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THE EFFECT OF EXCHANGE RATE MISALIGNMENT ON AGRICULTURAL TRADE

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Key words: Exchange rate misalignment, agricultural trade, and gravity model.

ABSTRACT

This paper examines whether exchange rate misalignment negatively affects agricultural trade, compared to other industrial sectors. Nominal exchange rate misalignment is obtained from the percentage deviation of real exchange rates from their long-run equilibrium based on the theory of purchasing power parity. In order to explore this issue, a bilateral trade matrix involving trade flows between ten developed countries is constructed. Using panel data analysis, a gravity model is estimated for four industrial sectors over the period from 1976 to 1999. The study has found that over-valuation (under-valuation) of the nominal exchange rate negatively (positively) affects export performance of the agricultural sector in particular. In the large-scale manufacturing sectors considered in this paper, exports are not significantly affected by exchange rate misalignment.

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Ⅰ. Introduction

Exchange rate *misalignment*[1], defined as the departure of nominal exchange rates from the long-run equilibrium levels, has long been problematic in international monetary system because it can possibly distort the value of currencies and international commodity trade flows.[2] In the late 1960s and early 1970, it was expected that a market based floating exchange rate system could avoid exchange rate misalignment. However, empirical evidence has suggested that it has still been the most important problem under the current floating system (e.g., Dornbusch 1987; Rogoff 1996; Frankel 1996). Although many studies (e.g., Gardner 1981; Batten and Belongia 1986; Tweeten 1989; Cho, Sheldon, and McCorriston 2002) have investigated the potential impacts of exchange rate misalignment on international agricultural trade, there are two remaining concerns that require further examination.

The first concern is the different sectoral effects of exchange rate misalignment. In other words, "Is exchange rate misalignment more critical to international agricultural trade than manufacturing trade?" Using a sunk cost model, Baldwin (1988) and Baldwin and Krugman (1989) theoretically showed that only a *large* exchange rate misalignment can affect the entry/exit decision of firms. Therefore, it can distort trade flows in the long run. In addition, because of the different initial sunk costs, the theory also implies that inaction ranges of industry sectors are different from each other. This suggests a possibility that a *moderate* exchange rate shock can distort trade flows for some industries, while others are not affected. Recently, Cho, Sheldon, and McCorriston (2002) found evidence that agricultural trade is

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1 In this paper, we used a normalized real exchange rate as a measure of nominal exchange rate misalignment. Therefore, we used the term 'misalignment' and 'real exchange rate movement' interchangeably.

2 A more detailed discussion about the cost of the misalignment is found in Williamson (1985).

more susceptible to long-term exchange rate uncertainty compared with other sectors, suggesting possible asymmetric impacts of exchange rate misalignment on different industries.

The second concern is impacts of *relative* exchange rate misalignments (or cross-country differences in exchange rate misalignments). When a country's currency is over- (under-) valued over time relative to other currencies, it does not necessarily affect the country's exports negatively (positively). If the over-valuation is relatively less than that of all competitors, it is possible to find a positive correlation instead (Cushman 1986). To incorporate the *relativeness*, Cushman examined the 'third country effect' of exchange rate in his time-series model. Because there are many trading partners, it is difficult to include all the relative exchange rate movements in a univariate time series model. Remaining 'fourth', 'fifth', and 'sixth' country effects could cause the omitted variable problems, resulting in misleading results.

Only a few studies investigated the both issues simultaneously. Using a cross-sectional analysis, Bergstrand (1985; 1989) found weak evidence that *relative* exchange rate movements have an important role in explaining trade flow in the case of total trade. However, his results were mixed over sectoral trades: he found the expected negative relationship between export and exchange rate in nine out of 36 cases, but found exactly the reverse sign of the estimated coefficients in 12 cases. In fact, we believe that these puzzling results are due to two reasons. First, he used nominal exchange rate movements to examine the issues. However, because countries have experienced different degree of inflation rates under the floating system, nominal exchange rate movements are not economically meaningful indicators. Second, for a cross-sectional comparison, exchange rate should be normalized. In fact, his choices of base years were arbitrary, which are not based on any theoretical and empirical consideration.

The focus of this paper is to study the effects of exchange rate misalignments on agricultural trade in comparison to other sectors. To measure the effect of *relative* (cross-sectional) exchange rate misalignment movements on commodity trade flows, a large panel data set was utilized. This enables us to examine the effect of absolute misalignment movements (time-series). The data are about bilateral trade flows for agricultural, machinery, chemicals, and other manufacturing (material) products in ten developed countries. Unlike Bergstrand (1985; 1989), based on the theory and empirical evidence of purchasing power parity (PPP), exchange rate misalignment was measured as percentage deviations of bilateral real exchange rates from their sample averages, which is expected to allow us to make a more reasonable cross-sectional as well as time-series comparison. As a conclusion, it was found that exchange rate misalignment affects agricultural trade in particular, while in the cases of the large scale manufacturing industries, there is no linkage between exchange rate misalignment and trade flows.

The paper is organized as follows. Section 2 outlines the relevant aspects of exchange rate misalignment. In Section 3, extending Baldwin and Krugman's model, the reason why the exchange rate shock causes different impact on different industrial sectors is explained. In Section 4, variable construction and data are discussed, while in Section 5, the econometric specification and results are reported. The principal results are summarized in Section 6.

Ⅱ. Exchange Rate Misalignment

2.1. Purchasing Power Parity

Exchange rate misalignment can be defined as the departure of the nominal exchange rate from its long-run equilibrium level. In other words, misalignment can be characterized as either over- or under-valuation of the currency relative to fundamentals.[3] Thus, a

[3] It is difficult to measure misalignment and is inherently imprecise, as it requires estimation of what is termed the fundamental equilibrium exchange rate.

proper measure of the fundamental is an important task. Purchasing power parity (PPP) has been known as a long-run equilibrium condition of nominal exchange rates between countries (Krugman and Obtsfeld 2003).[4] Essentially, the PPP should hold because exchange rates equalize relative price levels in different countries. The standard expression of *absolute* PPP is:

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

where s_t is the log of home currency price of a foreign currency, p_t is the log of domestic-currency price of a particular good(s), p_t^* is the log of foreign currency price of the good(s). The implication of (1) is that trade of goods will result in identical prices across countries. Allowing for factors such as transport costs, the PPP in its *relative* form is as follows:

(2) $$s_t = \beta + \alpha_0 p_t + \alpha_1 p^*_t + \varphi_t$$

The relative PPP (2) states that a stable price differential should exist for the same good(s) sold in different countries, implying that real exchange rates between countries should be constant in the long-run. Consequently, if there is no misalignment of exchange rates from relative PPP, the real exchange rate should be mean-reverting process (MacDonald 1999). Several studies rejected the random walk hypothesis of real exchange rates (Frankel and Rose 1996; MacDonald 1996; Lothian and Taylor 1997; Lothian 1997; Papell 1997; Papell 2002), indicating that real exchange rates revert to equilibrium values over the long run.[5] Correspondingly, nominal exchange rates and relative inflation

[4] Although the PPP is typically used to gauge misalignment, it is not the only measure. There have been more formal attempts to measure the equilibrium exchange rate based on an explicit characterization of fundamentals.

[5] Several early studies found no evidence of significant reversion of exchange rates toward PPP (Meese and Rogoff 1983; Mark 1990; Fisher and Park 1991).

rates between two countries converge, reviving the notion that the PPP is a long-run equilibrium condition of nominal exchange rates.

Specifically, if long-run PPP holds, as shown in (1) $\alpha_0 = 1$ and $\alpha_1 = -1$, the real exchange rate, $r_t = s_t - p_t + p_t^* = \beta + \varphi_t$, and the underlying innovation φ_t should be a stationary process, which has mean zero and finite long-run variance σ_φ^2. Therefore, the time-series movement of the estimated residuals $\hat{\varphi}_t$ can be thought of as the time-series movement of misalignment. In this paper, therefore, we calculate the percentage deviation of real exchange rates from their sample average as a proxy variable for the exchange rate misalignment.

2.2. Relative Movement of Exchange Rate Misalignment

Figure 1 presents relative movements of four different misalignments (franc/DM (FRA), guilder/DM (NET), pound/DM (UK), and dollar/DM (US)) calculated based on the PPP. By using percentage deviations from the sample averages, we can normalize different currency units and compare movements of relative misalignments with a unified measurement.

FIGURE 1. Movements of Misalignments in Comparison to the German Mark

In the figure, we can easily observe that Germany has faced different degrees of misalignment with each trading partner during the sample period. For instance, in the mid-1980s, the German Mark was undervalued compared to the US dollar, which was expected to negatively affect US agricultural exports to Germany. The US dollar started to revert to its equilibrium level after 1985. However, for a German importer, the US dollar was highly overvalued compared to other trading partners' currencies.

When the US dollar weakened in comparison to the previous period, US agricultural exports to Germany could possibly decrease further because the other currencies were under-valued relative to the US dollar in the German market. In the case of misalignment movements between Germany and the Netherlands, these countries faced a relatively small misalignment problem during the sample period. However, stable exchange rate movement between these countries alone cannot eliminate exchange rate effects on their bilateral trade, meaning that third country effects exist. During the mid-1970s, the US dollar was undervalued compared to the German Mark. In this case, German traders imported products from the United States rather than from the Netherlands. Although there was no misalignment problem between Germany and the Netherlands, relative misalignment among all competitors strongly affected trade flows between the countries. Thus, if we consider the movements of misalignment between Germany and the Netherlands only, the results might be misleading.

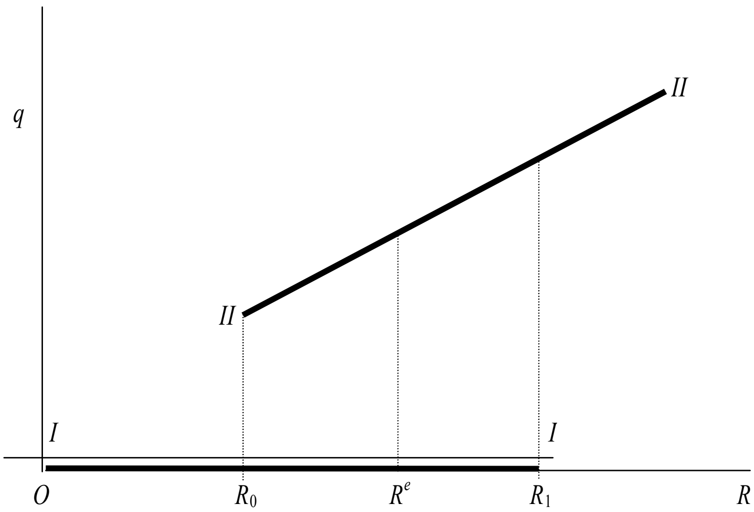
III. Theoretical Consideration

In this section, we first present a brief discussion of theoretical points of Baldwin and Krugman (1989) and develop our thought based on their model to show that inaction ranges are different by industry in response to exchange rate shock. Recognition of the different inaction ranges is a kernel process and it explains why trade flows differently respond to exchange rate movement in different industries.

3.1. Baldwin and Krugman Model

In their sunk cost model, Baldwin and Krugman assumed that it is costly to enter/exit a home market due to an initial sunk and maintenance costs, and hence, a firm enters/exits only if an exchange rate shock exceeds a cutoff. That is, the foreign firm has a range of inaction in response to the exchange rate shock. If the range is symmetric around equilibrium level of exchange rate, the export schedule has two parts as illustrated in Figure 2.[6]

FIGURE 2. Hysteresis



First, if a firm is not in the home market, exports should be equal to zero (schedule I, the horizontal bold line along the axis *OR* in Figure 2). Second, if the foreign firm is in the market, it is true that exports will be an increasing function of

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[6] In the figure, it is assumed that the nominal exchange rate S_t represents units of foreign currency to buy a unit of home currency, high (low) values of S_t means a weaker (strong) foreign currency. So, high (low) values of real exchange rate R_t means a real depreciation (appreciation) of foreign currency.

the exchange rate due to the additional profit gain (schedule II in Figure 2). There is a range of exchange rates from R_0 to R_1, where both schedules could apply. If the foreign firm is not in the home market, it will not enter unless the exchange rate goes above the critical value R_1. If it is in the market, then it will stay in as long as the exchange rate does not go below R_0.

Large exchange rate shocks often occur, which cause the firm either to enter or exit. Consequently, this large shock will influence the industry to shift to the other segment of the schedule, and cause a fundamental structural change in the exchange rate-export relationship. Furthermore, without countervailing large shock, this new market structure is quite persistent. This is the basic concept of *hysteresis* effect of exchange rates by Baldwin and Krugman, and implies the importance of large exchange rate misalignment.

3.2. Effects on Different Industries

To extend the model to the industry level, Baldwin and Krugman classified industries by difference between entry cost (N) and maintenance cost (M). However, an alternative criterion might be more useful for showing the main point of the present study. To show the criterion, we start by discussing the concepts of entry cost and maintenance cost in the Baldwin and Krugman model.

One way to interpret the difference between entry and maintenance cost is that the entry cost is an initial investment cost, for instance, a cost to develop a dealer system in the automobile industry. The maintenance cost is a cost of maintaining a reputation, for example, advertising costs. However, if we interpret these costs this way, it might be unclear why new entry does not need maintenance cost (M) at period t. In other words, it might be logically correct that the new entry needs both the costs of making a dealer system and a cost for advertising. In addition, there is no reason the condition $N > M$, which is important condition to show the existence of the inaction range of the model, should be satisfied. For instance, if a firm's entry and maintenance costs are the same, there is no reason for the firm to hesitate making the entry/exit decision. Therefore, we want to interpret the entry cost in a different way. There are two different parts of the entry cost. The first one might be initial investment cost (I), which is the cost needed to develop a dealer system in the automobile industry. The second one is a general maintenance cost like an advertising cost. Therefore, we believe $N=I+M$ might be satisfied. With this simple modification, it is easy to classify N industries based on the initial investment costs, such as.

(3) $$I_1 < I_2 < \cdots < I_N$$

Because all industrial sectors face the same size of exchange rate shock and the upper and lower bound of cutoff is symmetric, we can also classify the industry such as:

(4) $$\Delta R^1 < \Delta R^2 < \cdots < \Delta R^N, \text{ where } \Delta R^n = R_1^n - R_0^n.$$

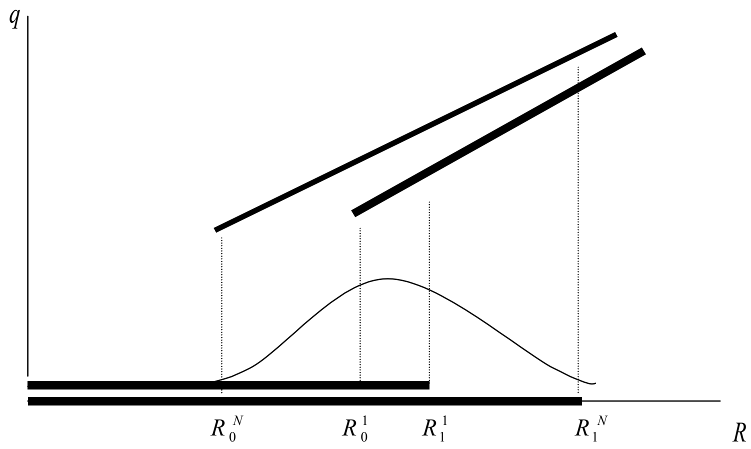
R_1^n is a upper bound of cutoff for industry n, while R_0^n is a lower bound of cutoff. It is important to note that real exchange rate is assumed to be at equilibrium on average, so that $\left|R_1^n - R^e\right| = \left|R_0^n - R^e\right|$ should hold for any industry n.

As a special case of this criterion, we will graphically examine two different industries: industry 1 that needs the lowest initial investment cost (I), and industry N, which needs the highest initial investment cost. Based on recent empirical evidence of the PPP, which find a stationarity of real exchange rate, we explicitly assume that real exchange rate is on its equilibrium *on average* and has a finite time invariant long-run variance. Because all the industries face the same exchange rate variability, we can express the situation as in Figure 3.

First, we will consider industry N. If there were a large nominal exchange rate shock, a structural change would occur. However, even if we accept the possibility that the exchange rate can deviate from market fundamentals, the huge shock-inducing structural change must be a rare phenomenon in this industry.

For simplicity, if we assume that the nominal exchange

FIGURE 3. Effects of Exchange Rate Movement on Different Industries



rate shock is always within the range from R_0^N to R_1^N, we might not find an explicit linkage between exchange rate movements and international trade flows in this industry. However, the effect of exchange rate movement should be different in the case of industry 1. A given movement in exchange rates can more easily cause real impact on this industry. In other words, there is a larger possibility that the given exchange shock can cause change in trade flow for industry 1 than in industry *N*. As a result, we can conjecture that trade in this industry might fluctuate more with movements of exchange rates than that of industry *N*.

In general, the agricultural sector could be considered as industry 1 of the example. Agricultural products are highly tradable, substitutable, and non-durable. In addition, products heavily depend on weather conditions and immobile land, implying initial investment cost to enter a new market does not seriously matter in the agricultural sector. Therefore, even if the exchange rate misalignment does not cause serious distortion in large scale manufacturing industries, given exchange rate shock can affect the agricultural trade.

IV. Estimation Model and Variable Construction

Under the assumption of monopolistic competition, each country is assumed to specialize in different products and to have identical homothetic preferences (Anderson 1979).[7] The export volume from country i to j (X_{ij}) at any time period t can be expressed as:

$$(5) \qquad X_{ij} = \theta_i Y_j \qquad \text{or} \qquad \theta_i = X_{ij} / Y_j ,$$

where θ_i denotes the fraction of income spent on country i's products (the fraction is identical across importers) and Y_j denotes real GDP in importing country j. Since production of country i must be equal to the sum of exports and domestic consumption of goods, country i's GDP is expressed as follows:

$$(6) \qquad Y_i = \sum_{j=1}^{N} X_{ij}^{*} = \sum_{j=1}^{N} \theta_i Y_j = \theta_i \left(\sum_{j=1}^{N} Y_j \right) \quad \text{or} \quad \theta_i = Y_i / \left(\sum_{j=1}^{N} Y_j \right) = Y_i / Y_W$$

where $Y_W = \sum_{j=1}^{N} Y_j$ is world real GDP, which is constant across country pairs. Rearranging (6) yields:

$$(7) \qquad X_{ij} = Y_i Y_j / \left(\sum_{j=1}^{N} Y_j \right) = Y_i Y_j / Y_W$$

The gravity equation (6) relies only upon the adding-up constraints of a Cobb-Douglas expenditure system with identical homothetic preferences and the specialization of each country in one good. By taking a natural logarithm of both sides of (7), the following empirical gravity model is obtained.

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7 It should be noted that recent theoretical work has shown that the gravity model is well-fitted to explain pattern of sectoral trades. See, for example, Bergstrand (1985), Feenstra, Markusen, and Rose (1998), and Evenett and Keller (2002).

(8) $\ln X_{ij} = \alpha + \beta \cdot \ln Y_i + \gamma \cdot \ln Y_j$, where $\alpha = (-\ln Y_w)$.

For our empirical study, we included additional components, which can explain both time and cross-sectional variations of trade flows (Z_{ijt}), cross-sectional variations of trade flows (θ_{ij}), and time-series variations of trade flows (λ_t) such as

(9) $\ln X_{ijt} = \alpha + \beta \cdot \ln Y_{it} + \gamma \cdot \ln Y_{jt} + \boldsymbol{Z}_{ijt} + \theta_{ij} + \lambda_t$

For convenience of econometric model derivation, we divided the variables as observable (or fixed) and unobservable components (or random) and assumed the linear relationship such as

(10) $Z_{ijt} = \delta_0 + \boldsymbol{\delta}'\boldsymbol{Z}^0_{ijt} + \eta_{ijt}$,

(11) $\theta_{ij} = \pi_0 + \boldsymbol{\pi}' \boldsymbol{\theta}^0_{ij} + \mu_{ij}$,

(12) and $\lambda_t = \phi_0 + \boldsymbol{\varphi}'\boldsymbol{\lambda}^0_t + \xi_t$

where $\boldsymbol{Z}^0_{ijt}$ is a vector of observable factors affecting both time-series and cross-sectional variation of the trade flows; $\boldsymbol{\lambda}^0_t$ is a vector of observable factors influencing time-series variation of trade flows; $\boldsymbol{\theta}^0_{ij}$ is a vector of observable factors explaining cross-country variation of trade flows; and η_{ijt} , ξ_t, and μ_{ij} are unobservable factors, which are assumed to be random variables distributed as $\eta_{ijt} \sim iid(0,\sigma^2_\eta)$, $\mu_{ij} \sim iid(0,\sigma^2_\mu)$, and $\xi_t \sim iid(0,\sigma^2_\xi)$.

For observable variable $\boldsymbol{Z}^0_{ijt}$, we employ exporter's and importer's per capita income ($\ln y_{it}$ and $\ln y_{jt}$), as used in Bergstrand (1985), and the misalignments (M_{ijt}). Log of distance ($\ln(DIST)_{ij}$), common national border ($BORD_{ij}$), and members of the European Union (EU_{ij}), as used in Cho, Sheldon, and McCorriston (2002) and Rose (2000), are included as observable factors $\boldsymbol{\theta}^0_{ij}$. Note that the world income $(\ln Y^w_t)$ in (8) is treated as a constant term in a cross-sectional analysis because world income is *fixed* at any given year *t*. However, in a panel data analysis, world income varies over time, which affects the share of income of a country, so that it also affects bilateral trade flows. For instance, although an importing country's income increases compared to the prior period, the share of income can decrease if world income increases faster than that of an importing country, resulting in less imports. Thus, log of world income $(\ln(Y_t^w))$ is included as an observable factor of λ_t^0. By inserting (10), (11), and (12) into (9), we have our empirical gravity equation as follows:

$$\ln(X_{ijt}^k) = \alpha_0 + \beta\ln(Y_{it}) + \gamma\ln(Y_{jt}) + \delta_1\ln\left(y_{it}\right) + \delta_2\ln\left(y_{jt}\right) + \delta_3 M_{ijt} + \theta_1\ln(DIST)_{ij} + \theta_2 BORD_{ij} + \theta_3 EU_{ij} + \pi_1\ln(Y_t^w) + \mu_{ij} + \xi_t + \eta_{ijt}, \quad (13)$$

where X_{ijt}^k is the real export value of country i to country j in year t for sector k, and where k refers to specific export sectors.

4.1. Variable Construction and Data

Annual data from 1976 to 1999 were used, covering most of the period, which the floating exchange rate system was applied. The variable X_{ijt}^k is the real export values of country i to country j in year t for export sector k. They are calculated in terms of the US dollar and deflated using the US consumer price index. Using the OECD bilateral trade data set taken from *Trade in Commodities* (one-digit standard international trade code (SITC)), we collected nominal export values in US dollars from i to j for each sector k, and deflated them by the US consumer price index (1982-84=100) taken from the *Bureau of Labor Statistics* (BLS). The selected sectors considered in this study include food and live animals (SITC 0: agriculture), chemical and related products (SITC 5: chemical), manufactured goods classified mainly as material (SITC 6: other manufacturing), and machinery and transport equipment (SITC 7: machinery).

The variable M_{ijt} is the measure of exchange rate misalignment between export country i and import country j at time t. The variable is constructed as follows: First, US dollar-based real exchange rates, which are constructed from nominal exchange rate data of the *International Monetary Fund* series, and deflated by a US/home country consumer price index (normalized 1990=100), were obtained from the *Economic Research Service* of the US Department of Agriculture. Bilateral real exchange rates between exporting and importing countries are based on the US dollar-based real exchange rate of the importing country *j*, which is divided by the US dollar-based real exchange rate of the exporting country *i*. From this, cross-rate R_{ijt} is earned as a result. The measure of misalignment is based on theory and recent empirical evidence of the PPP, which suggests that the real exchange rates among developed countries are mean-reverting. Therefore, deviation of real exchange rates from their sample averages could be treated as a measurement of misalignment movements. For each pair of real exchange rates, we calculated their sample averages, $\overline{\ln R_{ijt}}$, and then calculated the percentage deviation of real exchange rates from their sample averages ($M_{ijt} = \ln R_{ijt} - \overline{\ln R_{ijt}}$), which we treat as measures of misalignments. The advantage of this measure is that we have a unified measure to examine the effect of relative movements of misalignment on international trade.

The gross domestic products and per capita domestic products data for each country were taken in their nominal value in US dollars from the *World Economic Outlook Database* (IMF 2001), and were deflated by the US consumer price index (1982-84=100). Finally, the distance data between countries were obtained from Rose's data set.[8] Given the sample of ten countries (Belgium-Luxembourg, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, and the United States), there is a cross-section of 90 bilateral trade flows (10×9), with annual data covering 24 years (1976-1999) for each trade flow, and a complete panel of 2160 observations (90×24) is generated for each sector *k*.

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8 Rose's data can be found on his website http:/hass.berkeley.edu/~arose.

V. Estimation Results

The choice of a proper econometric specification to estimate the gravity model with panel data is hotly debated (e.g., Matyas 1997, 1998; Egger 2000). In this paper, we use a two-way random effects model followed by our empirical model specification (13). In addition, there are two practical reasons for our choice. *First*, the fixed effects model ignores the common cross-sectional variation of the data by adding a set of country-pair specific intercepts or forming deviations from individual means; therefore, the results should be interpreted as time-series evidence (Glick and Rose 2001; Head and Ries 2001).[9] Because one of our goals is to examine the effect of *relative* exchange rate misalignment as well as their time-series movements on export flows, the random effects model should be utilized to incorporate both time-series and cross-sectional information of the data (Maddala 1971; Baltagi 2001). The *second* reason is that the fixed effects model is quite sensitive to errors in variables (Hausman 1978). Since much variation of the data is removed using the fixed effects model, especially cross-sectional variation, the amount of inconsistency would be greater for the fixed effects estimates when errors in variables are presented. In our case, although the Hausman test suggests a fixed effects model, we found the results of a fixed effects model are economically unreasonable compared to the results of previous studies (e.g., Bergstrand 1985; Feenstra, Markusen, and Rose 1998, 2001). Also, the poor results are due to a multicollinearity problem between importer's and exporter's income. These variables are not correlated cross-sectionally but are highly correlated with each other over time. We can mitigate the problem by using relatively large cross-sectional units in our panel data set and random effects model.

Table 1 summarizes the regression results for each industry

[9] More detailed theoretical discussions about this econometric issue are made by Maddala (1971), Hausman (1978), and Baltagi (2001).

sector.[10] The exchange rate misalignment measure is central to this study. Interestingly, the estimated coefficient of the misalignment measure is statistically significant at the one percent level only in the case of agricultural trade. The estimated coefficient is -1.063, which implies a one-percent over- (under-) valuation of a currency compared to the long-run equilibrium level reduced (increased) agricultural exports by around 1.063 percent. In contrast, we did not find any significant relationship between the exchange rate misalignment measure and trade flow in other manufacturing sectors.

TABLE 1. Estimation Results: Sample Size=2160.

	Agriculture	Machinery	Chemicals	Other Manufacturing
M_{ijt}	-1.063[a] (-7.53)	0.026 (0.33)	-0.064 (-0.66)	0.073 (0.82)
$\ln Y_{it}$	-0.529[a] (-4.18)	1.092[a] (13.7)	0.481[a] (6.37)	0.472[a] (6.46)
$\ln Y_{jt}$	0.286[b] (2.26)	0.976[a] (12.3)	0.698[a] (9.23)	0.711[a] (9.72)
$\ln(y_{it})$	1.294[a] (8.47)	-0.652[a] (-6.92)	0.375[a] (3.68)	-0.465[a] (-4.89)
$\ln(y_{jt})$	-0.521[a] (-3.41)	-0.151[c] (-1.60)	-0.370[a] (-3.63)	0.118 (1.24)
$\ln(Y_T^w)$	-0.145 (-1.13)	0.273[b] (2.09)	0.144 (0.84)	-0.224[b] (-2.06)
$\ln DIS_{ij}$	0.332 (1.60)	-0.960[a] (-7.44)	-0.755[a] (-6.27)	-0.769[a] (-6.56)
$BORD_{ij}$	1.724[a] (4.64)	0.192 (0.84)	0.404[c] (1.93)	0.510[b] (2.48)
EU_{ij}	2.449[a] (6.21)	0.061 (0.25)	0.364 (1.61)	0.400[c] (1.82)
Constant	4.053 (1.60)	13.03[a] (6.94)	9.517[a] (4.61)	16.77[a] (10.4)

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

10 We use TSCSREG procedure of SAS 8.2 for the regression.

The estimated *t*-statistics are 0.33, -0.66, and 0.82 for machinery, chemical, and other manufacturing sectors respectively. These results indicate that there exist de-linkages between exchange rates and trade in these sectors. As discussed before, these results might be due to the different degrees of inaction range of different industries in response to exchange rate misalignment. In large-scale manufacturing sectors, inaction ranges are sufficiently large.

As a result, given exchange rate misalignment under the floating system does not significantly affect trade flows. In contrast, the given exchange rate misalignment is sufficiently large to distort trade flows in the agricultural sector.

In case of the income variables, the estimated coefficient of exporters' income is 1.092, which is larger than that of the importers' income or 0.976 in the machinery sector. Meanwhile, in the chemical and material sectors, the estimated coefficients on the exporter's income (0.481 and 0.472) are slightly less than those of the importer's income (0.698 and 0.711). The estimated coefficient of exporter's income in the agricultural sector is -0.529, which is far smaller than that of the importer's income or 0.286. According to the recent theoretical framework by Feenstra, Markusen, and Rose (1998), the sum of the exporter's and importer's income elasticities is economically and statistically higher for differentiated goods than for homogeneous goods.

Agricultural products are relatively homogeneous compared to products of other sectors in general. The results, therefore, are consistent with the empirical evidence of Feenstra, Markusen, and Rose (1998).

In case of the distance variable, all of the estimated coefficients show the expected negative sign and are statistically significant at the one percent level, except for in the agricultural sector. Interestingly, the negative impact is the largest (-0.960) in the machinery trade while the smallest (0.332) in the agricultural trade, although that is not significant. According to the theoretical consideration of Davis (1998), the transportation cost has a main role in deriving 'home market' effect suggested by Krugman (1981). If both differentiated and homogeneous goods have identical transportation costs, he concluded that the home market effect disappears. If we consider the transportation cost is one of the important parts of the distance, our results suggest that in case of large-scale industries transportation costs are much more negatively and sensitively related to trade flows compared to the agricultural sector. Therefore, even if transportation costs are similar between differentiated and homogeneous goods, our empirical evidence suggests that there could be a possible 'home market' effect.

In case of the common border variable, the estimated coefficients are all the expected positive signs and are statistically significant at the one percent level in the agricultural sector and the five to ten percent level in the machinery and chemical sector respectively. The results suggest that, in case of the agricultural sector, countries that have a common border trade about 5 times ($e^{1.724}$=5.607) more than the countries without a common border. The amount of trade for countries with a common border is 1.5 times ($e^{0.404}$=1.498) and 1.6 times ($e^{0.510}$=1.665) more than that of non-contiguous countries for manufacturing and chemical sectors, respectively.

In case of the EU dummy variable, the estimated coefficients show the expected positive sign, and statistically significant at the one and ten percent levels for the agricultural and other manufacturing sectors, respectively. The estimated coefficient of the EU dummy variable for the agricultural trade is 2.449, which is much higher than the one for other sectors. The result implies that when both countries are members of the EU, agricultural trade is approximately 11 times ($e^{2.449}$=11.58) greater than the trade between a member and a nonmember country. It shows that, under the common agricultural policy (*CAP*), the trade integration of the EU has been the strongest in the agricultural sector.

The most unexpected results came from the estimated coefficients of the world income because some of the estimated coefficients have a *positive* sign and are statistically significant at the five and ten percent levels.[11] Based on the idea of the

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11 We investigate the model using a cross-sectional approach followed by Feenstra *et al* (1998). The estimated coefficients on world income are

original gravity equation, the increase in world income must negatively affect the bilateral trade between countries *i* and *j*. However, it is important to note that the original idea of the gravity equation is to explain only the cross-sectional variation of trade flows. In the panel data analysis, however, there is no particular theoretical reason to believe that the sign of the coefficients should be negative. Rather, the estimated coefficients on world income might allow us to test Krugman's (1981) hypothesis of intra-industry trade of product differentiated goods. According to his model, countries having similar-and high-income levels produce differentiated goods under increasing returns to scale technology and they trade these types of goods with each other more than with lower income countries. Considering the fact that our sample consists of high-and similar-income countries, it is expected that the growth rate of bilateral trade for the differentiated goods between our sample countries has been relatively higher than that of agricultural goods. It implies that the estimated coefficient on the world income must be larger in case of the large-scale manufacturing products than in case of the agricultural products. The estimated coefficients of the variable are 0.273 for machinery trade and 0.144 for chemical trade. These coefficients are much higher than those for the agricultural (-0.145) and material trade (-0.224). This result implies that bilateral trade for a large-scale manufacturing industry (machinery and chemical) grows faster among OECD countries than it does for the agricultural sector, which can be regarded as supporting evidence for Krugman's hypothesis.[12]

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all negative and statistically significant in most cases. The results are available from the authors on request.

12 Although the method of interpretation for the estimated coefficient of exporters' and importers' per capita income was provided by Bergstrand (1985), our results are not quite consistent with his theoretical implication. The potential reason is that his theoretical model is derived to fit the cross-sectional approach, while our empirical results are based on the panel data approach. As estimated coefficients on world income indicates, the way of interpretation of estimated

5.1. Further Considerations

There are two further considerations that should be addressed to check the robustness of the results. These include: (a) the alternative normalization; and (b) separating of the potential influence of the US dollar. Each of these will be addressed in turn as below.

5.1.1. Alternative Normalization

To check the robustness of the regression results, another method of normalization to measure exchange rate misalignment was used. In this case, the measure of misalignment is calculated by $M_{ijt}^{1973} = \ln R_{ijt} - \ln R_{ij}^{1973}$, where R_{ij}^{1973} is the level of real exchange rate in 1973 for each country pair. This choice to use 1973 as the base year is based on the studies of Williamson (1985) and De Grauwe (1988).[13]

The underlying rationale of the choice is that, at the starting year of the floating exchange rate system, most developed countries decided their exchange rates using bilateral agreements. Therefore, nominal exchange rates in 1973 could represent properly aligned exchange rates.[14] The estimation results with the alternative measure of misalignment are presented in Table 2 and the results are, basically, similar to those in Table 1. The only important exception is a statistically significant negative relationship between the distance and agricultural trade. As a whole, the different choices of the base year do not change the main results of the study.

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coefficients using a panel data can be different from that of a cross-sectional approach.

[13] In his paper, Bergstrand (1985) chose 1960, 1965, and 1966 as base years. However, the choices of the base years do not have any theoretical or empirical justification.

[14] However, except for this intuitive reason, there is no theoretical reason why we believe real exchange rates among the sample countries are at their long-run equilibrium level in 1973. In fact, no economists know when nominal exchange rates have been perfectly aligned, and this is the reason why measuring misalignment is intrinsically imprecise.

TABLE 2. Estimation Results: Sample Size=2160.

	Agriculture	Machinery	Chemicals	Other Manufacturing
M_{ijt}^{1973}	-1.197[a] (-8.62)	0.118 (1.49)	-0.073 (-0.76)	0.093 (1.06)
$\ln Y_{it}$	-0.307[a] (-2.68)	1.106[a] (15.0)	0.481[a] (6.35)	0.472[a] (6.46)
$\ln Y_{jt}$	0.327[a] (2.85)	0.976[a] (13.3)	0.697[a] (9.20)	0.713[a] (9.78)
$\ln(y_{it})$	1.190[a] (8.17)	-0.726[a] (-8.02)	0.382[a] (3.75)	-0.479[a] (-5.05)
$\ln(y_{jt})$	-0.647[a] (-4.44)	-0.087 (-0.96)	-0.376[a] (-3.69)	0.130 (1.37)
$\ln(Y_T^w)$	-0.231[c] (-1.83)	0.266[b] (2.04)	0.144 (0.84)	-0.225[b] (-2.07)
$\ln DIS_{ij}$	0.162 (0.88)	-0.969[a] (-8.17)	-0.754[a] (-6.25)	-0.770[a] (-6.59)
$BORD_{ij}$	1.585[a] (4.80)	0.184 (0.88)	0.405[c] (1.93)	0.509[b] (2.49)
EU_{ij}	2.241[a] (6.38)	0.050 (0.22)	0.365 (1.61)	0.399[c] (1.82)
Constant	6.754[a] (2.94)	13.17[a] (7.39)	9.502[a] (4.60)	16.78[a] (10.4)

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

5.1.2. U.S. and Non-U.S. Trade

The de-linkage in the manufacturing sector may at first seem at odds because economists are worried about the recent persistent appreciation of the US dollar. However, as Papell (1997) discussed, the US dollar movements have been notoriously abnormal compared to the exchange rate movements between other developed countries. On the other side, real exchange rate movements between other developed countries, especially European countries, are much more stable than exchange rate movement between the US and these countries during the sample period. To further check the effect of the US dollar movements, the bilateral trade with the US was separated from the full sample, and the gravity model was re-estimated.

In Table 3 and Table 4, the results of the two-way random effects models for both US and non-US trades are presented. In

TABLE 3. Estimation Results (Non-U.S. Trade): Sample Size=1720.

	Agriculture	Machinery	Chemicals	Other Manufacturing
M_{ijt}	-0.703[a] (-4.53)	-0.021 (-0.02)	0.108 (0.96)	0.031 (0.32)
$\ln Y_{it}$	-0.752[a] (-5.75)	1.049[a] (11.7)	0.198[a] (2.22)	0.327[a] (3.83)
$\ln Y_{jt}$	0.072 (0.55)	0.703[a] (7.84)	0.478[a] (5.34)	0.462[a] (5.42)
$\ln(y_{it})$	1.137[a] (7.16)	-0.582[a] (-5.62)	0.648[a] (5.65)	-0.259[b] (-2.48)
$\ln(y_{jt})$	-0.028[a] (-0.18)	0.098 (0.95)	0.055 (0.48)	0.356[a] (3.40)
$\ln(Y_T^w)$	0.130 (-0.89)	0.329[b] (2.38)	-0.102 (-0.49)	-0.200[c] (-1.71)
$\ln DIS_{ij}$	0.220 (1.29)	-0.890[a] (-7.56)	-0.638[a] (-5.52)	-0.684[a] (-6.17)
$BORD_{ij}$	1.463[a] (4.92)	0.074 (0.36)	0.421[b] (2.12)	0.411[b] (2.14)
EU_{ij}	3.010[a] (9.10)	0.443 (1.94)	0.953[a] (4.26)	0.869[a] (4.05)
Constant	1.136 (0.48)	10.64[a] (5.64)	7.052[a] (3.01)	13.82[a] (8.36)

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

TABLE 4. Estimation Results (With-U.S. Trade): Sample Size=432.

	Agriculture	Machinery	Chemicals	Other Manufacturing
M_{ijt}	-2.533[a] (-8.35)	-0.146 (-0.82)	-0.615[a] (-3.78)	0.129 (0.70)
$\ln Y_{it}$	0.046[a] (0.17)	1.021[a] (5.69)	0.594[a] (3.65)	0.330[a] (2.04)
$\ln Y_{jt}$	0.536[b] (1.98)	1.211[a] (6.75)	0.804[a] (4.94)	0.677[a] (4.18)
$\ln(y_{it})$	1.552[a] (4.16)	-0.715[a] (-3.09)	0.245 (1.16)	-0.840[a] (-3.69)
$\ln(y_{jt})$	-2.732[a] (-7.32)	-0.817[a] (-3.53)	-1.244[a] (5.88)	-0.262 (-1.15)
$\ln(Y_T^w)$	0.299 (0.89)	0.685[a] (3.12)	1.130[a] (5.54)	0.560[b] (2.37)
$\ln DIS_{ij}$	2.743 (0.97)	-0.712 (-0.39)	-1.288 (-0.79)	0.917 (0.58)
$BORD_{ij}$	5.500 (1.62)	1.573 (0.72)	-0.016 (-0.01)	3.437[c] (1.82)
Constant	-6.561 (-0.26)	13.10 (0.81)	13.30 (0.91)	3.866 (0.28)

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

particular, note for the non-US country sample. Only agricultural trade and the exchange rate effect are negative, but in contrast to the full sample, the effect is much smaller (-0.703). For with-US trade, the negative effect on agricultural trade is much larger (-2.533) compared to the full sample. In addition, the effect of exchange rate movement on chemical trade is also negative (-0.615) and statistically significant at the one percent level. Taken with the results for the full sample, these results would suggest that the misalignment of the US dollar is more likely large to affect international trade flows than other currencies during the sample period.

VI. Conclusions

According to the theoretical model suggested by Baldwin (1988) and Baldwin and Krugman (1989), there is a strong possibility that the impacts of exchange rate misalignment on trade flow differ depending on different industrial sectors. This paper focuses on whether exchange rate misalignments (or real exchange rates) particularly affect agricultural trade, compared to other manufacturing sectors. Exchange rate misalignment was obtained from the percentage deviation of real exchange rates from their long-run equilibrium level based on the PPP theory. Moreover, unlike the usual time-series analysis, the potential impact on trade associated with *relative* as well as *absolute* misalignment was explored, using a large sample of panel data.

There are two findings. *First*, the impact of exchange rate misalignment on other large-scale manufacturing trade is not significant, meaning there is de-linkage between variables as mentioned by Krugman (1981). De-linkage results imply that exchange rate misalignments among developed countries are not sufficiently large to significantly distort international trade flows in large scale industrial sectors. *Second*, however, it was found that agricultural trade has been negatively affected by exchange rate misalignment, in contrast to the other manufacturing sectors. In fact, two different choices of the base years do not change the estimation results.

Recently, Cho, Sheldon, and McCorriston (2002) argued that relatively long-term variation of real exchange rate is an important factor to sectoral trade, and that long-term variations of real exchange rate between developed countries have a particularly negative effect on agricultural trade. Our study suggests the potential reason why the sectoral difference occurs, and our empirical results also support their main conclusion: the total trade aggregate does hide substantial variation across sectors caused by exchange rate variation under the floating exchange rate system.

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