test

For n = 36, k = 4, and a 5% one-sided level of significance, d_L =1.24 and d_U = 1.73. If the d statistic from our equations is less that d_L, there is indication of positive serial correlation. If it is greater that d_U, there is no indication of positive serial correlation, and if it lies between d_L and d_U, which is the inconclusive region, we cannot of course, conclude anything regarding positive serial correlation. The results of out Durbin-Watson d test are listed in the table below.

Case	d_L	D-W ***d***-stat.	d_L	Result
US imports from Japan				
Without lags	1.24	1.07	1.73	Indication of positive serial correlation
With lags	1.24	1.48	1.73	Inconclusive
Japan imports from US				
Without lags	1.24	2.39	1.73	No serial correlation
With lags	1.24	1.56	1.73	Inconclusive
US imports from UK				
Without lags	1.24	0.98	1.73	Indication of positive serial correlation
With lags	1.24	1.25	1.73	Inconclusive
UK imports from US				
Without lags	1.24	1.29	1.73	Inconclusive
With lags	1.24	1.39	1.73	Inconclusive
US imports from Germany				
Without lags	1.24	1.07	1.73	Indication of positive serial correlation
With lags	1.24	1.11	1.73	Indication of positive serial correlation
German imports from US				
Without lags	1.24	0.88	1.73	Indication of positive serial correlation
With lags	1.24	1.07	1.73	Indication of positive serial correlation

Six of the observations indicated some degree of serial correlation ore mostly inconclusive. US trade with Germany particularly showed somewhat strong signs of positive serial correlation, which could have surely affected the t and the F-statistics above. Upon implementing the AR(1) Method in E-views, the value of ρ was given to be 0.6 for German imports from the US without any lags and 0.75 with lags.

Conclusion

We found fairly strong indications that our hypothesis might be at least partially correct. Some observers are said to have interpreted the continued rapid growth of imports in recent years as evidence that changes in the dollar exchange rate have lost some of their power to influence the demand for foreign goods in the US. They contend that import behavior may have undergone a permanent structural shift in the first half of the 1980s when the dollar's value was persistently far above levels warranted by foreign and domestic price levels (Klitgard 1). In 1985, Thomas Klitgard wanted to know if structural changes have, in fact, significantly altered import behavior. His results indicated that ant changes in the market structures over the 1980s had not been large enough to alter import behavior significantly. He further contends that increasing demand for imports may well have been caused by increasing domestic prices relative to foreign prices.

The Law of One Price says that identical goods should cost the same in all nations; assuming that it is costless to ship the goods and trade barriers do not exist. It is said to be due to the tendency of goods that are easily tradable to be sold at the same price when expressed in common currency. If all goods were tradable and the law of one price held exactly, exchange rates would reflect no more than the differences in the way the price levels are expressed in the two countries. As the world is integrating ever more in terms of trade, exchange rates might just lose their importance as important determinants of trade and we might even adopt one universal current in the not so distant future. Ever growing volumes of trade and more and more specialization, exchange rates probably won't matter when people desire foreign goods and services.

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