

Exchange Rate Misalignment and Agricultural Trade*

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Abstract:

Using a sample consisting of bilateral trade flows across 10 developed countries between 1974 and 1995, this paper explores the effect of exchange rate misalignment on the growth of agricultural trade as compared to other sectors. Controlling for other factors likely to determine the growth in bilateral agricultural trade, the results show that long-run real exchange rate variability has had a significant negative effect on the growth of agricultural trade over this period.

Keywords: Exchange rates, misalignment, agricultural trade

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1. Introduction

There has been considerable dispute among international economists as to whether the high level of exchange rate volatility characterizing the world economy since the breakdown of the fixed exchange rate system has had a negative effect on international trade. Empirical observation shows that daily or monthly nominal exchange rate movements have become much more volatile since 1973. The most common assertion in the literature has been that uncertainty caused by exchange rate variability will reduce the level of exports, e.g., Hooper and Kolhagan (1978). This is countered by the argument that the use of forward markets could ameliorate uncertainty in the short- to medium-run. There have been many empirical studies that have attempted to shed light on this issue, though the econometric evidence is ambiguous. For example, in early research, Cushman (1988) found a negative effect, while Klein (1990) found a positive effect. More recently, Rose (2000), using bilateral trade data for a panel of 186 countries over the period 1970-1990, found a small negative effect of exchange rate volatility on trade.

De Grauwe and de Bellefroid (1986) argue that it is not short-run variability that is relevant; rather, it is long-run variability in exchange rates that is likely to affect trade. Furthermore, rather than focusing on levels of trade, which is the dependent variable in most empirical studies, De Grauwe and de Bellefroid argue that the relevant variable is the *growth* of international trade. With the emphasis on growth of international trade over periods of 5 to 10 years, they find variability of real exchange rates has negatively affected trade.

Reflecting the wider literature, empirical research relating to exchange rate variability and agricultural trade flows has given ambiguous conclusions. For example, Pick (1990) found that exchange rate risk had no effect on US trade flows to other developed countries, though it did have a negative effect on US exports to developing countries. In contrast, Klein (*op.cit.*)

found that short-run real exchange rate volatility negatively affected US agricultural exports compared to other sectors. In general, three criticisms can be made of the literature relating to exchange rate variability and agricultural trade. First, and most obviously, empirical studies that have addressed this issue have been rather sparse. Second, the emphasis has been on US agricultural trade flows with no studies considering the effect of exchange rate variability on bilateral trade flows of other countries. Third, the focus of attention has been on short-run exchange rate variability, the effects of long-run exchange rate variability having been ignored.

This paper addresses the issue of exchange rate *misalignment* on the *growth* of agricultural trade. The data used in this study comprises of bilateral agricultural trade flows for 10 developed countries between 1974-1995. The principal attraction of cross-sectional bilateral trade flow data is that it allows us to consider a range of factors that are likely to determine the growth of trade between countries including income growth, and the effects of trading blocs such as the European Union. Clearly the interest lies in whether exchange rate misalignment has affected the growth in agricultural trade once we have controlled for these other factors. The paper is organized as follows. In section 2, the meaning of exchange rate misalignment, and its connection with trade growth is discussed. In section 3, an overview of the data set and a review of key statistics relating to the growth of agricultural trade and exchange rate variability since the 1960s are presented. In section 4, variable construction and data are discussed, while in section 5 the econometric specification and results are reported. The paper is summarized in section 6.

2. Exchange Rate Misalignment

Exchange rate misalignment, in general, can be defined as the persistent departure of the nominal exchange rate from its long-run equilibrium level. Measuring misalignment is actually difficult and inherently imprecise, as it requires estimation of what is termed the fundamental equilibrium

exchange rate. Typically in the literature, it is assumed that purchasing power parity (PPP) is the long-run equilibrium condition of nominal exchange rates. Essentially, based on Cassel's (1922) argument, PPP should hold because exchange rates equalize relative price levels in different countries. The standard expression for *absolute* PPP is:

$$s_t = p_t - p_t^*, \quad (1)$$

where s_t is the home currency price of a foreign currency, p_t is domestic-currency price of a particular good(s), p_t^* is the foreign currency price of the good(s), and lower case letters denote logarithmic values. The implication of (1) is that trade in goods will result in identical prices across countries. Allowing for factors such as transport costs, PPP in its *relative* form implies that a stable price differential should exist for the same good(s) selling in different countries, the implication being that real exchange rates between countries should be equal to a constant in the long run, and, consequently, there is no persistent misalignment of exchange rates from relative PPP, i.e., the real exchange rate should be mean-reverting (MacDonald, 1999).

There has actually been a long debate in the literature as to whether such deviation exists. Traditional macroeconomic theory does not support the existence of a substantial and persistent deviation of nominal exchange rates from market fundamentals. Empirical evidence published mostly in the 1980s, however, was not very favorable to this view. Researchers essentially tested for whether the log of the real exchange rate, q_t , is stationary:

$$q_t \equiv s_t - p_t + p_t^* \quad (2)$$

Several studies could not reject the hypothesis of a random walk of real exchange rates under the flexible exchange rate regime (Adler and Lehman, 1983; Meese and Rogoff, 1983). As a result, it led to the belief that PPP was of little use empirically, and, real exchange rate movements were highly persistent (Dornbusch, 1987).

In more recent research, the focus has been on the use of co-integration methods applied to the following equation:

$$s_t = \beta + \alpha_0 p_t + \alpha_1 p_t^* + \varphi_t \quad (3)$$

If s_t , p_t , p_t^* are integrated of order one, I(1), then a weak form of PPP exists if the residual term from estimation of (3) is stationary, I(0), and a stronger form of PPP exists if homogeneity is satisfied, i.e., $\alpha_0 = 1$, and $\alpha_1 = -1$. Using this type of approach, several early studies found no evidence of significant mean reversion of exchange rates toward PPP (Mark, 1990; Fisher and Park, 1991). Several authors have argued, however, that the data period for the recent float is too short to have any confidence in the power of statistical tests for stationarity of real exchange rates (Frankel, 1990; Lothian and Taylor, 1997).¹ As a consequence, recent research has either been based on long-term, pre-float data (Lothian and Taylor, 1996), or multi-country panel data (Flood and Taylor, 1996; Frankel and Rose, 1996). This more recent evidence rejects the random walk hypothesis of real exchange rates. Essentially, real exchange rates revert to equilibrium values over the long run, and, correspondingly, nominal exchange rates and relative prices converge, reviving the notion that PPP is a long-run equilibrium condition of nominal exchange rates (MacDonald, *op.cit.*).

There is, however, an unsolved puzzle. Consensus estimates suggest that the speed of convergence to PPP is very slow, the deviations appearing to dampen out at a rate of roughly 15 percent per year (Rogoff, 1996). The puzzle is simply that the deviation is relatively more persistent than generally expected. This implies of course that deviation from the mean for real

¹ We tested for stationarity in bilateral real exchange rates for nine of the ten countries included in our subsequent analysis of trade and exchange rates: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the United Kingdom, and the United States. Fisher and Park's sample was the same, except for the addition of Sweden and Switzerland. Using monthly exchange rate and price data from January 1971 to December 1996, we were not able to reject the null of stationarity in bilateral real exchange rates in 18 of the 36 cases, which is more supportive of PPP than the results reported by Fisher and Park. This is likely due to the additional six years of data.

exchange rates may be regarded as a suitable measure of the magnitude of exchange rate misalignment between countries.

While the majority of studies in this field have focused on explaining this empirical phenomenon, economists have also begun to analyze the potential effect of misalignment on international trade. For example, it has been observed that when there is substantial over (under)-valuation of an exporting country's currency, exporting firms do not necessarily fully increase (decrease) their export prices in the destination market currency, known as pricing to market (Knetter, 1993). As a result, exports do not decrease (increase) by as much as would be the case with full pass-through. The typical explanation for this is that if the over (under)-valuation lies within some reasonable range, and the fixed costs of either re-entering or expanding the market are high, then firms will not fully adjust their prices. If there is a large exchange rate shock, however, it is possible that firms will either leave or enter an industry, and without a countervailing large exchange rate shock, the new market structure will persist (Baldwin and Krugman, 1989). It is likely that such a phenomenon, termed *hysteresis*, will vary across sectors depending on the nature of the products being sold. For example, many agricultural goods are homogeneous and non-durable, as compared to industrial goods, so, *a priori*, it might be expected that exchange rate misalignment might have quite different sectoral effects on trade.

There has actually been a debate in the literature as to whether the flexible exchange rate system could generate a large enough shock that would negatively affect long run growth rates in trade among developed countries (Frankel, 1996). Some economists argue that real exchange rate variability under the pure floating system has been much larger than that of a naturally acceptable range (McKinnon, 1996; Williamson, 1985, 1989). As a result, a managed exchange

rate system such as the target zones used among European Monetary System (EMS) countries is preferred. On the other hand, monetarist economists, following Friedman (1953), believe that misalignment under the pure floating system has been at a natural level, such that, in the long run, it has not been large enough to have an impact on international trade flows. Therefore, the question of whether exchange rate deviation from equilibrium levels has actually caused instability in international trade is ultimately an empirical question.

3. Exchange Rates and the Growth of Agricultural Trade: 1963-1995

As is well known even to the most casual observer of economic trends in the post-war period, the world economy was characterized by high rates of growth in world trade in all sectors during the 1960s. This was followed by considerably lower (and more variable) rates of growth in world trade over the 1970s, 1980s, and early 1990s. The high levels of growth in world trade were due to, or at least coincided with, high rates of growth of GDP in most developed countries, the reduction in tariffs resulting from successive GATT rounds and exchange rate stability under the auspices of the Bretton-Woods system. The 1970s through to the early 1990s told a very different story: the growth in world trade slowed considerably; GDP growth rates fell; protectionism increased; and exchange rates became more volatile following the collapse of the fixed exchange rate regime. Reflecting the patterns of manufacturing trade over the period 1960-1995, growth in trade of agricultural products was extremely high over the 1960s, but slowed dramatically in the post-1973 period.

Table 1: Average Annual Rates of Growth of Exports for Sample Countries 1963-1995¹

Export Growth Rates	1963-1972	1974-1985	1985-1995	1974-1995
Total Exports	8.02	3.73	1.98	2.83
Machinery	10.5	4.18	4.22	3.93
Manufacturing	7.66	1.05	1.34	1.19
Agriculture	6.49	0.52	-0.54	0.15

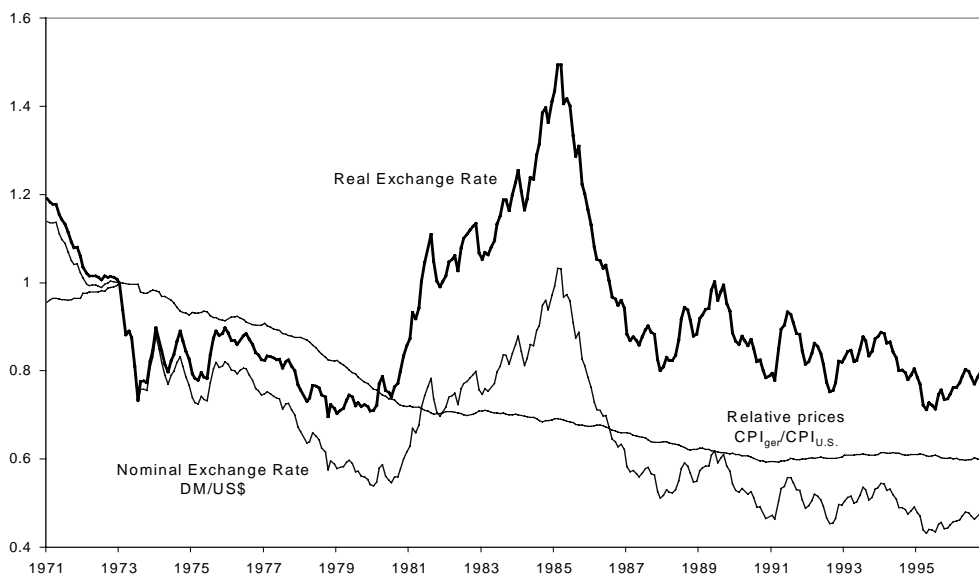
¹ Sample countries detailed in text

Relevant data highlighting these patterns are presented in Table 1. The summary figures reported in this table relate to bilateral trade flows for various sectors based on one-digit SITC definitions contained in the OECD series *Trade in Commodities*. The sample consists of 10 developed countries over the 1963-1995 period, the countries comprising the sample being the G10 countries Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the UK and the US. Taken together these countries accounted for 57 percent of total world imports of agricultural goods, and around 46 percent of total world exports at the mid-point of the sample period, 1985. The figures in the table highlight the differences during and following the Bretton-Woods system for these 10 countries. Over the period 1963-1972, total bilateral trade flows between the sample countries grew by an average annual growth rate of 8.02 percent, while for agriculture, bilateral trade flows grew at an average annual growth rate of 6.49 percent. In the 1974-1995 period, total bilateral trade flows between the sample countries grew at an average annual growth rate of 2.83 percent, while for agriculture, the average annual rate of growth fell to 0.15 percent. This represents a significant decline in the growth of agricultural trade since the end of the fixed exchange rate regime. Note, however, that other sectors also exhibited a decline in their average annual growth rates of bilateral trade following the collapse of the Bretton-Woods system. In part the slowdown in agricultural trade in the post-1973 period may reflect the slowdown in GDP growth in these 10 countries. In the period 1963-1972, the average annual growth rate of real GDP was 4.91 percent, while in the period 1974-1995, this had fallen to 2.27 percent. Since import elasticities tend to be high, one would expect growth rates in GDP to have a significant effect on growth of agricultural trade flows.

The focus of this paper is on the effect of exchange rate misalignment in affecting these trade flows. Figure 1 shows the monthly movements in relative consumer price indices (CPI) for

the US and Germany, along with nominal and real DM/US \$ exchange rates, where all data are normalized to January 1973 = 1.0.

Figure 1: DM/U.S.\$ Nominal and Real Exchange Rates, Relative Prices



It can be easily observed that the nominal DM/US \$ exchange rate has diverged from PPP as measured by relative prices. The first cycle goes from 1973 to 1981, and a second cycle goes from 1981 to 1987. Movement of the DM/US \$ exchange rate has been more stable since 1987. It can also be seen that the real exchange rate follows a similar long cycle, exhibiting mean reverting behavior, with long periods of misalignment. Similar patterns can be found between the US dollar and the currencies of other countries in the sample. In the case of the EMS, empirical evidence suggests that member countries have enjoyed relatively minimal nominal and exchange rate volatility since 1979, which may boost intra-European trade (Fountas and Aristotelous, 1999; Rose, *op.cit.*). For the sample of countries used in the present study, while the cycles are much shorter than in the case of the US, there is still evidence for cycles in real exchange rates and mean reverting behavior. For example, in the case of the DM/Lira exchange rate, there is a cycle between 1973 and 1984, and a second from 1985 to 1993, with the

half-life of the deviation from PPP being almost five years. The key question addressed in this paper, therefore, is whether exchange rate misalignment has negatively affected the growth of agricultural trade between the 10 sample countries, as compared to the growth of trade in other broadly defined sectors.

4. Variable Construction and Data

The focus in this paper is on the relationship between a measure of long-term real exchange rate variability ($\hat{\sigma}_{ij}^r$), derived from real exchange rates (r_{ijt}), and export growth rates ($\Delta \ln q^k_{ijt}$). q^k_{ijt} is the real export value of country i to country j in year t for sector k , where k refers to specific export sectors, 1=total exports, 2=machinery, 3=manufacturing, and 4=agriculture. q^k_{ijt} is constructed as follows: using the OECD bilateral trade data set *Trade in Commodities* classified by one-digit SITC code, the nominal value of exports from i to j for each sector k in US dollars is collected. This is converted into the exporting country's currency using nominal exchange rates from the IMF series *International Financial Statistics*, and deflated by the consumer price index of the exporting country (1982-84=100) from the Bureau of Labor Statistics. From this, the annual percentage rate of growth of exports, $\Delta \ln q^k_{ijt}$, is calculated, where Δ is the first difference operator, and \ln refers to the natural logarithm.

The real exchange rate series, r_{ijt} , is derived by taking the dollar based real exchange rate for the importing country j and dividing by the dollar based real exchange rate for the exporting country i giving the cross-rate. This is based on nominal exchange rate data from the IMF series, deflated by a US/home country consumer price index (1990=100), as reported by the Economic Research Service of USDA. The series is then normalized to 1973=100, and transformed into natural logarithms. Given the sample of 10 countries, there is a cross-section of 90 bilateral trade

flows (10x9), with annual data covering 22 years (1974-1995) for each trade flow, generating a complete panel of 1980 observations (90x22) for each sector k .

It is important to note at this point that the sample consists of countries that have had different international monetary systems during the post-Bretton Woods era. Most of the European countries have used a managed free-floating exchange rate system since 1979 under the EMS, albeit with different target zones for specific country pairings. In contrast, other countries, including the US, have generally operated under a pure free-floating system, although the degree of international coordination to stabilize exchange rate variation has differed by country. Therefore, it is also possible to empirically examine whether different monetary systems have had an important role in explaining long-run trade growth rates among the sample countries.

5. Econometric Specification

Cross-Sectional Analysis

In this section, the focus is on cross-sectional analysis of long-run real exchange rate variability and export growth rates. A cross-sectional approach is used because long-run real exchange variability is treated as a time-invariant variable. As discussed earlier, real exchange rates have deviated cyclically from long-run equilibrium, the deviation being pretty persistent. Therefore, from a practical standpoint, obtaining a time-varying measure of real exchange rate variability is difficult due to the short span of the floating exchange rate system. In addition, there is an underlying statistical rationale for treating real exchange rate variability as a time-invariant variable. Recent empirical evidence of long-run PPP indicates that real exchange rates among most developed countries can be characterized as a stationary process. According to the theory of time-series statistics, stationarity of a variable implies the existence of a finite long-run

variance of the series. Further, if it is assumed that underlying innovations of real exchange rates are Gaussian, the sample variance of the real exchange rate can be treated as a sample counterpart of the underlying long-run variance of the true population by ergodicity of a stationary process (Hamilton, 1994).

Initially, the following simple cross-sectional model is estimated for each of the sectors:

$$\Delta \ln \bar{q}_{ijt}^k = \alpha^k + \beta^k \hat{\sigma}_{ij}^r + \varepsilon_{ijt}^k. \quad (4)$$

$\Delta \ln \bar{q}_{ijt}^k$ is the average annual export growth rate of sector k from exporting country i to importing country j over the sample period, and $\hat{\sigma}_{ij}^r$ is the standard deviation of the real exchange rate during the sample period. $\hat{\sigma}_{ij}^r$ is a proxy measure of the magnitude of nominal exchange rate misalignment between exporting country i and importing country j during the sample period. The regression results are reported in Table 2, along with the Pearson and Spearman correlation coefficients.

**Table 2: Average Export Growth and Real Exchange Rate Variability
(Sample size=90)**

	Total	Machinery	Manufacturing	Agriculture
Constant	0.026 ^a (6.87)	0.027 ^a (5.99)	0.027 ^a (3.73)	0.049 ^a (5.08)
STD of real exchange rates	0.016 (0.55)	0.090 ^b (2.56)	-0.106 ^b (-2.02)	-0.342 ^a (-4.01)
R^2	0.003	0.059	0.049	0.150
Correlation Coefficient (Pearson)	0.051	0.242	-0.221	-0.387
Correlation Coefficient (Spearman)	0.096	0.251	-0.254	-0.365

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. t -ratios are in parenthesis; **a** and **b** denote significance at the 1 and 5 percent level

In the case of total trade, no statistically significant relationship between variables is found. The estimated t -statistic on real exchange rate variation is 0.478, so that we cannot reject the null hypothesis of no relationship at the 10 percent level. In addition, the correlation coefficients are 0.05 and 0.09 respectively, indicating almost no correlation between the variables. Interestingly, De Grauwe and de Bellefroid (*op.cit.*) found a significant negative relationship between variables using a sample of 1973-1984 with the same country pairs.

In the case of the agriculture and manufacturing sectors, the relationship between variables is negative and statistically significant. The estimated t -statistics are -3.93 and -2.126 respectively, so that we can reject the null hypothesis of no relationship at the 5 percent level. In contrast, for the machinery sector, the relationship is positive, the estimated t -statistic being 2.34 indicating that there is a statistically significant positive relationship between mean export growth and real exchange rate variation. The estimated coefficients imply that a one standard deviation increase in the measure of real exchange rate variability is associated with a 9 percent increase in trade growth rates in the machinery sector, an 11 percent reduction in trade growth in the manufacturing sector, and a 34 percent reduction in trade growth in the agriculture sector.

Given the different monetary systems in place during the sample period, the results for EMS and non-EMS country trade are compared in Table 3, where, for the whole sample, EMS, and non-EMS cases, the sample average of export growth rates in each sector is presented, along with the sample average of the standard deviation of normalized real exchange rates. The average standard deviation of real exchange rates among EMS countries is 0.073, which is lower than the whole sample average of 0.139, and that of the non-EMS case, 0.157. Without real exchange rate variation, average trade growth in the agriculture sector among developed countries would have been 4.9 percent annually, given the estimated coefficient on the constant

term. During the sample period, EMS countries faced an average standard deviation of real exchange rates of 0.073, and, as a result, lost 2.5 percent trade growth in the agriculture sector compared to no real exchange rate variation so that the realized average trade growth rate is 2.6 percent. In the case of the whole sample average, countries faced an average standard deviation of real exchange rates of 0.139, and, therefore, lost 4.73 percent trade growth in the agriculture sector compared to no real exchange rate variation, so that the realized average trade growth rate is 0.15 percent.

Table 3: Sample Average of the Variables

	EMS	non-EMS case	Average
Total	2.57	2.90	2.86
Machinery	3.49	4.05	3.93
Manufacturing	1.48	1.11	1.19
Agriculture	2.61	-0.55	0.15
STD of real exchange rates	0.073	0.157	0.139

It should be noted that over this period, most of the EMS countries were also members of the European Union (EU). These countries have also applied an integrated agricultural policy under the auspices of the Common Agricultural Policy (CAP). It is possible, therefore, that the previous results relating to the agriculture sector are due to agricultural policy rather than monetary coordination.² To examine this issue, bilateral trade between EMS countries is removed from the sample, and the regression re-run. The results reported in Table 4 do not differ significantly from those reported for the whole sample: in the case of total trade, the estimated coefficient on real exchange rate variability is still not statistically significant, while the signs on the coefficients for the other sectors remain the same.

² It is also possible that through the use of green rates, the CAP insulated domestic farm prices from radical swings in exchange rates over this time period.

Table 4: Average Export Growth and Real Exchange Rate Variability: Non-EMS Case (Sample size=70)

	Total	Machinery	Manufacturing	Agriculture
Constant	0.034 ^a (4.46)	0.025 ^a (2.82)	0.048 ^a (3.62)	0.059 ^a (3.14)
STD of real exchange rates	-0.031 (-0.67)	0.102 ^c (1.82)	-0.234 ^a (-2.73)	-0.409 ^a (-3.10)
R^2	0.006	0.041	0.129	0.119

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. t -ratios are in parenthesis; **a**, **b**, and **c** denote significance at the 1, 5, and 10 percent level.

At this point it is inappropriate to accept simple correlations as evidence of differing effects of long-term real exchange rate variation across sectors. In order to examine the robustness of the link, it is necessary to add some control variables. In line with De Grauwe and de Bellefroid, the annual average growth rate in real income of importing country j over the sample period is included, $\Delta \ln \bar{y}_{ijt}$. This is collected from the IMF series *International Financial Statistics*, (line 99b), the series already being deflated (1990=100).

Two additional control variables are derived from the real exchange rate series: specifically, the first and third moment of real exchange rates. In terms of the first moment, although recent empirical evidence suggests that the underlying process of real exchange rates is mean reverting, in reality, *ex-post* real exchange rate realization during the sample period could be asymmetric. For example, over-valuation of the US dollar during the period 1982-1986 was both substantial and persistent. As a result, without any countervailing movement in the US dollar, i.e., an under-valuation of similar magnitude, this event could dominate the average US dollar movement during the sample period, generating a slight over-valuation of the US dollar even on average. In other words, stationarity of real exchange rates does not guarantee that *ex-post* realization of real exchange rates is perfectly symmetric, and, as a result, the real exchange rate does not necessarily exactly converge to its long-run equilibrium level at the sample

average. Therefore, the average real exchange rate during the sample period, \bar{r}_{ijt} , is included in the regression model.

The second control variable is the third moment of real exchange rates, i.e., skewness of the distribution of real-exchange rates, $skew_{ij}$. While real exchange rates revert, on average, to their long-run equilibrium level, the possibility exists that a one-time, large, unfavorable (favorable) exchange rate shock might result in a significant decrease (increase) in exports, which is subsequently not recovered through several small favorable (unfavorable) shocks. This is essentially an extension of the *hysteresis* model: a one-time, large, unfavorable (favorable) exchange rate shock, reflected in right (left) skewness of the distribution, will induce significant exit (entry) of exporting firms in destination markets, and subsequent small favorable (unfavorable) exchange rate shocks will not induce an equivalent amount of entry (exit) into the market.

Given these additional variables, the following cross-sectional model is estimated:³

$$\Delta \ln \bar{q}_{ijt}^k = \alpha_0^k + \alpha_1^k \bar{r}_{ijt} + \alpha_2^k \hat{\sigma}_{ij} + \alpha_3^k skew_{ij} + \alpha_4^k \Delta \ln \bar{y}_{ijt} + \varepsilon_{ij}^k \quad (5)$$

The estimation results for the whole sample are shown in Table 5. In the case of average real exchange rates, we can reject the null hypothesis of no relationship at the 1 percent level for all sectors, and the sign of the estimated coefficients are negative as expected. However, some care should be taken in interpreting these results. To normalize real exchange rates, it has been assumed that real exchange rates were at their long-run equilibrium level in 1973. Although this normalization does not undermine one's intuition concerning the results, there is no particular reason why 1973 real exchange rates represent properly aligned real exchange rates.

³ Initially, an EU dummy variable was included in the model. However, as most EMS countries are also members of the EU, there is a strong negative correlation between the measure of misalignment and the EU dummy. Therefore, the EU dummy variable was eliminated from the regression.

**Table 5: Average Export Growth and Real Exchange Rate Variability
(Sample size=90)**

	Total	Machinery	Manufacturing	Agriculture
Constant	0.147 ^a (2.88)	0.213 ^a (3.77)	0.279 ^a (4.33)	0.555 ^a (6.19)
Average real exchange rates	-0.028 ^a (-2.64)	-0.043 ^a (-3.73)	-0.058 ^a (-4.53)	-0.123 ^a (-6.34)
STD of real exchange rates	-0.001 (-0.02)	0.068 ^b (2.16)	-0.135 ^a (-3.15)	-0.447 ^a (-6.87)
SKEW of real exchange rates	-0.035 (-1.37)	-0.009 (-0.30)	-0.078 ^b (-2.04)	-0.157 ^b (-2.40)
Average income growth rates	0.471 (1.31)	0.696 ^c (1.72)	0.914 (1.55)	3.317 ^a (4.11)
R^2	0.116	0.216	0.2450	0.473

Notes Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. *t*-ratios are in parenthesis; **a**, **b**, and **c** denote significant at 1, 5, and 10 percent level.

Interestingly, the response of trade growth rates to real exchange rates is highest for agriculture among the sectors considered here. The estimated coefficients imply that a one-unit appreciation (depreciation) in the average real exchange rate index during the sample period is associated with a 2.8 percent decrease (increase) in total export growth rates, compared to a 12 percent decrease (increase) for the agriculture sector. This result could be interpreted as being consistent with the belief of many agricultural economists that real exchange rate variation may cause more instability in agricultural trade compared to total trade (Chambers and Just, 1981).

With respect to the standard deviation of real exchange rates, the results do not change very much when compared to those reported in Table 2. In the case of total trade, the estimated coefficient on real exchange rate variability is not statistically significant, while the signs on the coefficient of this variable for the other sectors remain the same, i.e., positive in the case of the

machinery sector, and negative, and statistically significant in the case of the manufacturing and food sectors.

In the case of skewness of the real exchange rate distribution, the estimated coefficients are only statistically significant in the case of the agriculture and manufacturing sectors. The results indicate that a large real appreciation of a currency, although a rare occurrence, has a more unfavorable effect on exports than a small real depreciation of a currency, which is a more frequent occurrence. The estimated coefficients imply that a one-unit increase in right skewness of the distribution of real exchange rates is associated with a 7.8 percent decrease in export growth rates in the case of the manufacturing sector, and a 15.7 percent reduction in export growth rates in the case of the agriculture sector.

Interestingly, the country that has faced the most right skewness in the distribution of real exchange rates is the US. The associated reduction in US export growth rates is about 8.04 percent in the agriculture sector, and about 4 percent in the manufacturing sector. These results indicate that significant overvaluation of the US dollar in the mid-1980s had a significant impact on US agricultural exports. Although, after this event, the US dollar has occasionally experienced moderate real depreciation, this has not been enough to generate a recovery in export growth rates of the US agricultural sector.

Finally, the annual average growth rate in real income is statistically significant only for the case of the agricultural sector. The estimated coefficient, however, is unreasonably high at 3.07. This implies that a 1 percent increase in annual average income growth rates is associated with a 3.07 percent increase in annual average trade growth rates among sample countries, which seems unlikely given the expectation that the demand for food is income inelastic in developed

countries. This result is probably due to small sample bias, i.e., even though the cross-section consists of 90 bilateral trade flows, there are only ten annual average income growth rates.

As before, inter-EMS trade was omitted from the sample due to the fact that monetary coordination might be observationally equivalent to effects of the CAP. In this case, though, a dummy variable is added to represent trade between the UK and other EU members because while the UK is a member of the EU, it has not been a member of the EMS for the complete sample period.⁴ The following model is estimated with this sub-sample:

$$\Delta \ln \bar{q}_{ijt}^k = \alpha_0^k + \alpha_1^k \bar{r}_{ijt} + \alpha_2^k \hat{\sigma}_{ij} + \alpha_3^k skew_{ij} + \alpha_4^k \Delta \ln \bar{y}_{ijt} + \alpha_5^k EU + \varepsilon_{ij}^k, \quad (6)$$

EU being the dummy variable, and all the other variables are as previously defined.

Table 6: Average Export Growth and Real Exchange Rate Variability: Non-EMS Case (Sample size=70)

	Total	Machinery	Manufacturing	Agriculture
Constant	0.144 ^a (2.94)	0.214 ^a (3.89)	0.284 ^a (5.25)	0.545 ^a (7.47)
Average real exchange rates	-0.029 ^a (-2.85)	-0.046 ^a (-4.04)	-0.060 ^a (-5.29)	-0.124 ^a (-7.47)
STD of real exchange rates	-0.019 (-0.41)	0.119 ^b (2.15)	-0.266 ^a (-4.98)	-0.550 ^a (-7.22)
SKEW of real exchange rates	-0.047 ^c (-1.89)	-0.037 (-1.04)	-0.086 ^a (-2.69)	-0.198 ^a (-2.93)
Average income growth rates	0.798 ^b (2.12)	0.638 (1.43)	1.719 ^a (3.08)	4.468 ^a (5.70)
<i>EU</i>	0.026 ^a (6.97)	0.024 ^a (5.38)	0.031 ^a (6.11)	0.054 ^a (5.42)
<i>R</i> ²	0.361	0.341	0.510	0.648

Notes Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. *t*-ratios are in parenthesis; **a**, **b**, and **c** denote significant at 1, 5, and 10 percent level

⁴ In this sub-sample, there is little collinearity between exchange rate misalignment and the EU dummy.

The estimation results, reported in Table 6, are similar to those for the whole sample, although statistical power increases substantially in terms of R^2 and t-ratios. An important difference, however, is the weak evidence, in the total case, for a negative impact on annual average export growth rates of skewness in the real exchange rate distribution. Again, there is some evidence that overvaluation of the US dollar in the 1980s has more negatively affected US export growth rates than subsequent moderate depreciation of the dollar even in the case of total exports, providing some support for Baldwin and Krugman's (*op.cit.*) hypothesis.

Panel Analysis

There are two potential disadvantages of using a cross-sectional approach. First, by averaging the variables *a priori*, all time-series movement of variables is simply eliminated. Second, loss of observations from averaging the data could possibly have introduced small-sample bias. Therefore, in order to maximize data usage and properly control for time-invariant variables, a panel-data analysis is also conducted.⁵

The following regression model was estimated:

$$\Delta \ln q^k_{ijt} = \alpha_{0ij}^k + \alpha_1^k r_{ijt} + \alpha_2^k \Delta \ln y_{ijt} + \alpha_3^k \hat{\sigma}_{ij}^r + \alpha_4^k skew_{ij}^r + \varepsilon_{ijt}^k \quad (7)$$

$\Delta \ln q^k_{ijt}$, r_{ijt} , and, $\Delta \ln y_{ijt}$ are now time-varying variables, while the second and third moments of real exchange rates remain as time-invariant variables. Consequently, the empirical model contains two explanatory variables that move in both time and cross-sectional dimensions, and two variables, which move in only a cross-sectional dimension. Moreover, in (7), it is assumed that there is cross-sectional variation in the constant terms. In an economic sense, this restriction implies that there are specific cross-country effects such as distance and trade barriers that are not captured in the model.

⁵ A general theoretical discussion of panel econometric analysis can be found in Judge *et al.* (1985), and Hsiao (1986).

In order to aid discussion of the panel estimation method used, (7) is re-written in matrix form:

$$Y_{it} = \alpha_i + X_{it}\beta + Z_i\gamma + \varepsilon_{it}, \quad (8)$$

where Y_{it} is the dependent variable, $\Delta \ln q_{ijt}$, X_{it} is a vector of time-variant control variables, $\Delta \ln y_{jt}$ and $\ln R_{ijt}$, and Z_i is a vector of time-invariant control variables, $\hat{\sigma}_{ij}^r$ and $skew_{ij}^k$. This model assumes the slope coefficient, β , is the same for each cross-sectional unit, while the constant term, α varies across cross-sectional units.⁶

Panel estimation of (8) with the specified restrictions on α_i and β has been common in empirical research, several estimation procedures having been suggested, e.g., Amemiya (1971), Fuller and Battese (1973), and Wallace and Hussain (1969). However, with time-invariant variables, the estimation methods are restricted. Excluding the time-invariant variables, a general model specification is as follows:

$$Y_{it} = \alpha_i + X_{it}\beta + \varepsilon_{it}, \quad (9)$$

where Y_{it} is an $NT \times 1$ vector of the dependent variable, X_{it} is an $NT \times k$ matrix of independent variables, and ε_{it} is an $NT \times 1$ vector of the error term with mean zero and variance σ_ε^2 . If α_i is assumed fixed, the usual least squares with a cross-section dummy variable or with transformed data can be applied, known as a 'LSDV' or 'within' estimator.

If α_i is assumed to be a random variable, distributed with a mean μ , and variance σ_α^2 , it is a 'random effects' model, (9) being expressed as:

⁶ Usually, researchers implement a poolability test based on a Chow type F-test. However, Baltagi and Griffin (1983, 1997) argue that the statistical power of the Chow test is too strong so that the test usually rejects the null of poolability hypothesis. In addition, they argue that efficiency gains from pooling appear to more than offset the biases due to cross-section heterogeneity. On the other hand, Pesaran and Smith (1995) show that, estimation results under the random coefficient model (RCM), which is based on the assumption of different slope coefficients across

$$Y_{it} = \mu + X_{it}\beta + \eta_{it}, \quad (10)$$

where $\eta_{it} = \alpha_i + \varepsilon_{it}$. Now consider the case where a time-invariant variable, Z_i , is included to capture cross-section variation explicitly, and it is believed that Z_i is strongly correlated with the unobservable cross-section specific latent effect, α_i :

$$\alpha_i = \mu + Z_i\gamma + \eta_i, \quad (11)$$

(10) is re-written as:

$$Y_{it} = \mu + Z_i\gamma + X_{it}\beta + \xi_{it}, \quad (12)$$

where $\xi_{it} = \eta_i + \varepsilon_{it}$. While (12) is similar to the usual ‘random effect’ specification in (10), there is, however, an important difference between the usual ‘random effect’ model and our model specification. In the case of (10), there can be correlation between Z_i and the individual latent effect η_i (Hausman and Taylor, 1981). Given such correlation, only the ‘within’ estimator is unbiased and consistent. Moreover, additional instrumental variables are needed to estimate γ consistently. However, due to the orthogonality condition of (11): i.e., if (11) is true, then $E(\eta_i | Z_i) = 0$. As a result, Z_i can be treated as a strict exogenous variable, and γ can be estimated consistently using a two-step procedure suggested by Hausman and Taylor (*op.cit.*)

In the first stage regression, a ‘within’ estimator is used with the whole sample, which is an unbiased and consistent estimator given the assumptions on α_i .⁷ By transforming the data in order to implement a ‘within’ estimator, however, all the time-invariant variables, Z_i , and cross-

cross-sectional units, will converge to the results derived from estimating (7) if the lagged dependent variable is not included as a right-hand side variable.

⁷ According to Maddala (1971), within estimator used in the first stage of estimation in fact used time-series variation of the variables so that the estimation results should be interpreted as time-series sense.

country effects, α_i , must be eliminated. Hence, in the first stage, least squares methods are applied to:

$$\tilde{Y}_{it} = \tilde{X}_{it}\beta + \tilde{\eta}_{it}. \quad (13)$$

where $\tilde{Q}_{it} = Q_{it} - \bar{Q}_i$ and $\bar{Q}_i = (1/T)\sum_{t=1}^T Q_{it}$ for any variable Q .

In the second stage, a latent variable is constructed based on the unbiased and consistent estimates $\hat{\beta}_w$ from the first-stage regression, and the following regression is estimated using a cross-sectional approach:

$$\hat{\alpha}_i = \bar{Y}_i - \bar{X}_i\hat{\beta}_w = \mu_i + Z_i\gamma + \eta_i, \quad (14)$$

where the coefficients on the time-invariant variables can be estimated consistently if the number of cross-sectional units is large enough.

Table 7: Export Growth and Real Exchange Rate Variability (Hausman and Taylor estimator, sample size=1980)

	Total	Machinery	Manufacturing	Agriculture
Real exchange rates	-0.287 ^a (-15.53)	-0.283 ^a (-11.37)	-0.361 ^a (-11.83)	-0.325 ^a (-10.71)
Income growth rates	2.302 ^a (18.62)	1.973 ^a (11.85)	3.477 ^a (17.01)	0.659 ^a (3.237)
STD of real exchange rates	-0.058 (-0.62)	0.027 (0.31)	-0.216 ^c (-1.91)	-0.362 ^a (-3.63)
SKEW of real exchange rates	-0.060 (-0.63)	-0.035 (-0.39)	-0.105 (-0.91)	-0.206 ^b (-2.03)
Constant	1.306 ^a (93.0)	1.294 ^a (97.3)	1.626 ^a (95.7)	1.534 ^a (102.3)

Notes *t*-ratios are in parenthesis; **a**, **b**, and **c** denote significant at 1, 5, and 10 percent level

The estimation results are reported in Table 7, where the estimated coefficients for the first two variables are from the first-stage regression (13), and the remaining coefficients are

from the second-stage regression (14). It is important to note that because the estimated coefficients for the constant come from the second-stage regression, they contain no economic meaning.

Compared to the cross-sectional analysis, no statistically significant relationship is found between long-run real exchange rate variability and export growth rates in the case of the machinery sector. In the case of the manufacturing and agriculture sectors, however, this relationship remains negative and statistically significant. In the case of skewness of the real exchange rate distribution, the negative effect is statistically significant at the 5 percent level only in the case of the agriculture sector.

The estimated coefficients on the real exchange rate measure have the expected negative sign, but they are higher than those of cross-sectional regression. A possible explanation for this is that in the medium-run, annual movements of export growth rates decrease (increase) in response to unfavorable (favorable) real exchange rate movements. In the long-run, however, as a result of mean reversion in real exchange rates, the impact of real exchange movement on export growth rates will be less than in the medium-run. In other words, exchange rate neutrality holds in the long run.

Finally, in the case of income growth rates, the estimated coefficients all have the expected positive sign, and are statistically significant at the 1 percent level. The estimated coefficients, however, are quite different in magnitude to those estimated in the cross-sectional approach. As mentioned previously, these differences are likely due to small sample bias in the cross-sectional regression. In the case of the agriculture sector, the coefficient implies that a 1 percent increase in income growth rates for the sample countries is associated with only a 0.65 percent increase in trade growth rates among the sample countries, compared to increases in

trade growth rates of 2.3, 1.97, and 3.5 for the total, machinery, and manufacturing sectors respectively.

6. Summary

This paper has focused on whether exchange rate misalignment has negatively affected the growth of agricultural trade, as compared to other sectors. Exchange rate misalignment is interpreted to be the persistent deviation of nominal exchange rates from their long-run equilibrium of purchasing power parity, which implies that real exchange rates should be mean reverting. While there is some debate in the literature as to whether the flexible exchange rate system could generate a large enough shock that would negatively affect long-run growth rates in trade between developing countries, Baldwin and Krugman's model suggests that extreme under-(over) evaluations of a currency could result in a significant increase (decrease) in exports that are not matched by subsequent small unfavorable (favorable) exchange rate shocks. In addition, this effect may vary by sector, depending on the extent of sunk costs of (re-) entering export markets.

In order to explore this, we constructed a bilateral trade matrix involving trade flows between 10 developed countries. Using cross-sectional analysis, the data were collapsed to annual average growth rates of exports, which were regressed on the first, second, and third moments of the distribution of real exchange rates, and also the annual average rates of growth income. The model was estimated for 4 sectors over the period 1974-1995. The conclusion is clear: compared to other sectors, the growth of agricultural trade has been adversely affected by variability in real exchange rates, particularly bilateral trade between countries where one is not a member of the EMS. Where countries are members of the EMS, it would seem that the use of target zones has significantly reduced exchange rate variability, although in the case of the

agriculture sector, this may be observationally equivalent to the effects of CAP. Using Hausman and Taylor's two-step estimation procedure, extension of the analysis to the complete panel data set confirms the negative effects of real exchange rate variability on agricultural trade growth.⁸

Overall, the results presented in this paper make a contribution to our understanding of the connection between exchange rate movements and international trade flows. Typically, the literature has focused on the impact of increased short-run exchange rate volatility since the breakdown of the Bretton-Woods system. As pointed out by De Grauwe and de Bellefroid, short-run volatility can be hedged, and, therefore, it is long run variability in exchange rates that matters. This implies that if long-run variability is a function of the deviation of nominal exchange rates from underlying fundamentals, then macroeconomic policy may have a key role in influencing trade flows in the agricultural sector. The results of this paper suggest that this macroeconomic linkage is not restricted to the US and macroeconomic disturbances are likely to have long-run effects on international trade performance. In particular, more coordinated monetary/exchange rate policy between countries may have beneficial effects on trade flows.

⁸ We also estimated a random coefficients model (RCM) with the panel data set, where the slope coefficients are treated as heterogeneous. There is no current procedure in the literature for testing such a model with time-invariant variables. We used the two-stage estimation of Hausman and Taylor, and a modification of the Swamy (1970)-Hsiao ((1975) estimator. The RCM results were very similar to those based on the Hausman-Taylor estimator.

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