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The Effect of Exchange Rate Volatility on Wheat Trade Worldwide

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TABLE OF CONTENTS

List of Tables ii

List of Figures ii

Abstract iii

Highlights iv

Introduction 1

Trends of World Wheat Exports 2

Model and Estimation Method 8

Measures of Exchange Rate Volatility 10

Data 12

Estimation and Empirical Results 13

Conclusion 15

References 17

List of Tables

No.		Page
1	World Wheat Exports Matrix (1978-1997)……..	8
2	Data Description……	13
3	Empirical Results of Wheat Gravity Model……...	14

List of Figures

No.		Page
1	Total Export Quantities of Five Major Exporting Countries……	4
2	Total Import Quantities of FSU, China, Egypt, Japan, and Brazil……..	5
3	Total Import Quantities of Korea, Iran, Algeria, and Indonesia……..……	6
4	Total Import Quantities of Morocco, Pakistan, Philippines, and Mexico……	7

Abstract

A modified gravity-type model was employed to evaluate the effect of exchange rate volatility on wheat exports worldwide. Special attention was given to the econometric properties of the gravity model within a panel framework. Short and long-term measures of exchange rate volatility were constructed and compared. Both measures of exchange rate volatility exhibited negative effects on world wheat trade, with even greater effects in the long-term measure. This result implies that exchange rate volatility is an important factor in explaining the trade pattern of wheat worldwide.

Keywords: wheat, export, exchange rate, volatility, gravity model, and panel data.

Highlights

International wheat trade has exhibited several striking features during last two decades. Although the total world wheat trade volume has remained relatively stable around 100 million tons, the market has been quite dynamic from the perspectives of both individual exporters and importers. Among the major exporters, Argentina and Australia have been rapidly expanding their market shares, while the United States, the biggest exporter, has been losing its market share. More importantly, importer loyalty has been shifting among the major exporters. These changes in market shares lead to a natural question: What are the driving forces behind the changing world matrix of wheat trade?

Uncertainty in exchange rates has generally been perceived as one of the main determinants of international trade, including wheat trade. However, the issue of exchange rate volatility impacts on international trade has been controversial, and the results are inconclusive. These indeterminate results may be partially related to the focus on aggregate trade flows or on manufactured goods, which can obscure commodity or sector specific exchange rate effects (Anderson and Garcia 1989). Thus, this study is motivated by the need for empirical evidence at the disaggregate level. Focusing on the exchange rate effect on a specific commodity, i.e., wheat, for all major exporters and importers will enhance our understanding of the dynamics of the wheat export market and contribute to the literature of exchange rate volatility.

The objective of this study is to evaluate the effect of exchange rate uncertainty on wheat trade worldwide using a modified gravity-type model. The trade between 5 exporters and 13 major importers during the last two decades is analyzed. Short-term and long-term measures of exchange rate volatility are constructed and compared.

Results from the empirical model show that all the variables have the expected effects on wheat trade. The population variables, which are an indication of market size, show that bigger countries tend to trade more. Income growth in both exporting and importing countries has insignificant effects. These results are not a surprise considering that wheat is a food and a staple. Wheat production capacity has highly significant effects, indicating that international wheat trade is closely related to resource endowments for wheat production in each country. In addition, the Asia Pacific Economic Cooperation (APEC) trade agreement has a strong positive effect on trade. Ocean freight rates, on the other hand, are found to have small and insignificant effects on wheat exports.

Measures of both short-term and long-term exchange rate volatility have negative effects on world wheat trade, with even bigger effects from long-term changes. This result implies that exchange rate volatility is an important factor in explaining the worldwide wheat-trade patterns and cannot be neglected. It also shows that in investigating the effect of exchange rate volatility on international trade, conclusive results can be achieved by focusing on an individual commodity.

The Effect of Exchange Rate Volatility on Wheat Trade Worldwide

Changyou Sun, Minkyoung Kim, Won Koo, Guedae Cho, and Hyun Jin*

Introduction

International wheat trade has exhibited several striking features during the last two decades. Although total world wheat trade volume has remained relatively stable around 100 million metric tons (MTs), the market has been quite dynamic from the perspectives of both individual exporters and importers. Among the major exporters, Argentina and Australia have been rapidly expanding their market shares, while the United States, the largest exporter, has lost some market share. More importantly, importer loyalty has been shifting among the major exporters. Consequently, it is important to examine the driving forces behind the changing world matrix of wheat trade.

Uncertainty in exchange rates has generally been perceived as one of the main determinants for international trade, which is also true for wheat trade. However, the issue of exchange rate volatility impacts on international trade has been controversial, and the results are generally inconclusive. These indeterminate results may be partially related to focusing on aggregate trade flows, particularly on manufactured goods, which can obscure commodity or sector specific exchange rate effects (Anderson and Garcia 1989). Most of the existing empirical studies have examined trade data at a national or bilateral level. These studies implicitly assume that the impact of exchange rate volatility is uniform between countries and for all commodities in terms of both direction and magnitude (McKenzie 1999). Thus, this study is motivated by the need for empirical evidence at the disaggregate level. Focusing on the exchange rate effect on a specific commodity, i.e., wheat in this study, for all major exporters and importers will not only enhance our understanding of the dynamics of the wheat export market but also contribute to the literature of exchange rate volatility.

With regard to the effect of exchange rate volatility on international trade flows, there have been a large number of studies since the adoption of a flexible exchange rate system in the early 1970s. The standard hypothesis is that unexpected change in exchange rates impacts the decisions made by risk-averse traders and thereby reduces trade. However, in spite of the exhaustive attempts to explain these relationships, both theoretical and empirical contributions[1] to the literature fail to conclusively validate the hypothesis (Cote 1994; McKenzie 1999).

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[1] For theoretical studies, see Ethier (1973), De Grauwe (1988), Franke (1991), Sercu and Vanhulle (1992), and Dellas and Zilberfarb (1993); for typical empirical studies, see Thursby and Thursby (1987), Koray and Lastrapes (1989), Asseery and Peel (1991), and Chowdury (1993).

In agriculture, Pick (1990) analyzes the effects of exchange rate risk on U.S. agricultural trade flows. He concludes that exchange rate risk is not a significant factor affecting bilateral agricultural trade from the United States to seven out of eight developed markets, but indicates that exchange rate risk adversely affects US agricultural exports to some developing countries. Anderson and Garcia (1989) focus on the effect of exchange rate uncertainty on bilateral soybean trade flows. Imports for Japan, France, and Spain are found to be sensitive to short-term variations in nominal bilateral exchange rates. Langley, et al. (2000) reveal exchange rate volatility is significantly positive in explaining poultry exports in Thailand but not aggregate exports.

Overall, these studies suggest that the effects of exchange rate volatility may differ across countries and seem more measurable for specific commodities than for aggregate trade. Therefore, the use of disaggregated trade data in evaluating the impact of exchange rate volatility on trade flows may be potentially beneficial for trade policy formulation.

The objective of this study is to evaluate the effect of exchange rate uncertainty on wheat trade worldwide using a modified, commodity-specific gravity-type model. Trade between 5 exporters and 13 major importers during the last two decades is analyzed. The order of exposition is as follows. In the next section, the major trends of wheat exports worldwide are presented. The methodology employed in this study, a modified gravity-type model with a panel framework, is described in the third section. Two measures of exchange rate volatility are constructed and used in the analysis. Empirical results follow, and conclusions are drawn.

Trends of World Wheat Exports

From 1978 to 1997[2], the average annual exports of world wheat[3] were 95 millions tons (MTs, Table 1), about 18% of the total world production. The quantities range between 71.7 MTs in 1978 and 106.3 MTs in 1993. The coefficient of variation (CV), which is calculated as standard deviation over mean, is only 9%, indicating that the world wheat export market is quite stable. This may reflect that wheat is a staple for major importing countries (i.e., Japan), and/or that they do not have enough production capacity.

However, the trading history of individual exporters and importers reveals a quite dynamic picture. The 5 major exporters, the United States, Canada, the European Union (EU), Australia, and Argentina, account for an average of 92% of world exports (Figure 1). Argentina and Australia have been rapidly expanding their market shares at the expense of the United States and the EU, while Canada just barely maintains its export share with the smallest CV

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[2] Wheat exports quantities have been reported on the basis of crop year rather than calendar year in the *World Grains Statistics* (IGC). 1997 actually refers to July 1997/June 1998.

[3] Wheat in this study refers to wheat and flour (in wheat equivalent) as reported by IGC.

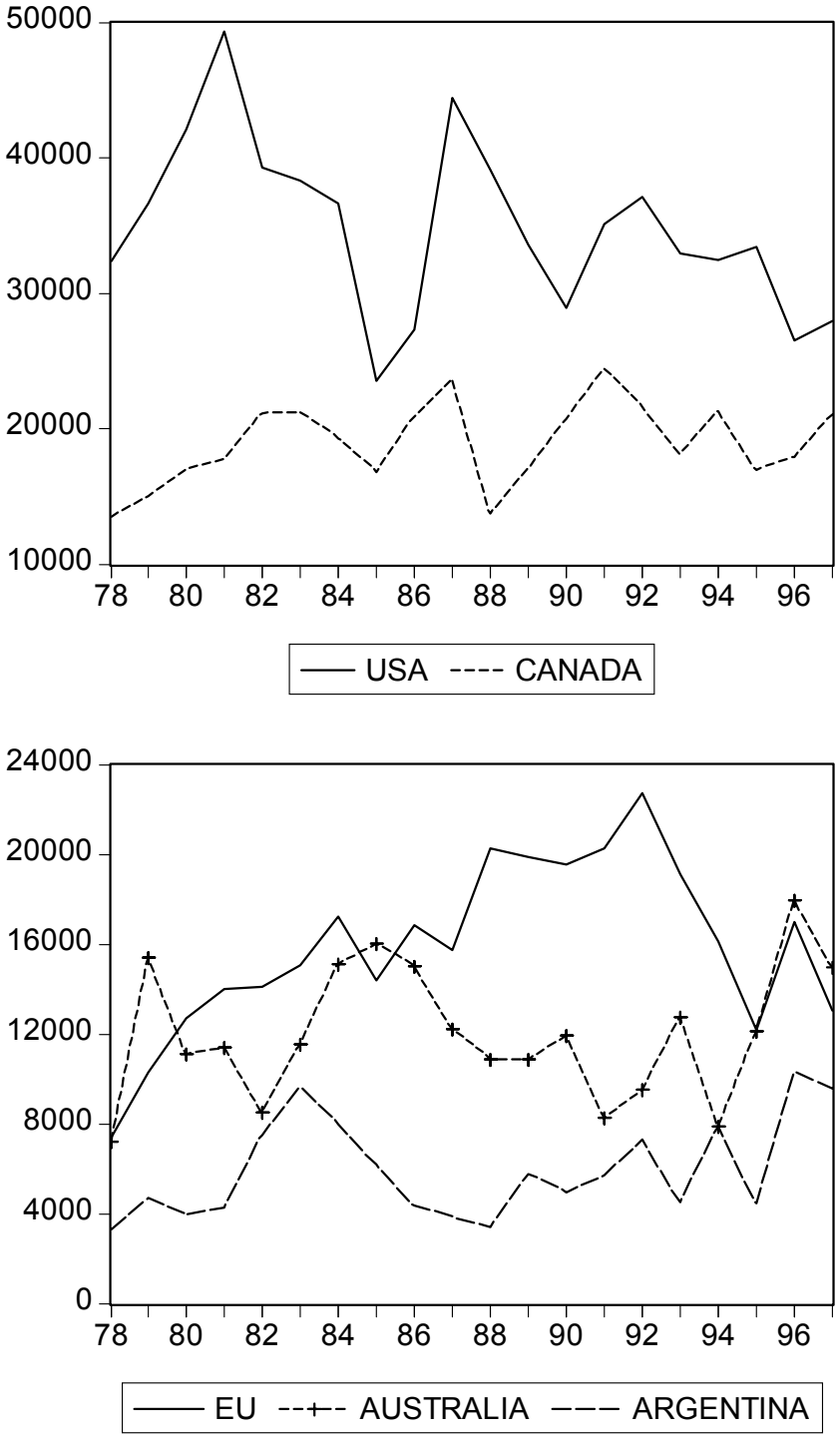
(16%) among exporters. As a result, the market share for the United States has been fluctuating and, especially in the last decade, dropping from 35% in 1989 to 28% in 1997.

On the importers' side, the Former Soviet Union (FSU)[4], China, Egypt, Japan, and Brazil are among the largest importers according to their average annual importing quantities (Figures 2, 3, and 4). Japan and Egypt are the most consistent buyers. Japan imports about 5.7 MTs annually with a CV of 3%. Egypt imports 6.5 MTs with a CV of 10%. These two importers are as stable as the overall world market, according to the CVs. With their huge imported quantities, Japan and Egypt actually serve as the stabilizers of the world wheat market. In contrast, among the other large importers, the FSU and China introduce significant instability to the market. The FSU was the biggest importer before 1992, with annual imports of 17.1 MTs from 1978 to 1992. However, due to the political turbulence after 1991 in that region, imports from the FSU decreased dramatically and only reached 1.3 MTs in 1997. China's imports also have been fluctuating widely with its trade policies and domestic harvests. Its imports were 15.5 MTs in 1991 and only 1.9 MTs in 1997.

More importantly, it is noted that individual importing countries have not always remained loyal to their supply sources during the past decades. First, for instance, as one of the two most stable importers, Egypt imported 6.3 MTs wheat in 1996 with 5.3 MTs coming from the United States; however, in 1997, Egypt imported 7.0 MTs with only 2.8 MTs from the United States. Australia and the EU are two important alternative suppliers for Egypt. For other importers, the variation is even larger, which is evident from the widely varying bilateral coefficients of variation in Table 1. Second, over the last two decades, both the FSU and China have been major importers for the United States and Canada, but their trading relationship has been more stable with Canada than with the United States. After 1992, however, the FSU reduced its imports more rapidly from Canada than from the United States and the EU. Third, Brazil's imports from Argentina have constantly been increasing, while their imports have decreased from the United States and have been fairly stable with Canada.

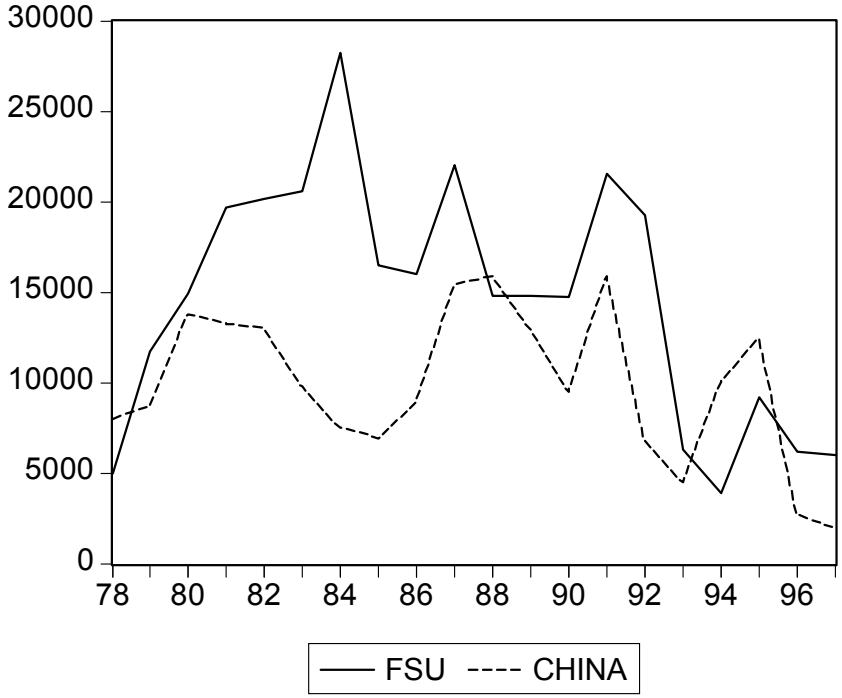
In summary, total world wheat trade has been relatively stable during the past two decades. Australia and Argentina have been expanding their market shares, while the U.S. market share has been decreasing. Egypt and Japan have been the most stable importers. Since the 1990s, the FSU and China's imports have been shrinking rapidly, while Brazil has emerged as a large importer. Finally, importing countries have different loyalties to the major wheat exporting sources. Overall, the world wheat export market has been characterized by overall stable trade quantities and dynamic bilateral trading volumes. This picture provides us an opportunity to examine the driving forces behind the trade matrix, especially the effect from exchange rate volatility.

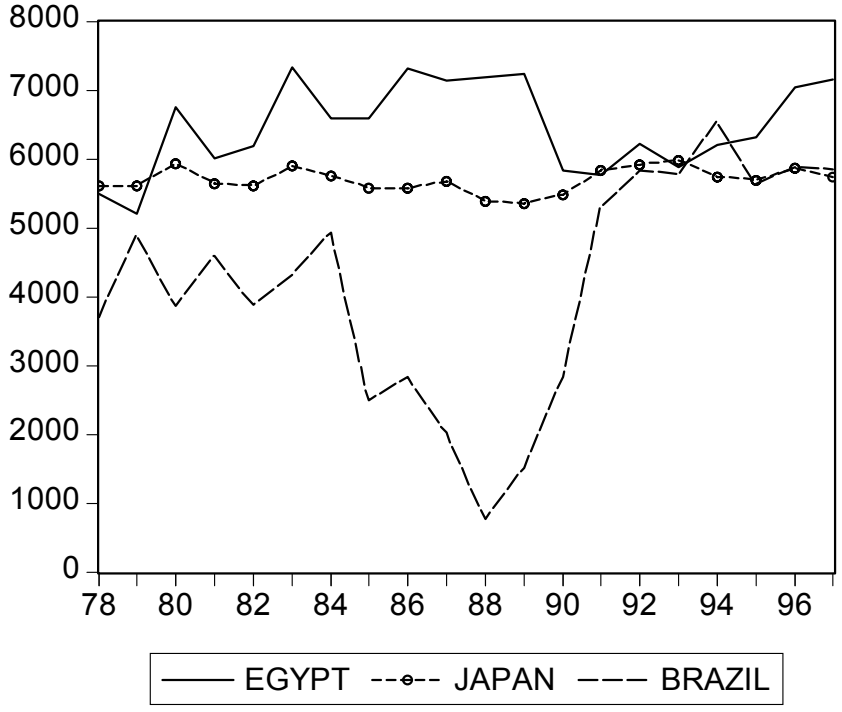
[4] FSU refers to the former Union of Soviet Socialist Republics and, after 1992, the 15 former soviet republics as a group.



(Unit: 1,000 tons)

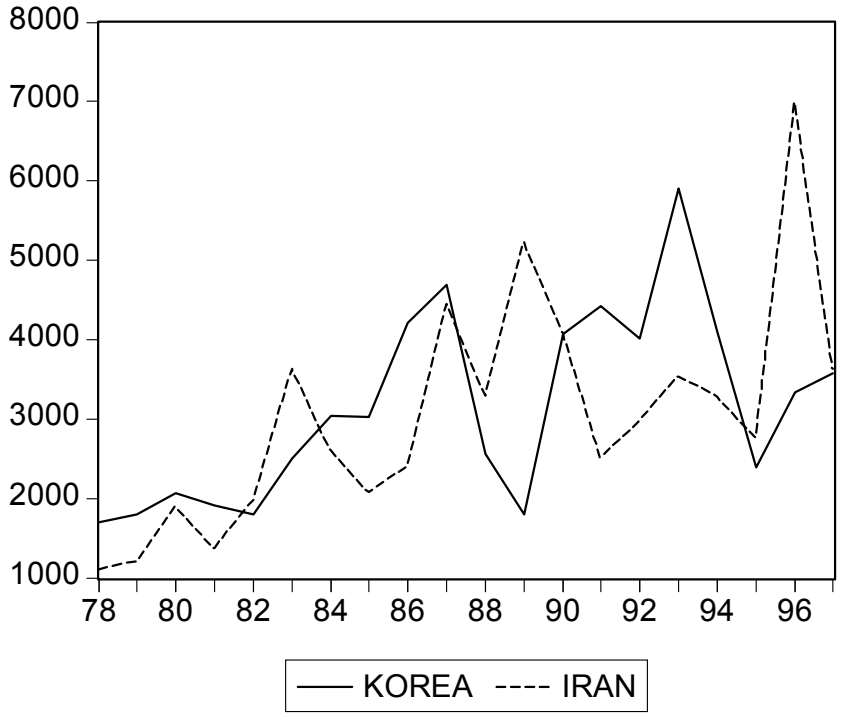
Figure 1. Total Export Quantities of Five Major Exporting Countries

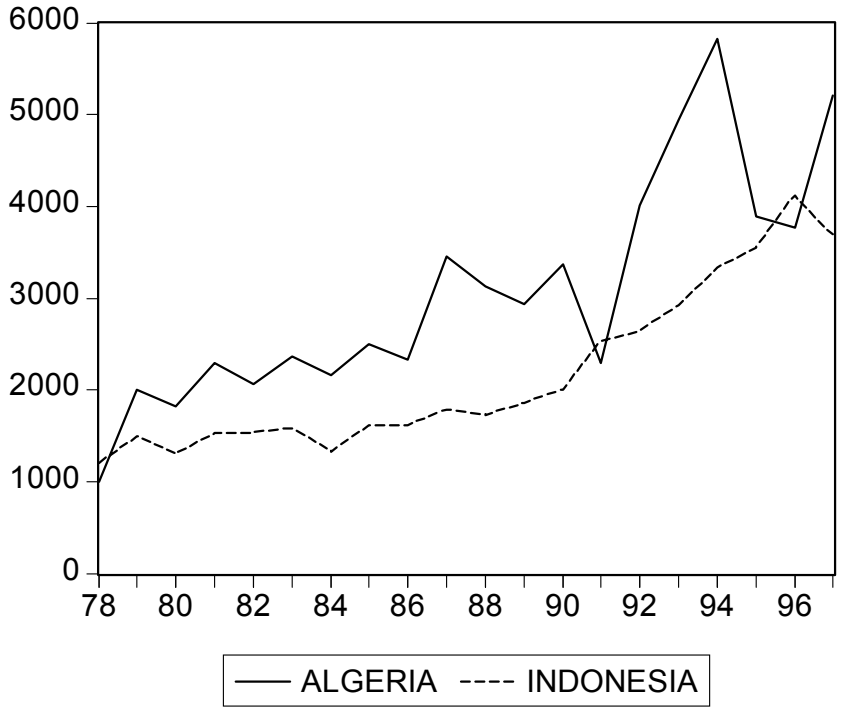




(Unit: 1,000 tons)

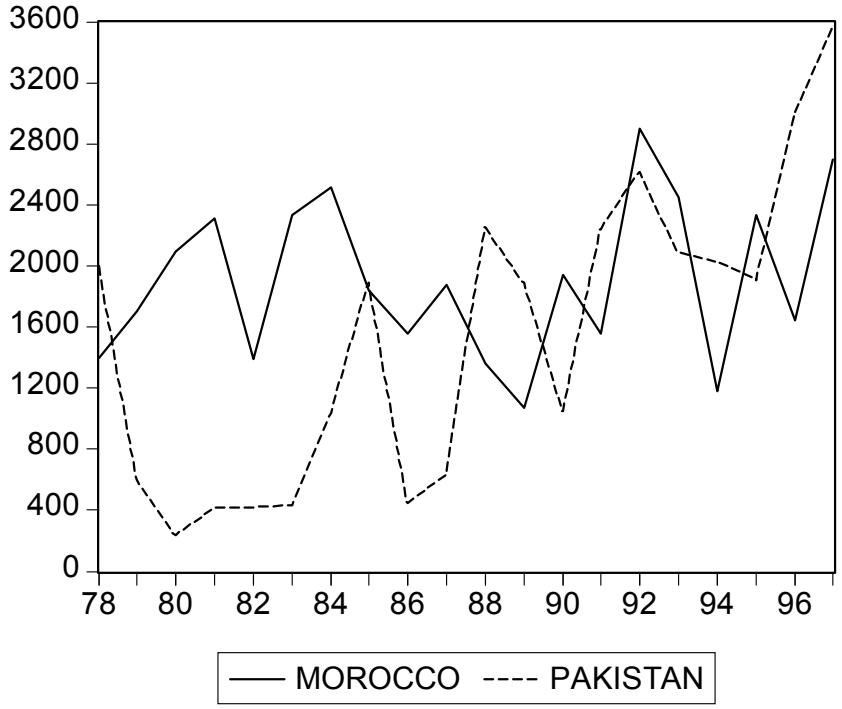
Figure 2. Total Import Quantities of FSU, China, Egypt, Japan, and Brazil

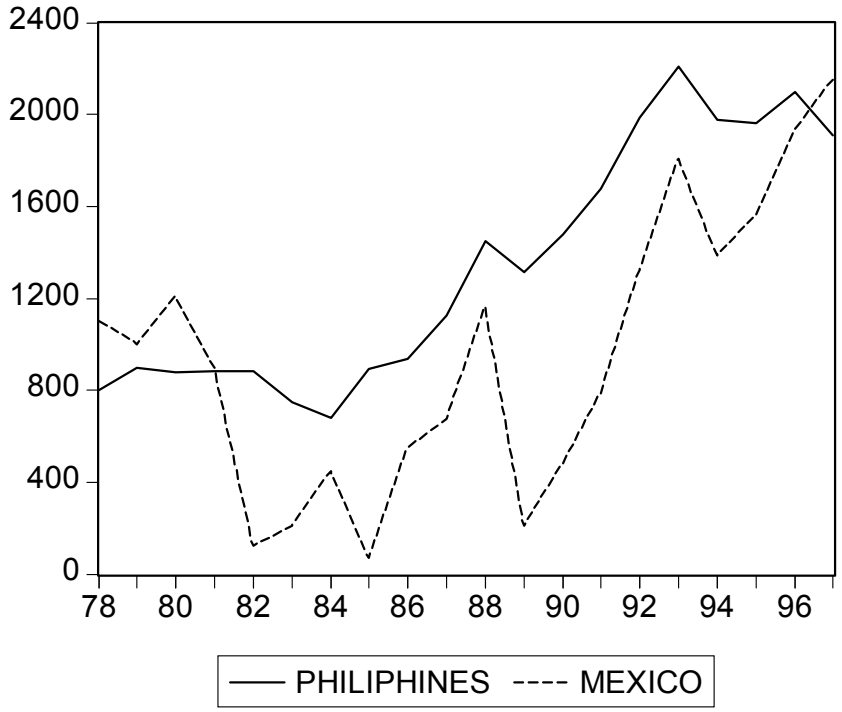




(Unit: 1,000 tons)

Figure 3. Total Import Quantities of Korea, Iran, Algeria, and Indonesia





(Unit: 1,000 tons)

Figure 4. Total Import Quantities of Morocco, Pakistan, Philippines, and Mexico

Table 1. World Wheat Exports Matrix (1978-1997)

	World		*Five Major Exporters*									
			US		Canada		EU		Australia		Argentina	
	mean	cv	mean	cv	mean	cv	mean	cv	mean	cv	mean	cv
World	95.0	9	34.8	18	19.0	16	15.9	24	12.0	25	6.0	37
Major Importers												
FSU	14.6	46	3.7	82	3.4	74	3.4	70	1.0	108	1.2	131
China	9.9	42	3.5	72	3.6	46	0.6	117	1.5	64	0.5	102
Egypt	6.5	10	3.3	30	0.1	135	1.3	43	1.6	34	0.1	294
Japan	5.7	3	3.2	6	1.4	7	0.0	285	1.1	9	0.0	447
Brazil	4.2	39	1.0	107	1.0	49	0.1	137	0.0	na	2.0	86
Korea	3.1	38	1.7	13	0.6	123	0.2	216	0.5	85	0.0	221
Iran	3.1	47	0.1	235	0.8	102	0.2	156	1.3	63	0.5	101
Algeria	3.1	40	0.9	57	0.8	70	1.2	59	0.0	na	0.0	255
Indonesia	2.2	42	0.4	87	0.4	100	0.1	114	0.9	60	0.2	96
Morocco	1.9	28	0.9	59	0.1	146	0.8	50	0.0	325	0.0	285
Pakistan	1.5	64	1.0	71	0.1	117	0.1	53	0.3	117	0.0	332
Philippines	1.3	40	1.2	38	0.1	122	0.0	136	0.0	130	0.0	na
Mexico	1.0	65	0.6	79	0.3	102	0.0	184	0.0	273	0.0	262

Note:
1. The table is sorted by the 2nd column;
2. "mean" is the average of annual export quantity in millions tons from each exporter to each importer from 1978 to 1997;
3. "cv" is the coefficient of variation (cv=100*standard deviation/mean);
4. The numbers in the "world" row and column for individual countries are the annual average total quantities imported by each importer or exported by each exporter;
5. "na" stands for not available because of zero mean or close to zero mean.

Model and Estimation Method

A modified gravity-type model is employed in this study. The gravity model has been extensively applied in studies on international trade, with empirical success coming first (Tinbergen 1962; Poyhonen 1963; Linnemann 1966) and theoretical foundations widely established later (Anderson 1979; Bergstrand 1985, 1989). Consensuses have been reached about the usefulness of the basic formulation of the gravity model as an instrument for bilateral trade flow modeling and the malleability to each particular situation by adding the proper variables (Sanso, et al. 1993).

At present, more attention has been paid to the econometric properties in the application of the gravity model. Cheng and Wall (2001) argue that standard methods for estimating the gravity model produce severely biased estimates. To address the problem, they adopt a two-way fixed effects model in which country-pairs and time period dummies are used to reflect the bilateral relationship between trading partners. Cheng and Wall also verify that the three-way

effects model proposed by Matyas (1997, 1998) and the difference specification by Bayoumi and Eichengreen (1997) are restricted versions of their model. Overall, a panel framework for the gravity model has revealed several advantages over cross-section analysis by capturing the relationships over a longer period and disentangling the time-invariant country-specific effects (Egger 2000).

Empirically, applications of the gravity model within the panel framework have produced significant results in several cases. Dell'Ariccia (1999) analyzes the effects of exchange rate volatility on bilateral trade flows in Western Europe. Exchange rate uncertainty is found to have a negative effect on bilateral trade. Koo, et al. (1994) reveal that trade policies and subsides, livestock production capacity, and long-term agreements play important roles in determining trade flows of meat worldwide.

Following this recent development and application of the gravity model, the empirical model for wheat trade in this study includes the traditional gravity variables: market sizes and transportation costs. Furthermore, as revealed in Bergstrand (1985, 1989) and Thursby and Thursby (1987), a gravity model is a reduced form equation from the general equilibrium of demand and supply systems. The underlying wheat supply from an exporter *i* to an importer *j* is assumed to be related to the wheat export price faced by exporter *i* and the supply possibility in exporter *i*. The latter can be approximated by the per capita wheat production and the per capita gross domestic product (GDP) in exporting countries. Higher wheat production per capita and lower GDP in exporting countries would result in more exports. The underlying demand model for wheat is mainly related to the import price faced by *j*, the purchasing power in *j*, and the domestic supply capacity of *j*. The export and import wheat prices are assumed to be the same after considering the transportation costs and exchange rate. Therefore, the reduced form equation for wheat export quantities contains the above demand and supply shifters and variables of trade barriers as follows:

$$Q_{ijt} = f\,(POP_{it},\ CAP_{it},\ GDP_{it},\ POP_{jt},\ CAP_{jt},\ GDP_{jt},\ FR_{ijt},\ APEC,\ V_{ijt}) \tag{1}$$

where *i* indexes exporters, *j* indexes importers, and *t* indexes time. *Q* is the quantities of wheat from exporter *i* to importer *j* at time *t*; the population of a country (*POP*) represents the country size for wheat trading. Considering wheat is a staple, population is supposed to be a better estimator than total GDP for this purpose; *CAP* is the per capita wheat production in a country; *GDP* is the per capita GDP; *FR* is the ocean freight rate[5] as a proxy for the transportation costs; *V* is the real exchange rate volatility[6]. In addition, to capture any effect from the regional trade

[5] Previous studies generally use distance as a proxy of the transportation cost. Vido and Prentice (2001) summarize the problems associated with this proxy and promote the use of freight rate as a more accurate measure of the transportation cost between trading partners. Therefore, for single and bulky commodities such as wheat, ocean freight rates are expected to be a better proxy than the time-invariant distances between countries and were adopted in this study.

[6] Following a reviewer's comment, the level variable of exchange rate was tried in the specification to capture any effect, but no significant effect was found. We followed the practice in the literature about exchange rate volatility and focused on exchange rate volatility only (e.g., Chowhury 1993; Dell'Ariccia 1999).

agreement, a dummy variable, *APEC,* is added to consider the trade effects of the Asia-Pacific Economic Cooperation since 1989. All variables are expressed in logarithms.

Further, Equation (1) in time series and cross-section form (i.e., two-way panel model) is presented as follows:

$$Q_{ijt} = \alpha + \gamma_{ij} + \lambda_t + \beta' X_{ijt} + \varepsilon_{ijt} \quad (2)$$

where α is the intercept, γ_{ij} is the trade effect associated with exporter *i* and importer *j* (country-pair effects), λ_t is the time effect specific to a particular year (time effects), β is the coefficient vector, X_{ijt} is the trade determinant vector composed of the variables on the left side of Equation (1), and finally, ε_{ijt} is a classical error term with zero mean and a homoscedastic covariance structure.

The two-way fixed effects model takes country-pair effects γ_{ij} and time effects λ_t to be group-specific constant terms in the regression model, while the two-way random effects model specifies them as group-specific disturbances similar to ε_{ijt}. Restricting either the country-pair or time effects to zero leads to one-way models. For the fixed effects model, time-invariant factors such as common border and language between countries may also affect trade, but they are contained in the country-pair effects.

Among various panel data models, there is no simple rule for the selection of the best model for a particular problem (Judge, et al. 1985; Greene 2000). The fixed effects model is analyzed conditional on the effects presented in the observed sample. It is a reasonable approach when we are confident that the differences between units can be viewed as parametric shifts of the regression function. However, if sampled cross-sectional units were drawn from a large population, it would be more appropriate to view individual specific constant terms as randomly distributed across cross-sectional units, as in the random effects model, which is the case for wheat trade in this study. Statistically, the Hausman's test has been constructed to select the models. In this study, both the economic nature of the model and the Hausman's test are examined in evaluating the model adequacy.

Measures of Exchange Rate Volatility

The appropriate measurement of exchange rate volatility has been debated extensively in the literature but with no unique definitions. Issues concerning the measurement include whether it should be bilateral or multilateral, real or nominal, short-term versus long-term horizon, *ex ante* versus *ex post*, and sustained deviations from trend versus period-to-period movements (see the summaries in Cote 1994 and McKenzie 1999). Two exchange rate measures were adopted in this study.

The first measure is the moving sample standard deviation of the percentage real exchange rates, which has been the most extensively used in the literature (Koray and Lastrapes 1989; Chowdhury 1993). Typically, it is one-period ahead and has a window of one or two years, so it has been referred to as short-term exchange rate volatility. Mathematically, it is

$$V_t = \left[m^{-1} \sum_{i=1}^{m} (\ln R_{t+i-1} - \ln R_{t+i-2})^2 \right]^{1/2} \quad (3)$$

where R_t is the real exchange rate at time t; m is the order of moving average, specified as two for this study[7].

Some studies have extended the time horizon and derived long-term measures of exchange rate risk. This distinction may be important as international trading contracts are typically long-term in nature, and firms generally do not know the magnitude or timing of their foreign exchange transactions with certainty. Thus, while short-term risk may be hedged, as long-term instruments are infrequently available, firms may be exposed to higher and possibly unhedgable exchange rate risk (McKenzie 1999). Similar to the long-term exchange rate volatility in Peree and Steinherr (1989), the second measure employed in this study is

$$V_t = \frac{\max R_{t-k}^t - \min R_{t-k}^t}{\min R_{t-k}^t} + \left[1 + \frac{\left| R_t - R_t^p \right|}{R_t^p} \right]^2 \quad (4)$$

where R_t is the real exchange rate at time t, $\max R_{t-k}^t$ and $\min R_{t-k}^t$ refer to maximum and minimum values of the real exchange rate over a given time interval of size k up to time t, and R_t^p is the 'equilibrium' exchange rate. k was specified as five following Perre and Steinherr (1989). The first part of above expression captures accumulated experience. It is postulated that the largest spread observed over some relevant past period is conditioning uncertainty. The second part takes current misalignment into account by assuming that as misalignment grows linearly, uncertainty increases exponentially. Identifying the 'equilibrium' exchange rate is an unsolved issue in the literature (Williamson 1985). In this study, following the practice in the previous studies, the average of the real exchange rate over the whole study period is used for simplicity[8].

[7] The volatility measures for different window value (m=2, 3 or 4) were highly correlated. Regression results did not differ significantly.

[8] Regression also has been tried with the ten-year average around time t as the 'equilibrium' exchange rate at t, but the results did not change statistically.

Data

The time period covered in this study is from 1978 to 1997, given the data availability of bilateral wheat export quantities. Five major exporters in the wheat market (the United States, Canada, the EU, Australia, and Argentina) were included. The EU is composed of 15 member countries. Over the years, the number of the countries in the EU has changed. Therefore, the wheat export of the EU is aggregated over the 15 members. Importing countries with annual average import quantities of more than one million tons during the study period were selected[9]. Thirteen importers were on the list (the FSU, China, Egypt, Japan, Brazil, South Korea, Iran, Algeria, Indonesia, Morocco, Pakistan, Philippines, and Mexico). The FSU has been treated as one importer for the whole period. After 1992, the 15 former soviet republics in the FSU were used to compose the series. The data set has a total of 65 country-pairs (cross-sections) and 20 years, leading to 1,300 observations.

The wheat export quantities between the 5 exporters and 13 importers were abstracted from the *World Grain Statistics* (IGC). Some of the quantities are zero or close to zero. They were replaced by a small number to be able to take logarithms in the estimation[10].

The *World Grain Statistics* (IGC) also reports the ocean freight rates for grain shipments between original and destination ports for major trading country-pairs. But the rates are missing for some country-pairs selected in this study. To fill the missing rates, cross-sectional regressions of the reported ocean freight rates on distance were estimated for each year[11]. The distance for each country-pair is the shortest actual ocean mileage between the major origin and destination ports and was collected from the *Distances Between Ports* (U.S. Defense Mapping Agency 1999). The coefficients for all the regressions were highly significant. The missing rates were filled by the prediction values using the estimated coefficients.

The population data are from the FAOSTAT database of the Food and Agricultural Organization (FAO 2001). The GDP data for each country are its nominal GDP in U.S. dollars from the *World Economic Outlook Database* (IMF 2001), deflated by the U.S. GDP deflator (IMF 2000, 1995=100). For the EU, both population and GDP series are the sum of the 15

[9] Bangladesh was on the primary list but later deleted because it has been receiving a lot of wheat as food aid (FAO 2002). In addition, it has been noted that the U.S. has been importing a significant amount of wheat from Canada. As analyzed by Uri and Beach (1996), the existing intra-industry trade between Canada and the U.S. could largely be contributed to the significance of wheat quality. Therefore the U.S. was excluded from the importer list.

[10] The other two approaches in dealing with zero trade data detailed in the literature are using the Tobit model (Biessen 1991) or deleting these observations (Ratnayake and Townsend 1999). In our raw data set, some country-pairs have traded for some years. It was assumed that all these zero trade data contain important information and cannot be neglected. Panel data techniques were one of the focuses in the estimation in this study, so the missing values were filled with small quantities.

[11] Cross-sectional regressions also have been checked with both the freight rate and distance-being-taken logarithm first. The results were similar.

members. For the FSU, population and GDP series after 1992 are the sum over the 15 former soviet republics.

The Economic Research Service of United States Department of Agriculture has reported the real bilateral exchange rates between the US dollar and other major currencies (Shane 2000). The real exchange rate for the FSU is represented by that of Russia. The real exchange rate for Iran is from the *International Financial Statistics Yearbook* (IMF 2000). For the EU, the real exchange rate is the sum of the exchange rates for the 14 members (without Luxembourg), weighted by the annual wheat export quantities of each country. The export quantities of each EU member country were abstracted from the PS&D Database (U.S. Department of Agriculture 2001). To make the comparison between cross-sections meaningful, all the exchange rates have been converted into indexes (1980=100). Finally, the wheat production in each country was from the PS&D Database (U.S. Department of Agriculture 2001). The data sources and expected signs are summarized in Table 2.

Table 2. Data Description

Variable Name	Expected Sign	Sources
Wheat export quantities	--	IGC
Population of exporter	+	FAO (2001)
Population of importer	+	FAO (2001)
Per capita GDP of exporter	-	IMF (2001)
Per capita GDP of importer	+	IMF (2001)
Per capita wheat production of exporter	+	USDA (2001)
Per capita wheat production of importer	-	USDA (2001)
Freight rate	-	IGC
APEC Dummy	+	--
Exchange rate volatility	?	Shane (2000)

Estimation and Empirical Results

One-way, two-way, fixed effects, and random effects models were estimated with both short-term and long-term measures of exchange rate volatility. Breusch and Pagan's Lagrange multiplier test, likelihood ratio test, and R-squared all revealed that two-way models were better than classical ordinary least square estimation and one-way models. For both volatility measures, the Hausman statistics for testing the random against fixed effects model were significant at the 5% level, which suggested that the fixed effects models were better than the random effects models. However, since the country-pairs and wheat trading volumes in the sample are just part of the world wheat trade, the random effects model is more appropriate in

this sense (Greene 2000, P 567). Comparison of the results from fixed and random effects models reveals they are quite consistent and similar, with only a small difference in the coefficients' magnitude. To facilitate comparison, the results for both two-way fixed and random effects models are presented in Table 3. The following analysis is based on the results from the random effects model.

Table 3. Empirical Results of Wheat Gravity Model

	Fixed Effects		Random Effects	
	Short-term Volatility	Long-term Volatility	Short-term Volatility	Long-term Volatility
Constant	-123.44[a]	-104.22[a]	-14.12[a]	-16.38[a]
	(-3.72)	(-3.12)	(-3.11)	(-3.54)
Population /exporter	4.53[c]	3.40	1.23[a]	1.48[a]
	(1.84)	(1.38)	(4.67)	(5.29)
Population /importer	6.41[a]	6.23[a]	1.01[a]	1.07[a]
	(5.60)	(5.48)	(3.91)	(4.10)
Per capita GDP /exporter	-0.44	-0.49	-0.39	-0.40
	(-1.25)	(-1.42)	(-1.48)	(-1.56)
Per capita GDP /importer	0.20	0.11	0.20	0.17
	(1.29)	(0.74)	(1.51)	(1.29)
Per capita wheat production	1.65[a]	1.59[a]	1.57[a]	1.52[a]
/exporter	(4.96)	(4.83)	(5.44)	(5.37)
Per capita wheat production	-0.62[a]	-0.61[a]	-0.18[a]	-0.16[b]
/importer	(-6.00)	(-5.94)	(-2.59)	(-2.24)
Freight rate	0.38	0.19	-0.02	-0.10
	(1.06)	(0.54)	(-0.07)	(-0.37)
APEC Dummy	0.87[a]	0.83[a]	0.65[a]	0.57[b]
	(3.24)	(3.09)	(2.62)	(2.35)
Exchange rate volatility	-0.18[a]	-0.47[a]	-0.14[b]	-0.34[a]
	(-2.70)	(-4.48)	(-2.27)	(-3.76)
R^2	0.73	0.73	--	--
Hausman *m* statistic			23.90	25.36
Lagrange Multiplier statistic			3051.14	3160.22

Note:
1. FEM (REM) is a two-way fixed (random) effects model; *t* statistics are in the parentheses;
2. Large values of the Hausman statistic are in favor of FEM over REM. Large values of the Lagrange Multiplier statistic argue in favor of one of the factor models against the classical OLS regression;
3. [a] statistically significant at the 1% level or better, [b] 5%, and [c] 10%.

Specifically, population variables as the indication of market size had positive effects and were highly significant. The estimated elasticities were all greater than one (1.01 to 1.48), and the effect was stronger for exporting countries with larger elasticities. This is consistent with the notion that larger countries tend to trade more. Per capita GDP variables were negative for exporting countries and positive for importing countries, as expected. Income growth in exporting countries reduces the export pressure, while income growth in importing countries increases the demand for wheat. However, the coefficients were not significant (*P* value around 15%). Because wheat is food and staple, both the strong effect from market size and the weak effect from income growth are reasonable.

Wheat production capacity had highly significant effects. For exporting countries, the coefficients were positive (1.57 and 1.52), indicating the production expansion in exporting countries like Argentina is an important factor for their increasing exports. For importing countries, the coefficients were negative (-0.18 and -0.16). This reflects the association between the increasing wheat imports and the limited resources endowment for wheat production in importing countries such as Korea and Japan.

The effect of ocean freight rate was negative and small (-0.02 and -0.10). Contrary to the significant findings in Vido and Prentice (2001), the effects were not statistically significant in explaining wheat exports. It might be that transportation cost is a small percentage of the total cost of wheat purchase and therefore it could not exert any significant effect. Koo and Karemera (1991) use distance as a proxy for transportation cost but also fail to find any significant effect. They postulate that the demand for heterogeneous types and quality of wheat might explain why the world wheat trade pattern has not been established on the basis of distances between trading countries. In addition, the trade agreement dummy for APEC was 0.65 and 0.57 and highly significant. This strong positive effect suggests that free trade agreements have been promoting trade between the members.

Finally, both volatility measures of exchange rate were significant in all cases. For the moving standard deviation representing the short-term volatility of exchange rate, the elasticity for the random effects model was -0.14 and significant at 2% level. For long-term volatility, the elasticity was -0.34 and significant at 1% level. Overall, the long-term volatility had a larger effect than the short-term moving standard deviation. This implies that exchange rate volatility had a significant negative effect on wheat trade worldwide during the past two decades.

Conclusion

A modified gravity-type model was employed to evaluate the effect of exchange rate volatility on worldwide wheat exports. It covered major trading partners worldwide over the past two decades. Short-term and long-term measures of exchange rate volatility were constructed and compared. Special attention also was given to the econometric properties of the gravity model within panel framework.

All the variables had the expected effects. The population variables as the indication of market size showed that larger countries tend to trade more. Income growth in both exporting

and importing countries had insignificant effects. These results are not a surprise considering that wheat is a food and a staple. Wheat production capacity had highly significant effects, indicating that international wheat trade is closely related to resource endowments for wheat production in each country. In addition, the trade agreement dummy for APEC had a strong positive effect, but ocean freight rate had a small and insignificant effect in explaining the wheat exports.

Both measures of short-term and long-term exchange rate volatility showed negative effects on world wheat trade, and the long-term effect was larger. This result implies that exchange rate volatility is an important factor in explaining the worldwide wheat trade pattern and cannot be neglected. It also shows that in investigating the effect of exchange rate volatility on international trade, focusing on an individual trade commodity can bring clear results and benefits. It would be interesting to investigate if there are any similar, significant effects of exchange rate volatility on international trade for other individual agricultural commodities when data are available.

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