Exchange Rate Volatility and Bilateral Agricultural Trade Flows:

The Case of the United States and OECD Countries

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Abstract

This study documents the effect of exchange rate volatility and the real exchange rate on bilateral agricultural exports, imports and total trade (exports + imports) flows between the United States and OECD countries. The effect of exchange rate volatility is estimated both separately from and in combination with the real exchange rate. In addition, implementation of Free Trade Agreements (FTAs) and use of the Euro as a national currency (Euro) are included as dummy variables and their effects on trade flows are also determined. A panel data set, which contains 28 cross-sections and 1148 observations, is used for bilateral trade flows between the United States and OECD countries from 1970 to 2010. With an empirical model based on a gravity equation, the results show that exchange rate volatility and the real exchange rate have a statistically significant and negative effect on agricultural, non-agricultural and total exports, imports, and trade (exports +imports) flows. Exchange rate volatility is found to have a greater impact on the agricultural sector, while the real exchange rate has a greater impact on the non-agricultural sector. Effects of FTAs and the Euro are always positive, with FTAs having a greater impact on the agricultural sector and the Euro on the non-agricultural sector.

Key words*:* bilateral agricultural trade, exchange rate volatility, OECD countries, gravity equation

Introduction

Since the 1970s, when the system of fixed exchange rates (Bretton Woods System) was abandoned, economists have been interested in exchange rate volatility and its effect on trade flows. Empirical evidences suggest that exchange rate markets have become more vulnerable and have had a negative effect on the level of exports (Cushman, 1988 and Thursby and Thursby, 1987). However, some researchers found positive trade flow effects stemming from uncertainty in the exchange rate (Klein, 1990 and Jozsef, 2011). Exchange rate volatility can have a negative effect on international trade flows, either directly through uncertainty and adjustment costs or indirectly through its effect on the allocation of resources and government policies. The volatile nature of exchange rates has always led risk-averse traders to reduce their trading activities ultimately reducing international trade flows.

Over the previous four decades, international trade liberalization along with the huge increase in cross-border financial transactions has increased exchange rate volatility. In contrast, the rapid spreading of credit and hedging instruments in financial markets, the proliferation of multinational firms, protection of agricultural industries, and the currency stabilization efforts of central banks and monetary authorities have indeed reduced exchange rate volatility to some extent. For instance, the currency crisis in the developing market economies is a solid example of increasing exchange rate volatility (Clark, Tamirisa, and Wei, 2004).

Many empirical studies have tried to determine the effect of exchange rate volatility on trade flows, but the result is ambiguous. For example, Dell'Ariccia (1999) found a negative effect for exchange rate volatility on international trade flows after controlling for simultaneity bias from the endogenous behavior of monetary authorities. Similarly, Kandilov (2008) found that exchange rate volatility had a negative impact on trade flows and the impact was larger in the agricultural sector and even worse in the case of developing countries. Similarly, Pick (1990), Cho, Sheldon and McCorriston (2002), Wang and Barrett (2007) and Chit et al. (2010) found that exchange rate volatility has had a negative impact on trade flows. On the other hand, Klein (1990), Pick (1990), Broll and Eckwert (1999), and Jozsef (2011) are some of the researchers who reported a positive impact of exchange rate volatility on agricultural and total trade flows.

The debate over the effect of exchange rate volatility on international trade flows has another perspective as well. Carter and Pick (1989) found that other market factors, rather than changes in the exchange rate, have had the primary impact on U.S. agricultural trade flows, while Doroodian et al. (1999) found a significant effect of exchange rate fluctuations on U.S. agricultural trade flows.

Schuh (1974) originally raised the issue of the exchange rate and its effects on agricultural trade flows. His effort was followed by several other studies where the effect of the nominal exchange rate and the real exchange rate were quantified. Later in the 1990s, Pick, for the first time, studied the effect of exchange rate volatility on agricultural trade flows. Since then, most studies in agricultural trade have concentrated on exchange rate fluctuations and the impact on agricultural exports and or agricultural commodity prices (Kristinek and Anderson, 2002).

Over the past couple of years, economists have recognized the influence and importance of the exchange rate on international agricultural trade. Agricultural producers have been both more sensitive to and interested in the role that exchange rates have in determining commodity prices. However, for many years, the role of exchange rates as a primary determinant of trade flows was overlooked. Economists have examined the influence of exchange rate movement on agricultural trade but disagreement persists as to the magnitude of the effect (ERS, 1984).

This article studies the effect of both the real exchange rate and exchange rate volatility on bilateral agricultural trade flows between the United States and OECD[1] countries. In an effort to compensate for the shortcomings of previous articles in this area, this study uses a yearly bilateral exchange rate to capture long run fluctuations. In addition to volatility, this study incorporates the real exchange rate level in the model assuming traders' decision on where and when to trade depends on the exchange rate level as well. It can be found in the literature that most of the studies equivocated export flows as trade flows (exports + imports). However, we expect some difference on the impact that exchange rate volatility has on both export and import

[1] OECD stands for Organization for Economic Co-operation and Development. The detailed list of member countries is presented in Table A1.2 in Appendix.

flows. The difference may arise from a simple distinction, such as importing sector concerns with domestic demand whereas exporting sector takes account of foreign demand and domestic supply conditions. Therefore, in addition to the effect on combined trade (exports + imports) flows, the effect of exchange rate volatility and the real exchange rate on both export and import flows are estimated separately.

This study considers long run exchange rate volatility as having a detrimental effect on international trade flows. The risk associated with short run exchange rate can be mitigated with risk management instruments like hedging and credit opportunities provided by central banks. The exchange rate market goes through "sustained misalignment" in the long run which cannot be hedged and is very costly if indeed it is hedged (De'Grauwe & De Bellefroid, 1998; Peree & Steinherr, 1989). Therefore, exchange rate volatility for the short term does not necessarily affect trade flows as extensively as does long run volatility.

The rest of the article is organized as follows. First, an overview of U.S. – OECD agricultural trade and trade in other sectors is presented. Then a section containing theoretical and econometric specifications of the gravity model is presented, followed by an overview of the dataset and the first difference method of measuring exchange rate volatility. Before the article concludes, empirical results are reported and discussed thoroughly.

U.S. – OECD agriculture trade

The United States is viewed as a large market in the sense of being both as an export destination of considerable magnitude and as a possessing formidable import demand. It is the largest importer of goods and services and merchandise trade. The majority of the trade partners of the United States are members of the OECD, save China and India for now. There is a long-standing history of trade between the United States and OECD countries. In 2010, 64.6 % of total U.S. exports were exported to OECD[2] countries, Canada being the topmost export destination followed by Mexico, Japan, United Kingdom, and Germany (Table A1). In the same year, 56.25% of total imports into the United States were imported from OECD countries (Table A2). Canada was the largest import market followed by Mexico, Japan, Germany, United Kingdom and Korea. Distribution of import share is similar to that of export share.

The United States is also a large agricultural exporter and most U.S. farm products that are exported are exported primarily to OECD countries. The top 15 US agricultural export markets are OECD members. For example, in 2010, Canada, which imported 15.25% of U.S. agricultural exports, was the largest agricultural export destination followed by China (13.87%), Mexico (12.82%), Japan (10.33%) and the EU (7.83%) respectively (USDA, ERS). Figure 1 illustrates the pattern of the U.S. – OECD agricultural trade (export + import) flows over the previous 41 years.

The overall trend of agricultural trade flows between the United States and OECD countries over the past four decades is an increasing trend (Figure 1). Although minor fluctuations are observed, there is a consistent increase in agricultural trade flows from 1984 to the present. This constant growth in agricultural trade between the United States and OECD countries could be attributed to Free Trade Agreements (FTAs) like Canada-US Free Trade Agreement (CUSTA) and North American Free Trade Agreement (NAFTA).

[2] In this particular case, OECD includes only 28 out of 34 countries. Those 28 countries are partner countries as defined in Appendix. Czech Republic, Estonia, Slovakia, Slovenia, and Luxemburg are not included given lack of data availability. However, Belgium incorporates Luxemburg as well.

Fig. 1 Agricultural trade flows between the United States and OECD countries (1970-2010).

Methodology and Data

Theoretical model

The fundamental economic principle of the gravity model resides on properties of expenditure systems with maintained hypothesis of identical homothetic preferences across regions (Anderson, 1979). Anderson rearranged the Cobb-Douglas expenditure system assuming a complete specialization, no tariff and transportation costs and identical Cobb-Douglas preference in each country *i* and *j*. Therefore, the value of consumption of good *i* in country *j* is $M_{ij} = b_i Y_j$, where Y_j is income in country *j*, and *bi* is fraction of income spent on country *i's* product. Accordingly, income in country *i* is $Y_i = b_i(\sum_j Y_j)$. The value of consumption of good *i* in country *j* is thus $M_{ij} = \frac{Y_i Y_j}{\sum_j Y_j}$, which gives the fundamental form of the gravity equation that Anderson came up with. This basic model has been modified by several researchers to obtain the relaxed gravity equation which have been used as a famous trade model.

Similarly, if countries *i* and *j* are producing differentiated products with economies of scale, which leads to specialization in production, then share of country *i* and *j* in world's spending and their GDP provide a theoretical explanations of the gravity model (Helpman, 1987). The gravity model and its use in empirical studies of international trade flows is substantiated because of its efficiency to include wide range of variables such as border effects, languages, infrastructure availability, custom unions effect, exchange rate volatility, historical and colonial ties and so on (Wang et al. 2010, and Dell-Ariccia, 1999).

The use of the gravity model in international trade is encouraged by theoretical literature that has developed the micro foundations for the gravity model (Helpman, 1987). Furthermore, this model is characterized by its widespread use under the auspices of imperfect competition and intra-industry trade theory (Krugman, 1991). The basic economic logic behind this model is that bilateral trade volume between two countries is directly proportional to the product of their respective GDPs but inversely proportional to their geographical distance. In light of this model, exchange rate volatility is expected to add up to the effect of distance thereby actually becoming inversely proportional to bilateral trade volume (Dell-Ariccia, 1999). Mathematically,

$TRADE_{ijt} \sim \frac{1}{(DIST_{ij}).(EXV_{ijt})}$, and $TRADE_{ijt} \sim GDP_{ijt}.POP_{ijt}$.

Therefore, (1) $TRADE_{ijt} = \beta_0.\frac{(GDP_{ijt})^{\beta_2}.(POP_{ijt})^{\beta_3}}{(EXV_{ijt})^{\beta_1}.(DIST_{ij})^{\beta_4}}$

where $TRADE_{ijt}$ is bilateral trade flows between countries *i* and *j* at time *t*, GDP_{ijt} is the product of GDPs, and POP_{ijt} is the product of population of countries *i* and *j* at time *t*. Similarly, $DIST_{ij}$ is a geographical distance between trading countries *i* and *j* and EXV_{ijt} is a measure of exchange rate volatility between countries *i* and *j* at time *t*. As the longer the distance between trading partners implies a higher transportation cost, the variable $DIST_{ij}$ is expected to have a negative impact on bilateral trade between countries *i* and *j*. Likewise, EXV_{ijt} is expected to have a negative impact on trade flows given the additional costs associated with increased uncertainty. Among additional variables, $LANG_{ij}$, $BORDER_{ij}$, $EURO_{ijt}$ and FTA_{ijt} are dummy variables representing common language, common border, use of euro as national currency, and enforcement of free trade areas, respectively.

The aforementioned specification of the gravity model is slightly modified in this study. Particularly, instead of using the product of the respective GDPs and the product of trade partners' populations, the product of GDP and population – defined as the *economic mass* of the country – is used. This is because an economic mass of a country is always the product of GDP and population of that country. In the gravity model, economic mass of a country is directly proportional to trade flows from and to the country. Therefore,

$TRADE_{ijt} \sim \frac{1}{(DIST_{ij}).(EXV_{ijt})}$, and $TRADE_{ijt} \sim EM_{it}.EM_{jt}$.

Therefore, (2) $TRADE_{ijt} = exp.^{(\beta_0)} \frac{(EM_{it})^{\beta_2}.(EM_{jt})^{\beta_3}}{exp.^{(\beta_1 EXV_{ijt})}.(DIST_{ij})^{\beta_4}}$

where EM_{it} and EM_{jt} are the economic mass for countries *i* and *j* at time *t*, respectively. Equation (2) is simply a redefined version of equation (1), where GDP and population are replaced by economic mass and exchange rate volatility is exponentiated for ease of econometric specification as described later. As far as the constant β_0 is concerned, using an exponentiated β_0 in place of β_0 is equivalent in the sense that both of them are arbitrary constants.

Econometric Specifications

Following the previous literature, the gravity equation is used to model the determinants of bilateral agricultural export flows between the U.S. and OECD countries as follows:

(3) $AGEXP_{ijt} = \exp(\beta_0). \frac{(EM_{it})^{\beta_2} \,.\, (EM_{jt})^{\beta_3}}{\exp(\beta_1 EXV_{ijt})\,.(DIST_{ij})^{\beta_4}}$

where $AGEXP_{ijt}$ is the agricultural export flows between countries i and j at time t, respectively. Country i is always a home country i.e. the U.S. and country j is a foreign country. The dummy variables, $Euro_{jt}$, 1 if country j is a member of the Eurozone at time t and 0 otherwise and FTA_{ijt}, 1 if a country is a member of the U.S. free trade agreements and 0 otherwise, are used. Other dummy variables, $LANG_{ij}$ and $BORDER_{ij}$ are dropped out of the equation as they are time invariant. A preliminary estimating equation is obtained when (3) is log-linearized and the dummy variables are added to the transformed equation.

(4) $ln\ (AGEXP_{ijt}) = \beta_0 + \beta_1\ EXV_{ijt} + \beta_2\ ln\ EM_{it} + \beta_3\ ln\ EM_{jt} + \beta_4\ lnDIST_{ijt} + \beta_5\ Euro_{jt} + \beta_6\ FTA_{ijt} + \varepsilon_{ijt}$

where ε_{ijt} is an error term varying with time and assumed to have conditional mean of '0' and be independent from other explanatory variables. Although estimating economic mass as a single variable restricts GDP and Population to have the same coefficient, mathematically, there is nothing wrong in doing so.[3] The dataset constructed herein for this study consists of 41 times series units and 28 cross sections. As the number of time series units is bigger than the number of cross-sectional units, the fixed effect one-way method for panel data estimation is employed. Therefore, the estimating equation no longer contains the time invariant variables. In addition, a variable for the real exchange rate level is included in the estimating equation (5).

(5) $ln\ (AGEXP_{ijt}) = \gamma_0 + \gamma_1 EXV_{ijt} + \gamma_2\ RER_{ijt} + \gamma_3 ln\ EM_{it} + \gamma_4\ ln\ EM_{jt} + \gamma_5\ FTA_{ijt} + \gamma_6\ EURO_{jt} + v_{ijt}$

where γ_0 is an intercept term which is different from β_0 in equation (4). Now the effect of time invariant variables and any other simultaneous variables is captured by the intercept term. In fact, the intercept term γ_0 is defined as $\gamma_0 = \beta_0 + \alpha_{ij}$, where α_{ij} accounts for the country pair specific effect and effect of any other time invariant variables and is known as the fixed effect.

[3] As defined above, $EM_{it} = GDP_{it}$ x POP_{it}, if we log linearize both sides we obtain, $\ln (EM_{it}) = \ln (GDP_{it}$ x $POP_{it})$ Or, $\ln (EM_{it}) = \ln (GDP_{it}) + \ln (POP_{it})$. Therefore, mathematically, natural log of an economics mass of a country at time t is equivalent to summation of natural log of GDP and population of the same country at time t.

A policy measure can be taken as a time invariant variable and therefore the fixed effect model is an easy solution to the problem of possible simultaneity bias that arises from policy measures for example, currency stabilization effort of the central banks and monetary authorities. Moreover, the error term in equation (5), v_{ijt} is different from the error in equation (4), ε_{ijt}. However, both of the error terms have conditional mean of zero and are assumed to have identical variances.

$E(\varepsilon_{ijt}) = E(v_{ijt}) = 0$, and

$Var(\varepsilon_{ijt}) = \sigma_E{}^2$, and $Var(v_{ijt}) = \sigma_V{}^2$

Equation (5) is estimated 9 times by replacing the explained variable $AGEXP_{ijt}$ with 8 other variables. Not only is the explained variable replaced, but the same equation is estimated three times with different sets of right hand side variables. Therefore, in addition of (5), two other equations (6) and (7) are also estimated. In total, there are nine different dependent variables for 3 different estimating equations which yield a total number of 27 equations to be estimated. The dependent variables are defined later in Appendix in detail. Three different estimating equations are given below in their general forms:

(5) $ln\ (AGEXP_{ijt}) = \gamma_0 + \gamma_1 EXV_{ijt} + \gamma_2\ RER_{ijt} + \gamma_3 ln\ EM_{it} + \gamma_4\ ln\ EM_{jt} + \gamma_5 FTA_{ijt} + \gamma_6\ EURO_{jt} + v_{ijt}$

(6) $ln\ (AGEXP_{ijt}) = \alpha_0 + \alpha_1 EXV_{ijt} + \alpha_2 ln\ EM_{it} + \alpha_3\ ln\ EM_{jt} + \alpha_4 FTA_{ijt} + \alpha_5\ EURO_{jt} + u_{ijt}$

(7) $ln\ (AGEXP_{ijt}) = \mu_0 + \mu_1\ RER_{ijt} + \mu_2 ln\ EM_{it} + \mu_3\ ln\ EM_{jt} + \mu_4 FTA_{ijt} + \mu_5\ EURO_{jt} + z_{ijt}$

The error terms u_{ijt}, and z_{ijt} also satisfy the properties of conditional mean and homogenous variance. Similarly, the intercept terms μ_0 and α_0 include the respective fixed effects.

Data

Annual data for the past 41 years (1970-2010) were used so that the long run volatility of the exchange rate and its effect on trade flows could be captured. The bilateral total exports and imports data came from the United Nation's Commodity Trade (COMTRADE) database and are disaggregated as per SITC Rev. 1 for the period 1970-1977 and as per SITC Rev. 2 for the period of 1978-2010. Similarly, data on agricultural exports and imports volume came from the U.S. Census Bureau, Foreign Trade Statistics as maintained by the Global Agricultural Trade System (GATS) of the United States Department of Agriculture (USDA). Moreover, data on GDP and population were obtained from the World Bank's World Development Indicators (WDI) and Global Development Finance.

It is important to note that both the bilateral exports and imports and GDP data values are in current U.S. dollars and therefore are converted to constant 2005 U.S. dollars using the U.S. Consumer Price Index (CPI, 2005=100). Moreover, data on CPI and bilateral nominal exchange rate came from International Monetary Fund's International Financial Statistics (IFS). Nominal exchange rates are in USD per National Currency (NC) and are deflated using both the United States and partner country's CPIs (2005=100) to obtain real exchange rate (USD/NC). The exchange rate volatility variable is constructed using real exchange rate data as described below. The dummy variables, Euro and FTA are also utilized. They, as they were defined earlier in this chapter, represent use of Euro as a national currency and member of common free trade areas, respectively.

Measurement of Exchange Rate Volatility

It is a widely accepted notion in the literature that there is significant risk on export and import activities because exchange rates are highly variable persistently deviate from Purchasing Power Parity (PPP). Thus any increase in exchange rate volatility forces traders to make costly adjustments regarding production inputs and can even force traders to leave the business altogether (Dell-Ariccia, 1999; Kandilov, 2008; Cho, Sheldon and McCorriston, 2002; and Wang and Barrett, 2007). As this study focuses on the potential impact of long run exchange rate volatility on U.S. bilateral trade flows, annual exchange rate data is used. Although various measures have been employed in the literature, there is no general consensus on choosing an appropriate variable to represent the uncertainty component of the exchange rate.

Among the variety of measures, most of them have used some variant on the standard deviation of the exchange rate as common (Cho, Sheldon and McCorriston, 2002). Among those measures, the moving standard deviation of the first difference of logarithmic real exchange rate, the standard deviation of the percentage change in the real exchange rate, and the standard deviation of the real exchange rate obtained from a first-order autoregressive equation have been frequently used. In recent years, use of various forms of Autoregressive Conditional Heteroskedasticity (ARCH) approaches for example, GARCH (1, 1) has become very common in the literature .This approach is capable to estimate the variability conditioning the variance by allowing to change over time based on past errors (Bollerslev, 1986). In a study in 2007, Kandilov finds significant effects of GARCH and ARCH approaches for three different categories of exchange rates for every year.

The use of the first difference method in this study is influenced by similar previous studies such as Cho, Sheldon, and McCorriston, (2002) and Kandilov, (2007). However, use of real exchange rate instead of nominal exchange rate has a fundamentally important foundation in economic reasoning. Theoretically, it is assumed that profits are affected by the nominal exchange rate as well as by commodity prices. In other words, a trader's decision whether to take part in trade largely depends upon commodity prices even if there is fixed exchange rate system. Therefore, the real exchange rate is used so as to include the inflationary pressures in model specification. However, Thursby and Thursby (1987) found that effects of real and nominal exchange rate volatility do not differ significantly.

The time varying volatility in the bilateral real exchange rate between countries *i* and *j* is estimated using the equation below:

$$EXV_{ijt} = \sqrt{\frac{\sum_{k=1}^{n}(X_{ij,(t-k)} - \mu_{ijt})^2}{9}}$$

where $X_{ijt} = \ln e_{ijt} - \ln e_{ijt-1}$ is the first difference of logarithmic exchange rate, e_{ijt} is real exchange rate between countries *i* and *j* at time *t* and $\mu_{ijt} = \frac{\sum_{k=1}^{10} X_{ij,t-k}}{10}$ is the mean of X_{ijt} over 10 years. This formula assures that exchange rate volatility at time *t*, say 1970 depends on real exchange rates in previous 10 years i.e. 1959 to 1969.

Measurement of exchange rate volatility between the U.S. and Canada is presented in figure 2. As the figure highlights, U.S.-Canada exchange rate volatility has generally risen over time with a very high degree of volatility for the periods of 2003-04 and 2008-09. This increasing trend of volatility makes the exchange rate perfectly unpredictable leaving significant impact on trading activities and the U.S.-Canada trade relationship. The unpredictable exchange rate worsens traders' ability to make early contracts for future trade activities reducing overall trade volume. This anomaly is more prominent in the agricultural sector as agricultural produce is perishable and cannot be stored for a longer period of time.

Similarly, figures 3, 4 and 5 portray exchange rate volatility between the United States and Germany, Japan, and the United Kingdom, respectively. We can see that no country has had a stable exchange rate with the United States over the past 41 years. Exchange rate between the US dollar and Canadian dollar looks to be the worst case having ever increasing volatility. The USD – British pound sterling (BPS) exchange market shows a trend of decreasing volatility from 1991 to 2003. However, there is a continuous increase in USD – BPS volatility after 2003 (Figure 5).

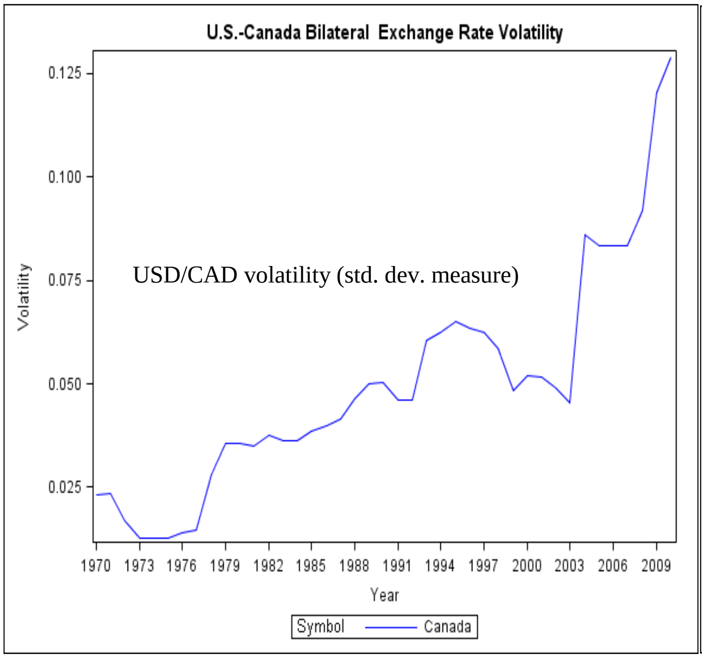

Fig. 2 US-Canada bilateral exchange rate volatility

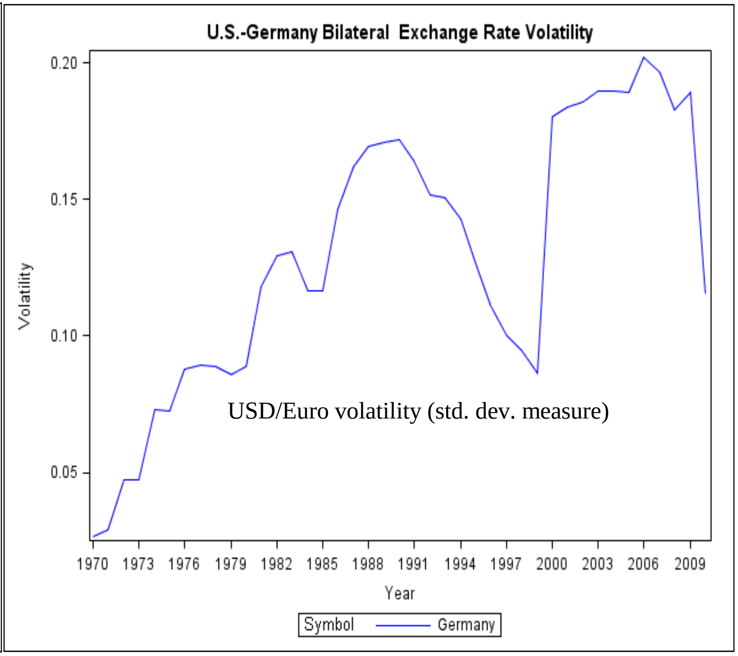

Fig. 3 US-Germany bilateral exchange rate volatility

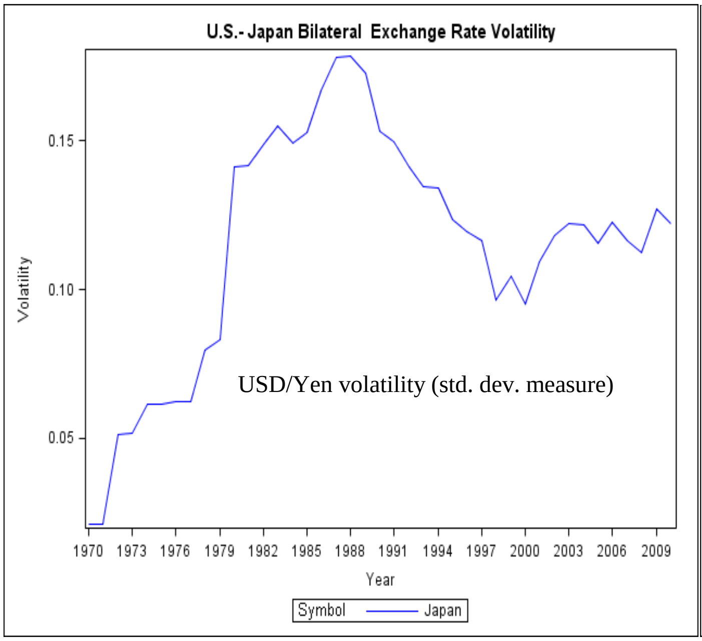

Fig. 4 US-Japan bilateral exchange rate volatility

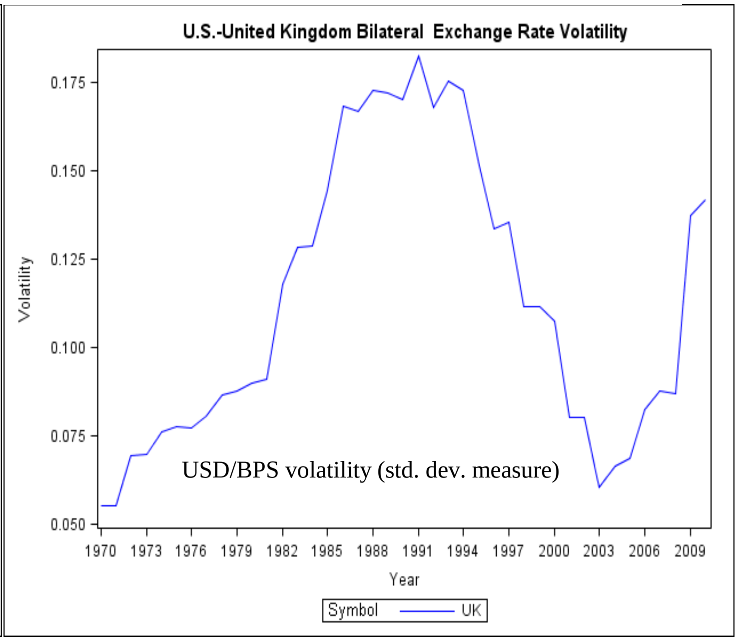

Fig. 5 US-UK bilateral exchange rate volatility

Results and Discussion

Despite multiple advantages of using panel data, there are some econometric issues that need to be addressed before estimating the model. The problem of heteroskedasticity in panel data analysis arises when a large country trades with a smaller country or two smaller countries trade between themselves (Frankel, 1997). The problem of heteroskedasticity is addressed by using heteroskedasticity corrected standard errors. However, no heteroskedasticity consistent standard errors are used in this study. In fact, even if it is present, "heteroskedasticity does not affect the consistency of the estimators, and it is only a minor nuisance for inference" (Wooldridge, 2002).

Another problem frequently faced by researchers in similar studies is the problem of simultaneity bias. Dell'Ariccia (1999) and Cho, Sheldon, and McCorriston (2002) identified the currency stabilization effort by the central bank or monetary authority as a potential source of simultaneity bias. In their words, "when exchange rate uncertainty affects trade between two countries, a national government or central bank may have attempted to stabilize the exchange rate between major trading partners". The stabilization effort that usually comes to improve the notoriously volatile exchange rate should be included in the estimating model to obtain an unbiased estimate.

Dell'Ariccia proposed the following solution to the potential source of simultaneity bias: $U_{ijt} = \alpha_{ijt} - \beta \frac{T_{ijt}}{T_{it}} - \gamma \frac{T_{jit}}{T_{jt}} + \varphi_{ijt}$, where U_{ijt} is exchange rate uncertainty between country *i* and *j* at time *t* and $\frac{T_{ijt}}{T_{it}}$, and $\frac{T_{jit}}{T_{jt}}$ are exports from country *i* to *j* and *j* to *i* relative to *i*'s and *j*'s total exports, respectively. The coefficients β and γ represent the stabilization effort functions of central banks of country *i* and *j*, respectively. If bilateral trade shares are more or less constant over time, then the equation reduces to the following form:

$U_{ijt} = \alpha_{ijt} + \theta_{ij} + \varphi_{ijt}$.

In this case, the central bank's effort is assumed to be constant over time and taken as a fixed effect. Therefore, estimating the equation as a fixed effect model corrects for simultaneity bias and yields an unbiased estimate.

Table 1 presents the effect of exchange rate volatility on bilateral trade flows between the United States and OECD countries. Exchange rate volatility has a significant negative impact in all three kinds of trade flows, agricultural, non-agricultural, and total. The magnitude of impact is larger in agricultural as compared to non-agricultural sector in all categories, export, import, and total flows. For example, a one unit increment in exchange rate volatility decreases agricultural exports from the United States to OECD countries by approximately[4] 16.8% and non-agricultural exports by 9.5%. At the same time, total exports decrease by 20.8% (Table 1). This result is consistent with Kandilov (2007), and Cho, Sheldon, and McCorriston (2002) where they found significant negative effect of exchange rate volatility on bilateral export flows. They further reported a larger impact on agricultural sector as compared to other sectors.

The effects of exchange rate volatility on U.S. imports are also presented in table 1. As expected, exchange rate volatility has a highly significant and negative effect on all types of import flows. The magnitude of impact is larger on agricultural imports than on that of non-agricultural and total imports. Particularly, a one unit increase in exchange rate volatility reduces agricultural, non-agricultural, and total imports of the United States from OECD countries by 23.4%, 14.6%, and 18.4%, respectively.

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[4] As the dependent variable is log linearized and independent variables are not, interpretation of coefficients is critical. In general, a one unit change in the independent variable results in β_i x100% change in the dependent variable holding all else constant. However, the exact % change can be calculated using back transformation. Consider equation (5): $\ln(TRADE_{ijt}) = \gamma_0 + \gamma_1 EXV_{ijt} + \gamma_2 RER_{ijt} + \gamma_3 \ln EM_{it} + \gamma_4 \ln EM_{jt} + \gamma_5 FTA_{ijt} + \gamma_6 EURO_{jt}$. Back transforming equation (5) yields:

$TRADE_{ijt} = e^{\gamma 0} + e^{\gamma 1EXVijt} + e^{\gamma 2RERijt} + e^{\gamma 3}EM_{it} + e^{\gamma 4}EM_{jt} + e^{\gamma 5\ FTAijt} + e^{\gamma 6\ EUROjt}$.

Replacing coefficients and variables with given values, we obtain the value of trade, say for 1970, and then can easily find the percent change in value of trade with 1 unit change in the independent variable. For simplicity, this analysis uses the approximate percent change, i.e. β_i x100%.

Table 1. Effect of Exchange Rate Volatility (EXV) on U.S. – OECD Trade Flows

Sector	Type of Flows		
	Export	Import	Total (export + import)
Agricultural	-0.168*	-0.234*	-0.209*
	(0.049)	(0.041)	(0.036)
Non-agricultural	-0.095*	-0.146*	-0.124*
	(0.028)	(0.039)	(0.028)
Total	-0.208*	-0.184*	-0.198*
	(0.027)	(0.033)	(0.026)

Note: Standard errors are in parentheses. The asterisks *, **, and *** indicate level of significance at 1%, 5% and 10% level, respectively.

Table 2. Effect of the Real Exchange Rate (RER) on U.S. – OECD Trade Flows

Sector	Type of Flows		
	Export	Import	Total (export + import)
Agricultural	-0.465*	-0.253*	-0.334*
	(0.097)	(0.082)	(0.072)
Non-agricultural	-0.247*	-0.766*	-0.509*
	(0.055)	(0.075)	(0.054)
Total	-0.313*	-0.672*	-0.526*
	(0.053)	(0.064)	(0.051)

Note: Standard errors are in parentheses. The asterisks *, **, and *** indicate level of significance at 1%, 5% and 10% level, respectively.

Table 3. Effect of EXV and RER on U.S. – OECD Trade Flows

Sector	Type of Flows					
	Export		Import		Total (export + import)	
	EXV	RER	EXV	RER	EXV	RER
Agricultural	-0.093***	-0.394*	-0.217*	-0.091	-0.169*	-0.207*
	(0.052)	(0.105)	(0.044)	(0.088)	(0.039)	(0.077)
Non-agricultural	-0.057***	-0.205*	-0.001	-0.765*	-0.032	-0.485*
	(0.029)	(0.059)	(0.041)	(0.081)	(0.029)	(0.059)
Total	-0.173*	-0.183*	-0.066***	-0.623*	-0.115*	-0.439*
	(0.028)	(0.057)	(0.035)	(0.069)	(0.027)	(0.054)

Note: Standard errors are in parentheses. The asterisks *, **, and *** indicate level of significance at 1%, 5% and 10% level, respectively.

When exchange rate volatility increases, risk-averse traders either leave the business and greatly reduce their production activities, or require a risk premium to maintain their previous level of economic activity. Those who stay in business are often forced to adjust their production costs by reducing the size of their production facilities and the volume of production (Dell'Ariccia, 1999; Cho, Sheldon, and McCorriston, 2002 and Kandilov, 2008). Other traders, who are risk takers, increase their export prices to offset the potential losses from the associated risk. This makes markets vulnerable and reduces export flows. Moreover, the volatile exchange rate indirectly reduces trade flows by distorting the allocation of resources and government policies (Orden, 2002).

The effect of the real exchange rate on export, import, and total trade between the United States and OECD countries is presented in table 2. The real exchange rate has a significant negative impact on all types of export flows, giving the highest impact on agricultural exports (-0.465). On average, a one unit increase in USD per foreign currency decreases U.S. agricultural exports to OECD countries by 46.5%. The same change in the real exchange rate reduces non-agricultural and total exports by 24.7% and 31.3%, respectively. The exchange rate is measured as U.S. Dollars (USD) per foreign currency and therefore any decrease in the real exchange rate depreciates the U.S. dollar. When the dollar weakens, U.S. export prices are reduced and foreign importers will increase their imports of U.S. product. Hence, U.S. export increases with any decrease in the real exchange rate.

In practice, traders' decisions on doing business are based not only on their past experiences of exchange rate fluctuations, but also on their experiences with market rates. The combined effect of exchange rate volatility and real exchange rate needs to be estimated to figure out how exactly the exchange rate affects trade flows. These combined effects are presented in table 3.

While taking exchange rate volatility into consideration, the real exchange rate always has a larger impact on all kinds of trade flows and its impacts are in the same direction as those of exchange rate volatility. Putting this all together, a one unit increase in the real exchange rate (exchange rate volatility) reduces total exports by 18.3% (17.3%). The same effect in the case of agricultural and non-agricultural exports is 39.4% (9.3%), and 20.5% (5.7%), respectively.

The effect of volatility on non-agricultural imports is negative but not significant as is the case with the effect of the real exchange rate on agricultural imports. Non-agricultural products consist of those products which can be stored until when the market price is desirable but, agricultural products often have to be sold irrespective of price fluctuations. In the other words, non-agricultural traders always can make exports and imports an option which is practiced when profitable. In either case, exchange rate volatility does not necessarily have a significant impact on non-agricultural trade flows. Based on these results, it can be argued that the U.S. non-agricultural importers care more about spot exchange rate while agricultural importers pay more attention to exchange rate fluctuations.

Effects of FTAs on Exports, Imports, and Total Trade Flows

It is expected that the promotion of free trade agreements (FTAs) encourages bilateral and multi-lateral trade flows not only among the members but also with non-members in several ways, such as reducing the risk premium of the traders (Grant and Lambert, 2008). Although there are few trade agreements between the United States and the other members of the OECD,[5] it is still expected that overall U.S.–OECD bilateral trade increases when FTAs are in force. The effect of promotion of FTAs on exports, imports and total (exports +imports) flows between the United States and the OECD is presented in table 4.

[5] The United States has four Free Trade Agreements (FTAs) with five member countries of OECD; they are a) the North American Free Trade Agreement (NAFTA), b) the U.S.–Australia FTA, c) the U.S.–Israel FTA, and d) the U.S.–Chile FTA.

The first row of table 4 reports the effect of FTAs on agricultural exports, imports, and total trade flows between the United States and OECD countries over the past 41 years. Similarly, the corresponding effects on the non-agricultural sector and the total economy are presented in the second and third rows of table 4, respectively. Clearly, participation in free trade agreements always has the largest impact on the agricultural sector, giving more benefits to U.S. agricultural importers (63.3%) as compared to U.S. exporters of agricultural products (54.6%). More importantly, the effect of FTAs on the non-agricultural sector is never significant, although it is always positive. This suggests that none of the non-agricultural exporters, either in the United States or in foreign countries have gained from FTAs. This result is consistent with the findings of Grant and Lambert (2008), Sun and Reed (2010), and Rose and Wincoop (2001). They found a positive impact of regional trade agreements (RTAs) on international trade flows and that the impact is always bigger on agricultural sector.

Table 4. Effect of FTAs on U.S. – OECD bilateral trade flows.

Sector	Type of flows		
	Export	Import	Trade
Agricultural	0.546*	0.633*	0.589*
	(0.089)	(0.075)	(0.066)
Non-Agricultural	0.037	0.046	0.071
	(0.051)	(0.079)	(0.049)
Total	0.154*	0.168*	0.168*
	(0.048)	(0.046)	(0.046)

Note: Standard errors are in parentheses. The asterisks *, ** and *** denote the level of significance at 1%, 5% and 10% level respectively.

Effects of the Euro on Exports, Imports, and Trade Flows

One of the purposes of constructing a monetary union (e.g. Eurozone) within the European Union was to promote intra-member and international trade flows (European Commission, 1990). Given this, it is important to empirically examine the validity of this assertion.

Unfortunately, none of the studies reviewed have estimated the effect of the Eurozone on international trade flows. This situation led to the creation of a dummy variable, $EURO_{jt}$, which equals 1 if county *j* uses the Euro as its national currency and 0 otherwise. The effects of the Euro on exports, imports and trade flows between the United States and OECD countries are summarized in table 5.

Table 5. Effect of the Euro on U.S. – OECD bilateral trade flows.

Sector	Type of flows		
	Export	Import	Trade
Agricultural	0.074	0.566*	0.409*
	(0.107)	(0.09)	(0.079)
Non-Agricultural	0.131***	0.694*	0.465*
	(0.061)	(0.083)	(0.06)
Total	0.213*	0.751*	0.529*
	(0.058)	(0.071)	(0.055)

Note: Standard errors are in parentheses. The asterisks *, ** and *** denote the level of significance at 1%, 5% and 10% level respectively.

The establishment of the Eurozone appears to have had a positive effect on international trade flows. However, unlike FTAs, the size of the impact of the Euro is larger in the non-agricultural sector than in the agricultural sector. For example, U.S. – OECD bilateral trade in non-agricultural goods increased by a coefficient of 0.465 as compared to a 0.409 increment for agricultural trade (Table 5, column 4). Moreover, U.S. agricultural exports to OECD countries (or agricultural imports of the Eurozone countries) are independent of the establishment of the Eurozone (Table 5, column 1, row 1). This result makes sense both economically and practically. First, Eurozone countries account for a very small proportion of U.S. agricultural exports to OECD countries and are not a major export destination of U.S. agricultural products. Second, the relatively strong market power of the United States gives its traders increased options. They may switch exports to an alternative destination if a partner's currency exchange rate is unfavorable.

Conclusion

This study investigates if exchange rate volatility has a negative effect on bilateral trade flows between the US and OECD countries. The effect of exchange rate volatility on trade flows is estimated both separately and in combination with the real exchange rate. Exchange rate volatility was defined and determined as a moving standard deviation of the first difference of the logarithmic exchange rate.

Balanced panel data is used and analyzed using a fixed-effects model as guided by the gravity equation. The estimated coefficients indicate both exchange rate volatility and the real exchange rate have a significant and negative effect on all types of trade flows in general. Interestingly, no positive effect of the real exchange rate is observed as claimed by a number of previous studies. The established notion that the agricultural sector is more responsive to exchange rate volatility is confirmed. Although exchange rate volatility always has the biggest impact on agricultural trade flows, the real exchange rate level has a bigger impact on non-agricultural imports. Similarly, the same pattern holds for agricultural and non-agricultural trade flows where the latter is more responsive to the real exchange rate. Interestingly, the results show that the impact of the real exchange rate on either kind of trade flows (exports, imports, or exports + imports) is always bigger relative to the impact of exchange rate volatility. This result led us to conclude that the effect that the real exchange rate has on international trade flows has been greatly overlooked.

The positive effect of FTAs and the Euro on all three kinds of trade flows suggests that the adoption of free trade agreements and construction of monetary unions enhance international trade flows. Although FTAs have a greater positive impact on the agricultural sector, agricultural importers have benefitted more than agricultural exporters. However, the effects of FTAs on the non-agricultural sector are not significant. When it comes to the effect of a monetary union on trade flows, positive effects are reported in all cases. Nevertheless, construction of the Eurozone turned out to be more beneficial to non-agricultural traders. In general, importers experience a greater positive effect than do exporters.

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Appendix

Table A0 Organization for Economic Co-operation and Development (OECD).

S.N	Country	Member Since	S.N.	Country	Member Since
1	Australia	6/7/1971	18	Japan	4/28/1964
2	Austria	9/29/1961	19	Korea, Republic of	12/12/1996
3	Belgium	9/13/1961	20	Luxembourg	12/7/1961
4	Canada	4/10/1961	21	Mexico	5/18/1994
5	Chile	5/7/2010	22	Netherlands	11/13/1961
6	Czech Republic	12/21/1995	23	New Zealand	5/29/1973
7	Denmark	5/30/1961	24	Norway	7/4/1961
8	Estonia	12/9/2010	25	Poland	11/22/1996
9	Finland	1/28/1969	26	Portugal	8/4/1961
10	France	8/7/1961	27	Slovak Republic	12/14/2000
11	Germany	9/27/1961	28	Slovenia	7/21/2010
12	Greece	9/27/1961	29	Spain	8/3/1961
13	Hungary	5/7/1996	30	Sweden	9/28/1961
14	Iceland	6/5/1961	31	Switzerland	9/28/1961
15	Ireland	8/17/1961	32	Turkey	8/2/1961
16	Israel	9/7/2010	33	United Kingdom	5/2/1961
17	Italy	3/29/1962	34	United States	4/12/1961

Source: OECD, Country Database, 2011

Table A1 U.S. Export destinations and share of total export by OECD countries in 2010.

S.N.	Partner	% of Total exports	S.N.	Partner	% of Total exports
1	Canada	19.416	15	Turkey	0.822
2	Mexico	12.777	16	Spain	0.794
3	Japan	4.736	17	Ireland	0.569
4	United Kingdom	3.788	18	Sweden	0.367
5	Germany	3.758	19	Norway	0.243
6	Korea	3.039	20	Poland	0.233
7	Netherlands	2.738	21	New Zealand	0.221
8	France	2.173	22	Austria	0.181
9	Belgium	1.999	23	Finland	0.171
10	Australia	1.661	24	Denmark	0.166
11	Switzerland	1.619	25	Hungary	0.101
12	Italy	1.110	26	Greece	0.087
13	Israel	0.882	27	Portugal	0.083
14	Chile	0.851	28	Iceland	0.049
	OECD				**64.632**

Table A2 Import sources of the U.S. and share of total imports by OECD countries in 2010.

S.N.	Partner	% of Total Imports	S.N.	Partner	% of Total Imports
1	Canada	14.598	15	Spain	0.464
2	Mexico	12.122	16	Australia	0.458
3	Japan	6.458	17	Chile	0.390
4	Germany	4.410	18	Norway	0.376
5	United Kingdom	2.646	19	Austria	0.361
6	Korea	2.645	20	Denmark	0.321
7	France	2.048	21	Turkey	0.231
8	Ireland	1.779	22	Finland	0.211
9	Italy	1.538	23	Poland	0.162
10	Israel	1.109	24	New Zealand	0.154
11	Netherlands	1.023	25	Hungary	0.133
12	Switzerland	1.019	26	Portugal	0.116
13	Belgium	0.830	27	Greece	0.044
14	Sweden	0.568	28	Iceland	0.040
	OECD				**56.253**

Table A3: Top U.S. export destinations by fiscal year; (in US $ millions).

Country	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Canada	15.52	16.26	13.26	11.61	10.38	9.61	9.13	8.31	7.99	7.51
Mexico	13.46	15.58	12.33	10.39	9.25	8.41	7.61	7.06	7.28	6.31
Japan	11.22	13.06	9.69	8.15	7.85	8.52	8.81	8.59	8.94	9.3
EU-27	7.62	10.66	8.04	7.18	7.15	6.97	6.37	6.52	6.51	6.49
World	96.63	115.3	82.22	68.59	62.52	62.41	56.014	53.32	52.72	50.76

Source: USDA/ ERS 2009

Table A4: Top 15 U. S. Trading Partners (Year-to-Date August 2010).

Rank	Country	Exports %	Imports %	Total Trade %
1	Canada	19.8	14.8	16.8
2	China	6.8	18.5	13.8
3	Mexico	12.7	12.0	12.3
4	Japan	4.8	6.2	5.6
5	Germany	3.8	4.3	4.1
6	United Kingdom	3.9	2.6	3.2
7	Korea, South	3.1	2.5	2.8
8	France	2.1	2.0	2.0
9	Taiwan	2.0	1.8	1.9
10	Brazil	2.8	-	1.9
11	Netherlands	2.7	-	1.7
12	India	-	1.6	1.6
13	Singapore	2.4	-	1.5
14	Venezuela	-	1.8	1.4
15	Saudi Arabia	-	1.6	1.4

Source: U.S. Census Bureau/ Foreign Trade Statistics