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Third-Country Effects on the Market Shares of U.S. Wheat in Asian Countries

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An import demand model, augmented with third-country effect variables, is developed to examine the effects of strong U.S. dollar, volatility of the U.S. dollar, and competition among the exporting countries on the shares of U.S. wheat in Asian markets. In the empirical model, the dependent variable is the market shares of U.S. wheat. Explanatory variables include wheat prices of exporting countries, exchange rates between the importing and exporting countries, and volatilities of the exchange rates. Panel estimation results show that the U.S. currency value and volatility, Australian wheat price, and the volatilities of Canadian and Australian currency values have significant effects on U.S. market shares.

Key Words: exchange rate, international grain trade, market share, panel analysis, panel unit-root test, third country effect

JEL Classifications: F14, Q17

The market shares of U.S. wheat in Asian countries have decreased since the early 1980s. During the past two decades, the average U.S. market share in the markets of China, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand has decreased from 65% to 35%. Market shares in individual Asian countries have more dynamic features.[1] The decreased U.S. market shares may be associated with sales displaced by competing suppliers. Since the early 1980s, according to *Wheat Yearbooks* by the Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA), foreign competitors, mainly Australia and Canada, have increased their market shares in the Asian countries; Australia's wheat export has increased by 100% and Canada's by 40%.

Three factors have received attention as having negative effects on U.S. wheat export performance: 1) the relatively strong U.S. dollar in real terms, 2) increased volatility of the U.S. exchange rate, and 3) increased competition among grain exporting countries, especially increased export performance by Australia and Canada in the Asian markets.

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[1] South Korea, the Philippines, and Taiwan have been loyal to U.S. wheat, with some variations. However, in recent years, this loyalty has been deteriorating in the Philippines. Malaysia and Indonesia (Thailand and Hong Kong) increased their imports from the United States during the period from 1973 through the early 1980s (through the late 1980s), but they have decreased imports from the United States since the mid-1980s (the early 1990s). Especially in Indonesia and Hong Kong, the United States has been losing its market share by a large percentage. China and Singapore have been disturbing the market share of U.S. wheat with large variations. On the other hand, U.S. market share of wheat in Japan has been stable at around 50%.

According to the theory of purchasing power parity (PPP), the real exchange rate is not expected to deviate from a constant equilibrium value. However, many studies have indicated that real exchange rate movement under the floating system differs from what the theory suggests (e.g., Dornbusch; Krugman; McKinnon; Mundell). Empirical studies show that real exchange rates revert to equilibrium values over the long run, and, correspondingly, nominal exchange rates and relative prices converge (e.g., Frankel and Rose; Lothian and Taylor; MacDonald; Taylor and Sarno). This revives the notion that PPP is a long-run equilibrium condition of nominal exchange rate. However, the studies also suggest that the speed of convergence to PPP is slow (Rogoff) and the size of the deviation is substantial (Baldwin and Krugman; Baldwin and Lyons; Dornbusch; Frankel; Krugman). Papell (1997, 2002) confirms that the U.S. dollar has relatively slow speed of convergence, so the deviation should be treated as a substantial phenomenon. The appreciation of the U.S. dollar has been observed during the 1980s and recent several years.[2] The U.S. dollar has appreciated even more than the currencies of its competitors, making U.S. grain exports less competitive in world markets.[3] This appreciation may have allowed the Asian importers to switch their imports of wheat from the United States to other exporting countries.

Wheat is traded in U.S. dollars between the Asian importing countries and the United States, implying that the importers may be concerned with large changes in exchange rates. A number of studies of international trade have suggested that uncertainty in exchange rates has a detrimental effect on the volume of trade (e.g., Bahmani-Oskooee and Ltaifa; Chowdhury; Kenen and Rodrik; Pick; Pozo). This suggests that volatility of the U.S. dollar values against the Asian countries' currencies may have influenced the decision making by the Asian importers. Remarkable export performance by foreign competitors would also affect U.S. market shares because increased exports by the competitors might be at the expense of U.S. wheat.

The objective of this study is to test whether these three factors had significant effects on the declined market shares of U.S. wheat in the Asian markets. To analyze the impact of competition among the exporting countries, a third-country effect model, similar to that of Cushman (1986), was developed.[4] Considering the third-country effect might help reduce specification errors that arise from the fact that wheat import decisions by the Asian traders depend on the costs of purchasing grain not only from an exporting country but also from its competitors. In the empirical model, the dependent variable is the market shares of U.S. wheat in the Asian markets. Using the methods of previous studies that investigated the influence of exchange risk on trade (e.g., Cushman 1983; Kenen and Rodrik; Pick; Pozo)[5], explanatory variables include wheat

[2] The U.S. real agricultural trade-weighted exchange rate appreciated by 25% between 1995 and 2000, and the U.S. dollar appreciated by 42% relative to the currencies of its trade competitors during the same period.

[3] According to the USDA-ERS, the United States lost 10.5% of its wheat market share between 1992 and 1998 in foreign markets. Historically, movements in exchange rates have accounted for approximately 25% of the change in U.S. agricultural exports.

[4] His study analyzed the effect of exchange rate risk on international trade. A major difference in his approach from previous studies is that his model included variables regarding other competitive exporting countries. His argument for including those third-country variables was that importers might switch from an exporting country, say country A, to another competing exporting country, say country B, if they found that import from country A is more expensive or risky than that from country B. Omitting third-country effects could cause a bias for the measurement of the effects of country A's variables, and third-country variables are of interest for their own sake as well. Our model is basically similar to Cushman's but differs on the following two aspects: first, the dependent variable in our study is U.S. wheat market share rather than quantity exported, so importing countries in our model maximize unit profit on purchasing wheat from competitive exporting countries; second, our model is expanded to allow multiple competitors.

[5] Cushman (1983) used real exchange rate and a measure of exchange rate volatility in a frame. The dependent variable was real exports, and explanatory variables included income, costs, real exchange rate, and an exchange risk measure. Kenen and Rodrik used

prices of major exporting countries—the United States, Australia, and Canada—to the markets, exchange rates between the 10 Asian importing and three exporting countries (panel data for U.S., Canadian, and Australian dollars, respectively, against the currencies of 10 Asian countries), and volatilities of the exchange rates.

Four different methods of measuring exchange rate volatility are used to see the sensitivity of empirical results to different measurements because there is a class of different volatility measures, and empirical results might differ by each volatility measure. Two historical measures of volatility (the prediction error from the AR(1) equation and the moving sample standard deviation of changes) and two conditional measures of volatility [AR(1) − ARCH(1) and ARMA(1,1) − GARCH(1,1)] are used for the comparison of different implications between *ex post* and *ex ante* volatility. Our analysis focuses exclusively on the floating-rate period, running from 1973 through 2000. Excluding the pegged-rate period precludes the possibility of specification bias stemming from the change in the exchange-rate regime. In the estimation procedure, a panel unit-root test, developed by Maddala and Wu, was performed to determine whether the panel data were nonstationary and whether there was a cointegration relationship caused by interactions of nonstationary variables. Most studies have ignored this step in order to simplify empirical procedures.

The results of the panel unit-root test indicate that the panel of market shares is stationary and that the panel of exchange rates and the time series of wheat prices are stationary with a time trend, i.e., they are trend stationary. Thus, we included a time variable to capture the trend, which might reduce any errors from the existence of time trends in the estimation. The empirical results of the panel estimation show that the U.S. currency value and volatility are important factors affecting market shares of U.S. wheat in the Asian countries. Among the third-country effect variables, Australian wheat price and the volatility of Canadian and Australian currency values in the Asian markets have significant effects on the market shares.

The remainder of the article is organized as follows. A theoretical model is specified in the second section. Data used in the study are detailed in the third section. The fourth section presents a description of Maddala and Wu panel unit-root test and results from the test. The fifth section displays the procedure for the empirical analysis, and the sixth section shows empirical results. A summary and conclusion follows in the last section.

Theoretical Model

A Third-Country Effect Model

Suppose that an international firm in an Asian importing country, M, purchases wheat from two different exporting countries, A and B. Let X_t be the amount of wheat purchased from country A at time t and Y_t from country B at time t. Without any risk management tools used,[6] such as offshore futures hedging or options hedging, the profits of the firm in engaging offshore trade at time t can be written as follows:

$$(1)\quad \Pi_t = -c_{xt}\cdot X_t - c_{yt}\cdot Y_t,$$

the import-weighted real exchange rate and volatility in the same regression. In their study, the volume of manufactured imports was a function of real exchange rate, exchange volatility, an index of industrial production, and a time trend term. Pick used exchange rate and a measure of exchange rate volatility in an estimation, in which the real export value is a function of the importer's real income, the importer's real unit production cost, the exporters' real unit production cost, exchange rate, and volatility. Pozo also used real exchange rate and volatility in a frame. The volume of export is a function of gross national product, real exchange rate, and a measure of exchange rate volatility. Our model is simpler than those used by Cushman and by Hooper and Kohlhagen in terms of variables.

[6] It is assumed for simplicity that risk management tools for dealing with risks in international trade, such as long-term forward contracts, hedging in commodity and financial futures markets, or options markets, are not used by the importers in the 10 Asian countries. However, if one includes one of such risk management tools, then the importers can reduce and manage exposure to risk. This may affect the market shares of an exporting country in the markets.

where c_{xt} is the unit cost of purchasing wheat from country A at time t and c_{yt} is the unit cost of purchasing wheat from country B at time t. The unit costs, c_x and c_y, are stochastic random variables. If we divide both sides by the total import, Z_t, which is the sum of X_t and Y_t, then Equation (1) is rewritten as follows:

$$(2) \qquad \pi_t = -c_{xt} \cdot x_t - c_{yt} \cdot y_t,$$

where π_t is the unit profit at time t and x_t and y_t are the market shares of exporting countries A and B, respectively, at time t.

The objective of the trader is changed to maximize unit profit. Writing the maximization problem on the mean-variance utility framework produces

$$(3) \qquad U_t = E_{t-1}(\pi_t) - \frac{\gamma}{2} V_{t-1}(\pi_t),$$

where E_{t-1} is the mathematical expectation operator at time $t - 1$ for period t, V_{t-1} is the volatility of $(\cdot)$ and the one-period-forward estimated volatility of the unit profit, and γ is the coefficient of risk aversion, which is assumed to be positive under risk aversion and fixed at a specific level. It is assumed that the utility function of the representative grain importer is continuous, monotonic increasing, and strictly concave. The objective of the firm is now to maximize unit profit and at the same time to minimize the risk associated with the profit.

Substituting Equation (2) into the mean-variance utility, Equation (3), yields the following objective function:

$$(4) \qquad \begin{aligned} U_t \equiv & -E_{t-1}(c_{xt})x_t - E_{t-1}(c_{yt})y_t \\ & - \frac{\gamma}{2}[x_t^2 V_{t-1}(c_{xt}) + y_t^2 V_{t-1}(c_{yt}) \\ & + 2x_t y_t \mathrm{Cov}_{t-1}(c_{xt}, c_{yt})], \end{aligned}$$

where $\mathrm{Cov}_{t-1}(\cdot)$ denotes the covariance of variables in parenthesis. Maximizing the objective function in Equation (4) with respect to the market shares, x and y, produces the first-order conditions

$$(5a) \qquad \begin{aligned} & -E_{t-1}(c_{xt}) - \gamma x_t V_{t-1}(c_{xt}) \\ & - \gamma y_t \mathrm{Cov}_{t-1}(c_{xt}, c_{yt}) = 0, \end{aligned}$$

$$(5b) \qquad \begin{aligned} & -E_{t-1}(c_{yt}) - \gamma y_t V_{t-1}(c_{yt}) \\ & - \gamma x_t \mathrm{Cov}_{t-1}(c_{xt}, c_{yt}) = 0. \end{aligned}$$

The second-order condition is satisfied by the assumption of strict concavity of the utility function $U(\cdot)$. Hereafter, for simplicity, let us drop the subscript t. Solving the first-order conditions with respect to x and y yields demand functions for market shares as follows:

$$(6a) \qquad x = \frac{\mathrm{Cov}(c_x, c_y)E(c_y) - E(c_x)V(c_y)}{\gamma D},$$

$$(6b) \qquad y = \frac{\mathrm{Cov}(c_x, c_y)E(c_x) - E(c_y)V(c_x)}{\gamma D},$$

where $D \equiv V(c_x)V(c_y) - \mathrm{Cov}(c_x, c_y)^2$. $D > 0$ unless the correlation between c_x and c_y reaches ± 1, which would correspond to corner solutions.[7] From Equations (6a) and (6b), the effects of own-cost and cross-cost changes on the market share of country A, x, can now be derived. The effects of expected own-cost, $E(c_x)$, and the volatility of the cost, $V(c_x)$, on its market share x are

$$(7) \qquad \frac{\partial x}{\partial E(c_x)} = \frac{-V(c_y)}{\gamma D} < 0,$$

$$(8) \qquad \frac{\partial x}{\partial V(c_x)} = \frac{-xV(c_y)}{D} < 0.$$

These equations suggest that if country A's cost and volatility of the cost increase, the importer decreases purchases of country A's wheat.

The effects of the expected cross-cost, $E(c_y)$, and volatility of the cost, $V(c_y)$, on country A's market share x are

[7] Using the statistical relationship between covariance and correlation, the sign of $V(c_x)V(c_y) - \mathrm{Cov}(c_x, c_y)^2$ can be defined. The covariance between c_x and c_y is expressed as follows: $\mathrm{Cov}(c_x, c_y) = \rho_{cx,cy}\sqrt{V_t(c_x}\sqrt{V_t(c_y}$. The following relation holds unless $\rho_{cx,cy} = \pm 1$. $V(c_x)V(c_y) - \mathrm{Cov}(c_x, c_y)^2 = [\mathrm{Cov}(c_x, c_y)^2]/\rho_{cx,cy}^2 - \mathrm{Cov}(c_x, c_y)^2 > 0$.

$$(9)\quad \frac{\partial x}{\partial E(c_y)} = \frac{\mathrm{Cov}(c_x, c_y)}{\gamma D} \lesseqgtr 0,$$

$$(10)\quad \frac{\partial x}{\partial V(c_y)} = \frac{y\,\mathrm{Cov}(c_x, c_y)}{D} \lesseqgtr 0.$$

These equations represent the third-country effects. The signs of Equations (9) and (10) depend on the sign of the covariance between the two countries' costs, $\mathrm{Cov}(c_x, c_y)$. The sign of the correlation between the costs is treated as positive in the literature (e.g., Cushman 1986). Thus, because D is defined to be greater than zero, the signs of Equations (9) and (10) are expected to be positive. This implies that if country B's cost or volatility of the cost rises, the importer reduces import from country B, and the market share of country A's wheat in the importing country M increases.

The effect of the covariance between the two countries' costs on the market share x is

$$(11)\quad \frac{\partial x}{\partial\,\mathrm{Cov}(c_x, c_y)} = \frac{x\,\mathrm{Cov}(c_x, c_y) - yV(c_y)}{D} \lesseqgtr 0.$$

The sign of Equation (11) remains obscure. If $\mathrm{Cov}(c_x, c_y)$ is positive, the sign depends on the sizes of $x\,\mathrm{Cov}(c_x, c_y)$ and $yV(c_y)$. If $x\,\mathrm{Cov}(c_x, c_y) > yV(c_y)$, the effect of the covariance on the market share x would be positive. Otherwise, the effect would be negative or zero.

U.S. Market Shares with Multiple Competitors

The countries exporting wheat to Asia are the United States, Australia, and Canada. According to the *World Agricultural Trade Flows* by USDA-ERS, the market shares of the three exporting countries range from 86% to 96% in the East and Southeast Asian countries for 1973–2000. With multiple competitors, the objective function of Equation (4) needs to be expanded to derive the equation for U.S. market shares as follows:

$$\begin{aligned}(12)\quad U \equiv\ & -E(c_x)x - E(c_y)y - E(c_w)w \\ & - \frac{\gamma}{2}[x^2V(c_x) + y^2V(c_y) + w^2V(c_w) \\ & + 2xy\,\mathrm{Cov}(c_x, c_y) \\ & + 2xw\,\mathrm{Cov}(c_x, c_w) \\ & + 2yw\,\mathrm{Cov}(c_y, c_w)],\end{aligned}$$

where c_w is the exporting cost of another exporting country W, w is the market share of country W, and other variables are previously defined. Maximizing the objective function with respect to the market shares, x, y, and w, yields the demand functions for x as follows:

$$\begin{aligned}(13)\quad x = & -\{\mathrm{Cov}(c_y, c_w)^2E(c_x) \\ & - \mathrm{Cov}(c_x, c_w)\mathrm{Cov}(c_y, c_w)E(c_y) \\ & - \mathrm{Cov}(c_x, c_y)\mathrm{Cov}(c_y, c_w)E(c_w) \\ & + \mathrm{Cov}(c_x, c_w)E(c_w)V(c_y) \\ & + \mathrm{Cov}(c_x, c_y)E(c_y)V(c_w) \\ & - E(c_x)V(c_y)V(c_w)\} \\ & \div \{\gamma[\mathrm{Cov}(c_x, c_y)^2V(c_w) \\ & \quad + \mathrm{Cov}(c_x, c_w)^2V(c_y) \\ & \quad + \mathrm{Cov}(c_y, c_w)^2V(c_x) \\ & \quad - 2\,\mathrm{Cov}(c_x, c_y)\mathrm{Cov}(c_y, c_w) \\ & \quad \times \mathrm{Cov}(c_x, c_w) \\ & \quad - V(c_x)V(c_y)V(c_w)]\}.\end{aligned}$$

The demand functions for y and w have the same variables. The function in Equation (13) shows that the costs of all three exporting countries and variance-covariance of the costs are at play in determining the market share x. Because wheat is traded in the exporters' currencies, the international firm faces two cost components: wheat prices and exchange rates.

From the demand function in Equation (13), we specified an empirical model, similar to the standard long-run relationship model found in Asseery and Peel, Cushman (1983), Kenen and Rodrik, and Chowdhury. Explanatory variables were chosen on the basis of previous studies that have investigated the influence of exchange risk on trade (e.g., Cushman 1983; Kenen and Rodrik; Pick; Pozo). In the empirical equation, the dependent variable is the market shares of U.S. wheat in the Asian countries. The explanatory variables are wheat prices of the United States, Australia, and Canada and exchange rates and exchange-rate risks between the 10 Asian importing and the three wheat exporting countries. The equation is expressed as follows:

$$
\begin{aligned}
(14)\quad \ln x_{it} = {} & \alpha_0 + \alpha_1 \ln P_{ut} + \alpha_2 \ln P_{ct} + \alpha_3 \ln P_{at} \\
& + \alpha_4 \ln R_{uit} + \alpha_5 \ln R_{cit} + \alpha_6 \ln R_{ait} \\
& + \alpha_7 \ln V(R_u)_{it} + \alpha_8 \ln V(R_c)_{it} \\
& + \alpha_9 \ln V(R_a)_{it} + \alpha_{10} \ln \mathrm{Cov}(R_u, R_c)_{it} \\
& + \alpha_{11} \ln \mathrm{Cov}(R_u, R_a)_{it} + e_{it},
\end{aligned}
$$

where ln denotes the natural logarithm of the variables; x denotes the market shares of U.S. wheat in the 10 Asian countries; P_u, P_c, and P_a denote wheat prices of the United States, Canada, and Australia, respectively; R_u, R_c, and R_a represent U.S., Canadian, and Australian dollar values, respectively, in the Asian markets; and e is an error term. Price variables are time variant but cross-sectional invariant. All other variables are both time and cross-sectional variant. The variable i denotes cross-sectional changes for the 10 Asian importing countries. t represents time changes from 1973–1974 to 1999–2000 by fiscal year.

An increase in the U.S. export price would reduce the import demand for U.S. wheat, thus reducing U.S. market share, whereas competitors' increased export prices would encourage more imports from the United States. If the U.S. dollar value rises, holding Australian and Canadian dollar values constant, then the import price of U.S. wheat increases, resulting in comparatively lower import prices of competitors' wheat. The countries, then, would import more from Canada or Australia and reduce imports from the United States. On the other hand, if Australian and/or Canadian dollar values rise, holding the U.S. dollar value constant, then the countries would increase imports of U.S. wheat while decreasing imports of Australian and/or Canadian wheat.

Inquiries into the effect of exchange-rate volatility on the volume of international trade have been numerous, and much has been written on both the theoretical and empirical sides of this question (c.f., Asseery and Peel; Bahmani-Oskooee and Ltaifa; Chowdhury; Cushman 1988; De Grauwe; Hooper and Kohlhagen; Kenen and Rodrik; Langley et al.; Pick; Pozo). Up to this point, there has been no real consensus about the effect of exchange risk on trade volume. The results from the theoretical and empirical studies are mixed. However, an overall review of the empirical literature seems to support the hypothesis that exchange risk depresses international trade. Therefore, expected signs of the coefficients are negative for the U.S. dollar risk measure and positive for the competitors' dollar risk measures. According to Equation (13), wheat importers are concerned about covariances between exchange rates, $\mathrm{Cov}(R_u, R_c)$, $\mathrm{Cov}(R_u, R_a)$, and $\mathrm{Cov}(R_a, R_c)$, in addition to exchange rate volatility, $V(R_u)$, $V(R_c)$, and $V(R_a)$. Therefore, the variables for the covariances are also included in Equation (14). However, the covariance between R_a and R_c, $\mathrm{Cov}(R_a, R_c)$, is not included in the empirical equation, because the covariance is not independent from other variables, i.e., the covariance, is a redundant variable.[8]

According to Equation (8), if the volatility of the U.S. dollar value increases, the Asian countries decrease imports of U.S. wheat to reduce the risk. The effect of the volatility of the Australian (Canadian) dollar value on the U.S. market shares is inconclusive, according to Equation (10), and it depends on the sign of the covariance between U.S. and Australian (Canadian) dollar values in the Asian markets. The effects of covariance variables also remain obscure and depends on the sizes of the covariance and variance of exchange rates.

If the dependent variable is the quantity imported, then importing countries' income levels should be included in the model as an independent variable. However, because the dependent variable is market share, an income

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[8] In the preliminary review of our data, the following relationship was found: $E(R_u, R_c)E(R_u, R_a) = E(R_u^2)E(R_c, R_a)$. The covariance between R_c and R_a is expressed by the relationship: $\mathrm{Cov}(R_c, R_a) = E(R_c, R_a) - E(R_c)E(R_a)$. If we substitute these two relationships into the equation for covariance between R_c and R_a, the following equation is obtained. $\mathrm{Cov}(R_c, R_a) = \{E[R_u]E[R_a]\mathrm{Cov}(R_u, R_c) + E[R_u]E[R_c]\mathrm{Cov}(R_u, R_a) + \mathrm{Cov}(R_u, R_c)\mathrm{Cov}(\mathrm{R}_u, R_a) - E[R_c]E[R_a]V(R_u)\}/[V(R_u) + E(R_u)^2]$. The equation shows that $\mathrm{Cov}(R_c, R_a)$ is not independent from other variables, suggesting that the variable is redundant.

variable is not included in Equation (14), under the assumption that changes in income level in an importing country will not affect the market share of an exporting country unless consumers' preferences for wheat in the importing countries significantly change toward an exporting country's wheat over other competitive countries' wheat as their income levels change. Note that we implicitly assume that quality of wheat from three different exporting countries is homogeneous.

The variables of destination-specific transportation costs are not included in Equation (14). In most cases, the importers negotiate the freights via shipping brokers before they select an exporter to purchase a specific amount of wheat, and the exporters try to account for differences between the transportation cost for their route and those for competitors' routes, to increase their competitiveness.[9] So, it is implicitly assumed that differences between transportation costs are absorbed in the wheat prices, indicating that transportation costs are already accounted for. Therefore, one may not need to include transportation cost as an independent variable. However, an error can occur if the assumptions are not correct for some Asian importers. If the true coefficients of the variables of transportation costs are not zero, this may cause a bias from omitting relevant variables. The direction and size of the bias depend on the signs and values of real coefficients of omitted variables and signs and values of covariances between the included explanatory variables and omitted variables.

Table 1. The Average and Standard Deviation of Wheat Imports by the 10 Asian Countries

	Total Wheat Imports		Imports of U.S. Wheat	
Country	Average	Std. Dev.	Average	Std. Dev.
China	8,008	4,781	2,686	2,531
Hong Kong	337	181	90	42
Indonesia	2,102	1,085	402	293
Japan	5,756	291	3,209	200
Malaysia	783	350	64	37
Philippines	1,359	727	1,117	537
Singapore	281	91	40	19
South Korea	3,000	1,159	1,690	229
Taiwan	815	169	731	160
Thailand	380	273	165	93

Notes: The wheat imports are denoted by quantity (1,000 metric tons). Data were run from 1973/1974 through 1999/2000 by fiscal year. For the reason of space, other statistics, such as maximum or minimum, are not presented in the table.

Data

The data in this study consist of the market shares of U.S. wheat in the 10 Asian importing countries (China, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand), aggregate wheat export prices of three exporting countries (the United States, Canada, and Australia), and real exchange rates between the 10 Asian importing and three wheat exporting countries. The data are annual and range from 1973–1974 to 1999–2000 by fiscal year.

The data for total wheat imports and imports from the United States by the Asian countries are obtained from the *Foreign Agricultural Trade of the United States,* by the Foreign Agricultural Service of the USDA. The average and standard deviation of the total imports and imports of U.S. wheat are presented in Table 1. Real exchange rate data are obtained from the *Agricultural Exchange Rate*

[9] For some Asian countries, such as Hong Kong, Japan, South Korea, and Taiwan, it is not popular for exporters to sell wheat on a cost and freight basis because of generic problems in the destination ports, such as unloading delay or unstable labor costs. The foreign exporters usually do not handle the matters well. Unloading is a considerable portion in the total transportation cost. The importers negotiate the freights with the shipping brokers. Freight is settled between an agreed charterer and an agreed owner via a shipping broker. There is no open market like a board of trade but the interested parties create the market of the freight among the professionals. The importers usually have an offer of the freight rates from shipping brokers before they select an exporter to purchase a specific amount of wheat, and they can fix the freight rate to a level with an owner. The importers and exporters consider a number of related variables including the offered freight rate in negotiating wheat prices. To increase competitiveness, exporters usually try to capture the difference between transportation cost for their route and those for competitors' routes.

Table 2. The Average and Standard Deviation of U.S., Australian, and Canadian Dollar Values in the Asian Markets

	vs. United States		vs. Australia		vs. Canada	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
China	5.9	2.2	4.4	1.4	4.7	1.7
Hong Kong	9.2	2.4	7.0	1.6	7.4	2.0
Indonesia	2,038.7	1,056.6	1,492.9	618.8	1,594.9	687.4
Japan	144.8	32.8	112.6	34.8	118.4	34.0
Malaysia	903.0	120.0	686.8	79.4	727.2	88.5
Philippines	2.5	0.5	1.8	0.3	2.0	0.3
Singapore	28.0	3.9	21.3	2.4	22.6	3.6
South Korea	1.7	0.2	1.3	0.1	1.3	0.2
Taiwan	31.9	4.0	24.6	4.6	25.9	4.3
Thailand	26.1	4.0	19.8	1.7	21.0	2.4

Notes: Std. Dev. denotes the sample standard deviation of each series. The exchange rates are average annual real rates. Data were run from 1973/1974 through 1999/2000 by fiscal year. For the reason of space, other statistics, such as maximum or minimum, are not presented in the table.

Data Set by the USDA-ERS. There are three panel data variables of real exchange rate with respect to each exporting country's currency: exchange rates between the Asian importing countries' currencies and the U.S. dollar (R_u), those between the Asian importing countries' currencies and Australia's (R_a), and those between the Asian importing countries' currencies and Canada's (R_c). Therefore, each exchange rate panel data has 10 time series. The average and standard deviation of each exchange rate series (total 30 time series) are displayed in Table 2.

The wheat export price data were provided by the *World Grain Statistics*, published by the International Grains Council. The wheat prices for the United States, Canada, and Australia are freight-on-board measures, and they are expressed in U.S., Canadian, and Australian dollars, respectively, per ton. For U.S. wheat, No. 2 Dark Northern Spring 14%, No. 2 Hard Red Winter Ordinary, and No. 2 Soft Red Winter in Gulf ports and No. 2 DNS 14%, No. 2 Western White, and No. 2 Hard Winter 13% in Pacific ports were selected. For Australian wheat, Prime Hard and Australian Standard White were selected and, for Canadian wheat, Canada Western Red Spring (CWRS) 13.5% in St. Lawrence ports and CWRS 12.5% in Pacific ports are selected. From the 10 price series, the average export prices of U.S., Australian, and Canadian wheat are calculated.[10] The mean (standard deviation) of the wheat prices are 154.67 (19.09), 224.68 (37.41), and 231.85 (35.09), respectively, for the United States, Australia, and Canada.

Maddala-Wu Fisher Test for Panel Unit Root

Cross-sectional time series data can be characterized by the unit-root process as much as univariate time series data. The presence of a unit-root process makes the panel data nonstationary, which may lead to serious errors in inferences. After the pioneering work of Levin and Lin, the panel unit-root test has been applied in empirical studies. The panel unit-root test helps to increase the power of the unit-root test, compared with the univariate unit-root test, such as Augmented Dickey-Fuller (ADF) and Phillips-Perron, in panel data analyses (e.g., Frankel and Rose; Maddala and Wu; Wu).

Using the additive property of χ^2 distribution, Fisher suggested a test that uses the sum of N independent tests for a null hypothesis, in which $-2\cdot\Sigma_i \log_e \alpha_i$ has χ^2 distribution with $2N$ degrees of freedom. Maddala and Wu de-

[10] It is implicitly assumed that wheat from the three competing countries are substitutable for the importers.

Table 3. Results of Panel and Univariate Unit-Root Test

Test	Variables	Drift	Trend
MWF Test	Market Shares of U.S. Wheat in 10 Asian Countries	31.990** (0.043)[b]	59.947** (0.000)
	Exchange Rate between the United States and 10 Asian Countries	22.842 (0.297)	51.971** (0.000)
	Exchange Rate between Canada and 10 Asian Countries	17.881 (0.595)	43.984** (0.002)
	Exchange Rate between Australia and 10 Asian Countries	12.976 (0.878)	37.719** (0.010)
ADF Test[a]	U.S. Wheat Export Price	−3.7530** (0.009)	−3.6651** (0.048)
	Canada Wheat Export Price	−2.2561 (0.234)	−2.7594* (0.086)
	Australia Wheat Export Price	−1.2214 (0.258)	−3.2241* (0.074)

[a] Because the price variables are univariate, the ADF test was performed instead of the MWF test.
[b] The values in parentheses represent p values.
Notes: * and ** denote rejection of the null hypothesis of unit root at the 10% and 5% significance level, respectively.

veloped the Maddala-Wu Fisher (hereafter, MWF) test for panel unit root on the basis of Fisher's method. The methodology is based on the significance of the results from N-independent tests of the unit-root hypothesis. On the assumption of continuous test statistics, the significance levels, α_i, are independent uniform variables, $\alpha_i \in (0, 1)$, where $i = 1, 2, \ldots, N$. The random variable, $2 \cdot \log_e \alpha_i$, has χ^2 distribution with 2 degrees of freedom. The MWF method has advantages in that it also works for an unbalanced panel data, it fits with any univariate unit-root test derived, and it allows specification of different lag lengths in the individual unit-root regression.

This study adopts the method, and the MWF test was performed for the market share and exchange rate data. The procedure of the MWF is as follows: first, a univariate unit-root test, here ADF(p), was applied for each individual time series of the panel data; second, using the Dickey-Fuller t distributions, asymptotic p values were generated by 20,000 simulations for the corresponding ADF t-test statistics; and lastly, the test statistic, $-2 \cdot \Sigma_i \log_e \alpha_i$, was calculated. Test results are presented in Table 3. When applying the drift model, the null of the unit root was rejected for the market share panel data but not for exchange rate data at the 5% significance level; when applying the trend model, the null hypothesis was rejected for all series at the 5% level. For the wheat price series, the ADF test was performed because the series are univariate. Under the drift model, the null of the unit root was rejected for only U.S. wheat price series at the 5% level; whereas, under the trend model, the null was rejected for all the price series at the conventional significance levels. The results from the MWF and ADF tests suggest that observations do not follow a random walk with drift, but they are stationary with a linear trend. Therefore, a linear time trend is included in the empirical regression to reduce any erroneous inference due to the existence of time trends in the panel variables.

Panel Estimation Procedure

The real exchange rate data, R_u, R_a, and R_c, are normalized to make each series in the panel data equivalent in magnitude. For example, to normalize R_u, the sample average was calculated for each time series and the series are divided by the corresponding sample average and multiplied by 100.[11] From the normalized

[11] There are 10 time series in each panel data of real exchange rates. For example, in the R_{uit}, where $i = 1, \ldots, 10$ and $t = 1, \ldots, 28$, each time series has different magnitude so one needs to normalize to make each time series equivalent in magnitude. Let $\bar{R}_{ui}$ be the sample average for the ith series, calculated as $\bar{R}_{ui} = \Sigma_{t=1}^{28}/t$, where T is the total number of observations in the time series. To produce a normalized series, each observation is divided by the sample average and multiplied by 100 as follows: $100 \cdot (R_{uit}/\delta R_{ui})$.

series, the variances and covariances of the exchange rates were calculated using four different types of volatility measures.

Two historical volatility measures and two conditional volatility measures are used for the comparison of different implications between *ex post* and *ex ante* volatility in the model. The first measure is the prediction error, $\{\varepsilon_t\}$, computed from the first-order autoregressive equation, AR(1), as follows:

$$(15)\quad R_t = \alpha + \beta R_{t-1} + \varepsilon_t,$$

where R_t is the normalized real exchange rate at time t. The first measure is denoted by $V(1)$. Residual series were derived from univariate AR(1) for each time series for the normalized real exchange rate data set. Last, a variance-covariance matrix was calculated from the residual series.[12]

The second measure of volatility is the moving sample standard deviation of changes in the normalized real exchange rates and is denoted by $V(2)$. This measure has been used extensively in the literature (e.g., Chowdhury; Koray and Lastrapes), and it is calculated as follows:

$$(16)\quad V_t = \sqrt{k^{-1}\sum_{i=1}^{k}(R_{t+i-1} - R_{t+i-2})^2},$$

where V_t is the volatility and k is the order of moving average. In this study, k is specified to be one.

The third measure is an autoregressive conditional heteroskedasticity (ARCH) process (Engle) and is denoted by $V(3)$. The stochastic error is obtained from an AR(1) conditional mean equation, and the lag p in the ARCH model is specified to be one, resulting in an AR(1) − ARCH(1) process as follows:

$$(17)\quad \text{AR(1)}: \quad R_t = \delta + \phi R_{t-1} + \upsilon_t,$$
$$\text{ARCH(1)}: \quad V_t = \omega + \eta\upsilon_{t-1}^2 + \xi_t,$$

where ν_t and ξ_t are stochastic error terms; the two error terms are independent; and δ, ϕ, ω, and η are unknown parameters. In the ARCH model, the conditional variance is specified to depend on the past values of the variance itself.

The fourth measure is the generalized ARCH (GARCH) process (Bollerslev) and is denoted by $V(4)$. The stochastic error is obtained from an autoregressive moving-average [ARMA(1, 1)] equation, and the lags p and q in the GARCH model are specified to be one, respectively, resulting in an ARMA(1,1) − GARCH(1,1) process as follows:

$$(18)\quad \text{ARMA(1, 1)}: \quad R_t = a + bR_{t-1} + \theta\upsilon_{t-1} + \gamma_t,$$
$$\text{GARCH(1, 1)}: \quad V_t = \vartheta + \alpha\gamma_{t-1}^2 + \beta V_{t-1} + \zeta_t,$$

where γ_t and ζ_t are stochastic error terms; the two error terms are independent; and a, b, θ, ϑ, α, and β are unknown parameters. It appears that the GARCH model with a small number of terms performs as well as or better than an ARCH model with many terms (Hsieh; McCurdy and Morgan). In this specification, market participants infer today's variance on the basis of last period's forecast variance and last period's news about volatility.

The empirical estimation of Equation (14) was performed using a two-way panel model. To account for any country-specific effects and time-specific effects that cannot be captured by the explanatory variables in the model, both group and time effects are included. The inclusion of both effects is based on a Lagrange multiplier (LM) test devised by Breusch and Pagan. In the LM test, the null hypothesis states that there are no group and time effects in the following error component model:

$$(19)\quad \ln x_{it} = \mathbf{z}'_{it}\boldsymbol{\beta} + e_{it}, \qquad i = 1, \ldots, N; \quad t = 1, \ldots, T,$$
$$e_{it} = \phi_i + \omega_t + \varepsilon_{it},$$

where $\mathbf{z}'$ is the matrix of explanatory variables

[12] The Akaike information criterion (AIC) was used to ensure that AR(1) is an appropriate lag. For most exchange rate series, the AIC statistic of AR(1) was the smallest, compared with those of higher orders of AR equations.

and the subscript it denotes an observation for the ith cross-sectional unit and the tth time point. $\boldsymbol{\beta}$ is the vector of unknown parameters. The error term, e_{it}, is decomposed into three components: ϕ_i is a time-invariant cross-section effect, ω_t is a cross-sectionally invariant time effect, and ε_{it} is a residual effect unaffected by the explanatory variables and both time and cross-sectional effects. The Breusch and Pagan LM test was constructed, and the null hypothesis of no group and time effects was rejected at the 5% level. Therefore, inclusion of the two effects is appropriate in the estimation specification, and it helps reduce bias and inconsistency problems caused by omitting relevant variables.

In the time processes of wheat trade between the United States and importing countries, a big shock may not die out promptly, and the shock could have possible lag effects, implying that the first few serial correlations could be substantial and statistically significant. To account for the lag effects, a variance-component moving average (MA) model[13] was used in which the residual effect, ε_{it}, in Equation (19) was specified as a finite MA time process of order $m < T - 1$ for each cross-section i. It is expressed as follows:

$$(20) \quad \varepsilon_{it} = a_0\theta_t + a_1\theta_{t-1} + \cdots + a_m\theta_{t-m},$$

where $\boldsymbol{a}$ is the vector of unknown constant parameters and θ_t is a white noise process. In the variance-component MA model, the three random terms, ϕ_i, ω_t, and θ_{t-k}, have normal distributions: $\phi_i \sim N(0, \sigma_\phi^2)$, $\omega_t \sim N(0, \sigma_\omega^2)$, and $\theta_{t-k} \sim N(0, \sigma_\theta^2)$, for $i = 1, \ldots, N$; $t = 1, \ldots, T$; $k = 1, \ldots, m$.

The estimator of $\boldsymbol{\beta}$ is a two-step Generalized Least Squares (GLS)-type estimator, i.e., GLS with the unknown covariance matrix replaced by an estimator of the covariance matrix. In the model, the group and time effects are treated as random on the basis of a Hausman m-statistic that is estimated using the method of Hausman and Greene (pp. 632–35). The result of the Hausman test shows that the null hypothesis of no correlation between the effect variables and the regressors was not rejected at the 5% significance level. This suggests that the random-effects model is more appropriate than the fixed model. The third-country effect import model performs best when m is specified to be 5, judged by a generalized R-square.[14]

Empirical Results

Before presenting and interpreting the empirical results, it is worthwhile to mention a possible multicollinearity problem that might arise from comovements of price or exchange rate variables of the three exporting countries, because there may be a common time trend or a common cycle (caused by a business cycle) in the three different countries' variables, or since the variables of three exporting countries may vary together. Although the estimation procedure does not break down when the independent variables are correlated, severe estimation problems could arise. The estimator in the presence of multicollinearity remains unbiased, and the R^2 statistic is unaffected. The estimator retains its desirable properties. However, the major undesirable consequence of multicollinearity is that the variances of the parameter estimates of the collinear variables are quite large. Therefore, one needs to note that multicollinearity among the explanatory variables may cause the estimation to have less significant coefficients than those under

[13] Specifically, the Da Silva method was used for the variance-component MA process model. We compared the results by this method to those by an autoregressive error component model (Parks) and two-way random-effect error component model (Fuller and Battese). The variance-component moving average model performed best among the three error component models when we considered economic signs and statistical significance of the estimates.

[14] The conventional R^2 measure is inappropriate since a number outside the 0-to-1 range may be produced in the case of GLS estimation. Thus, a generalized R-squared statistics is reported according to Buse.

no multicollinearity.[15] If the t-statistic of a coefficient is in the acceptance area at a conventional significance level but close to the critical point, when interpreting these coefficients individually, special attention should be given since the hypothesis testing is not powerful due to larger variance caused by multicollinearity.

For the purpose of comparing panel estimation results with and without the third country variables, panel estimation of the empirical model, Equation (14), was performed first without third-country variables and then with the variables. Table 4 shows the estimation results without third-country variables. Four models are specified with different measures of exchange rate volatility; each model, M(n), is associated with each volatility measure, V(n), respectively. The specification of each model is the same, except only for the volatility measure. The variable of U.S. wheat price is significant only in model 1 at the 5% level. Positive signs appear in models 2 and

[15] There are several remedy methods for the multicollinearity, as has been suggested in literature. Blanchard and Conlisk support the "do nothing" method. They suggest following "the rule of thumb," which says "Don't worry about multicollinearity if the R^2 from the regression exceeds the R^2 of any independent variable regressed on the other independent variables or if large portion of t-statistics are still significant." Other econometricians (e.g., Silvey) support "adding more data" that would be most useful in resolving the multicollinearity problem. Another frequently suggested method is "omitting one of the collinear variables." However, this method may create a specification error when the true coefficient of the deleted variable in the equation being estimated is not zero, which causes econometricians to face a question whether, by dropping a variable, one can reduce the variances of the remaining estimates by enough to compensate for the bias introduced. Based on the three frequently used methods, the following justifications for our interpretation of the results can be made. 1) We interpreted the results based on the coefficients that have a significant t-statistic. If there is no collinear problem at all, we might have had more coefficients that have a significant t-statistic. 2) Using panel data has been suggested as one of the "adding more" approaches (e.g., Baltagi, p. 4). Because we used cross-sectional time series data, the multicollinearity problem could be somewhat reduced. 3) In this paper, dropping a variable would cause estimations unmatched with the theoretical model derived in the second section and cause an omitted variable problem.

Table 4. Panel Estimation Results without Third Country Variables

Variables	Expected Sign	M(1)[a]	M(2)	M(3)	M(4)
U.S. Wheat Price (P_u)	Negative	−0.2085** (−2.56)	0.0470 (0.11)	0.3671 (0.61)	−0.8863 (−1.43)
U.S. $ Values in the Asian Markets (R_u)	Negative	−1.0980** (−10.93)	−1.0248** (−9.35)	−1.3115** (−2.93)	−7.8145** (−48.16)
Volatility of R_u	Negative	−0.0418** (−58.18)	−0.0410** (−52.25)	−0.0429** (−2.50)	0.0163** (9.31)
Time Trend	Negative	0.0187** (6.74)	0.0064 (0.51)	−0.0063 (−0.36)	−0.0851** (−5.04)
R^2 [b]		0.58	0.49	0.25	0.41
Number of Observations		260	260	260	260

[a] M(n) denotes different model specification, changing the volatility measure V(n).

[b] R^2 is a generalized R^2 statistic because the equations are estimated by GLS.

Notes: Durbin-Watson statistic is not reported because the equations are corrected for autocorrelation by the Da Silva method. The values in the parentheses denote t-statistics.

** Denotes statistical significance at the 5% level.

3, but they are not statistically significant at any conventional significance level. The U.S. exchange rates against the Asian countries' currencies and volatility of the exchange rates are statistically significant at the 5% level, and they have negative signs, as expected in the model specification, except for the exchange rate volatility in model 4, which has a positive sign. Note that the R^2 values of all models are relatively low, suggesting that the U.S. wheat market shares are not explained effectively using only own-effect variables.

To see whether adding the third-country variables makes a significant contribution in explaining the variation of the dependent variable, an F-test was performed with the null hypothesis that the additional set of regressors are not jointly significant. From estimations of restricted (without the third-country effects) and unrestricted (with the third-country effects) equations, R^2 values are derived and corresponding F-statistics are calculated. The calculated F-statistics—6.14 for $V(1)$, 7.37 for $V(2)$, 8.32 for $V(3)$, and 6.48 for $V(4)$—are larger than the 95% critical value, 3.04, indicating a rejection of the null hypothesis. This suggests that the third-country variables are relevant in the model.

Table 5 presents the empirical results with third-country variables. When considering economic sign and statistical significance, model (1) with the first volatility measure $V(1)$—prediction errors computed from the AR(1) mean equation—seems to perform best among the four different equations.[16] The price variables have expected signs. The U.S. wheat price has negative signs, whereas Canadian and Australian wheat prices have positive signs. The Australian wheat price is most significant among the price variables in models 1 and 3, indicating that Australian wheat price affects U.S. market shares more than U.S. and Canadian wheat prices. This implies that one factor for increased Australian market shares in the Asian markets is the price competitiveness of Australian wheat.

The variable of U.S. currency values in the Asian markets has negative signs, whereas those of competitors' currency values have positive signs, except for the Australian currency values in model 2. The U.S. currency value is significant in models 1 and 3, and the Canadian exchange rate is significant in model 3. The results suggest that a strong U.S. dollar has a negative effect on U.S. market shares, whereas competitors' exchange rates were not as important as U.S. dollar values, i.e., third-country exchange rate effects were less significant than own exchange rate effect on the U.S. market shares. An appreciation of the U.S. dollar against importing countries' currencies makes U.S. agricultural commodities more expensive, and the Asian countries reduce their imports from the United States.

The volatility of the U.S. currency values in the markets has a negative effect in models 1 and 2 and a positive effect in models 3 and 4, suggesting that the effect of volatility on the model is sensitive to different volatility measures. This implies that historical and conditional volatility measures have different implications in empirical analysis. The volatilities of Canadian and Australian exchange rates are statistically significant in all models except for model 1. The volatility of the Canadian dollar value has a positive effect in all models, indicating that higher uncertainty in Canadian exchange rates causes an increase in U.S. wheat market share in the Asian countries. The volatility of Australian dollar value has a positive sign in models 1 and 4, but a negative sign in models 2 and 3, and the negative signs are rather puzzling.

Covariance terms are statistically significant in most models. A noticeable result is that signs differ between the cases of historical and conditional volatility measures. Covariance between U.S. and Canadian dollar values in the Asian markets, $\mathrm{Cov}(R_u, R_c)$, has a positive effect in the historical volatility measures, models 1 and 2, and a negative effect in the conditional volatility measures, models 3 and 4. $\mathrm{Cov}(R_u, R_c)$ is statistically significant in all

[16] Theoretically, volatility of the exchange rate should not have different signs in explaining the same dependent variable in a model although one may use different measures of volatility. However, empirical studies have reported different results (e.g., Kenen and Rodrik), which suggests that some measures may be inappropriate in the model.

Table 5. Panel Estimation Results with Third Country Variables

Variables	Expected Sign	M(1)[a]	M(2)	M(3)	M(4)
U.S. Wheat Price (P_u)	Negative	−0.2785 (−0.14)	−0.1557 (−0.08)	−3.3623 (−1.40)	−1.3126 (−0.52)
Canadian Wheat Price (P_c)	Positive	0.2470 (0.14)	0.4382 (0.26)	1.4698 (0.62)	0.7630 (0.33)
Australian Wheat Price (P_a)	Positive	3.8790** (2.10)	2.8013 (1.52)	7.2374** (3.11)	1.9411 (0.81)
U.S. $ Values in the Asian Markets (R_u)	Negative	−4.3986* (−1.72)	−3.2544 (−1.21)	−12.662** (−3.91)	−3.4546 (−1.07)
Canadian $ Values in the Asian Markets (R_c)	Positive	3.2463 (1.30)	2.8506 (1.19)	8.7679** (2.96)	1.0560 (0.37)
Australian $ Values in the Asian Markets (R_u)	Positive	2.4837 (1.19)	−2.3594 (−1.15)	2.0303 (0.80)	1.3058 (0.50)
Volatility of R_u	Negative	−0.0590** (−11.78)	−0.0010 (−0.56)	0.2154** (28.47)	0.1969** (60.89)
Volatility of R_c	Positive	0.0056 (0.86)	0.0242** (9.27)	0.1372** (21.72)	0.0506** (23.80)
Volatility of R_a	Positive	0.0007 (0.12)	−0.0351** (−14.51)	−0.1023** (−16.20)	0.0089** (3.41)
Covariance between R_u and R_c	—	0.0034** (12.01)	0.0001 (0.67)	−0.0105** (−22.53)	−0.0125** (−47.85)
Covariance between R_u and R_a	—	−0.0038** (−12.98)	−0.0006** (−4.32)	0.0001 (0.01)	0.0016** (5.79)
Time Trend	Negative	−0.0495 (−1.42)	−0.0487 (−1.41)	−0.0618 (−1.53)	−0.0388 (−0.91)
R^2		0.87[b]	0.74	0.85	0.71
Number of Observations		260	260	260	260

[a] M(n) denotes different model specification, changing the volatility measure V(n).

[b] R^2 is a generalized R^2 statistic because the equations are estimated by GLS.

Notes: Durbin-Watson statistic is not reported because the equations are corrected for autocorrelation by the Da Silva method. The values in the parentheses denote t-statistics.
* and ** denote statistical significance at the 10% and 5% level, respectively.

models of conditional volatility, in which it has a negative sign. Covariance between U.S. and Australian dollar values in the markets, Cov(R_u, R_a), has a negative effect with the historical volatility measures in models 1 and 2 and a positive effect with the conditional volatility measures in models 3 and 4. Cov(R_u, R_a) is statistically significant in all models of historical volatility measures, in which it also has a negative sign. Overall, on the basis of the statistical significance of the results from the four models, the two covariance terms suggest negative effects on U.S. market shares. Theoretically, the negative sign of the covariance term is consistent with significant, positive third country risk effects (Cushman 1986) and our empirical results support this argument.

Conclusion

This study analyzed the effects of 1) a strong U.S. dollar, 2) volatility of U.S. dollar, and 3) increased export performance of other wheat exporting countries on the U.S. wheat market shares in 10 Asian importing countries. A third-country effect model was developed to capture the effect of competition between wheat exporting countries. The empirical model was estimated by the two-way random variance component model with the MA process.

The empirical results show that adding the third-country variables makes a significant contribution in explaining the U.S. market shares. When considering sign and statistical significance of estimated coefficients, the model with the volatility measure of prediction errors computed from the AR(1) mean equation seems to perform best among four different empirical equations. If we see the results from model (1), a strong U.S. dollar has a negative effect on the market shares, whereas Canadian and Australian currency values are not as important. The volatility of U.S. currency values has a negative effect on the U.S. market shares, whereas the volatilities of Canadian and Australian currency values have less significant effects than that of U.S. dollar volatility. This study also shows that Australian wheat price, covariance between U.S. and Canadian currency values in the Asian countries, and covariance between U.S. and Australian currency values in the Asian markets have a significant effect on the U.S. market shares.

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