Journal of Rural Development 19(Summer 1996) 53~68

COINTEGRATION TESTS AND THE LAW OF ONE PRICE IN THE KOREAN BEEF MARKET*

Myung-Hwan Sung**

I. Introduction

The law of one price (LOP) is an important factor in theory of international trade. The LOP maintains that the foreign price of a commodity will be equal to the domestic price of the commodity. This equality will be established and maintained by the profit-seeking actions of international commodity traders. The international trade literature contains several theoretical and empirical investigations of the LOP. Empirical results regarding price parity among disaggregated commodities generally contradict the LOP theory. Officer (1990) notes that "of 40 tests, 28 reject the LOP, eight have mixed findings, and only four ambiguously cannot reject the LOP". Crouhy-Veyrac, Crouhy, and Melitz (1982) argue the negative conclusions of many LOP tests can be attributed to a neglect of transportation costs. Jabara and Schwartz (1987) also find that disaggregated agricultural commodity prices commonly violate the LOP. Protopapadakis and Stoll (1986) point to transport costs and other impediments to commodity arbitrages as reasons for short-run failure of the LOP. Goodwin, Grennes, and Wohlgenant (1990) also point to transportation costs as rejecting the LOP in conventional tests. They have argued that rejections of the LOP may have results in part from a failure to consider the intertemporal aspects of international commodity arbitrage. The intertemporal elements of trade suggest that the LOP will receive stronger empirical support when the role of price and exchange rate expectation is given explicit consideration. So, they suggest that price expectations may play an

* I thank Kiseok Lee, assistant professor in the Department of Economics at the University of Missouri, for helpful comments and explanation.
** Research Associate, Korea Rural Economic Institute, Seoul, Korea.

important role in tests of the LOP.

In a bivariate cointegration testing framework, Ardeni (1989) concluded that the LOP fails as a long run equilibrium relationship in which deviations from the pattern are permanent in international commodity markets. Karbuz and Jumah (1995) used the concept of cointegration to examine long-run relationships between the future (and spot) prices of commodities. The results show that cointegration was found to exist in 13 out of 14 cases. The LOP was valid for these prices. Goodwin (1992) used the multivariate cointegration test to evaluate the law of one price for prices in five international wheat markets. The results indicate that the LOP fails as a long-run equilibrium relationship when transportation costs are ignored. However, when wheat prices are adjusted for freight rates, the LOP is fully supported.

The objective of this paper is to find the relationship between prices and exchange rate in the Korean beef market. The hypothesis will be tested: whether or not the law of one price with two kinds of equations, such as the price transmission and the exchange rate pass-through, holds as a long-run relationship in the Korean beef market. The subsequent sections are organized as follows. Section II reviews the work on theoretical specification, emphasizing the conceptual framework. Section III presents the relevant methodology and data used to the test hypotheses. Section IV presents and discusses empirical results. Finally, section V contains the conclusions of the main results and implications.

II. Theoretical Basis

Exchange rate among currencies are simply the prices of a country's money in terms of other currencies. Domestic prices of goods are translated by exchange rates. Like other prices, exchange rates are subject to change. When a country's currency rises in value relative to those of other countries, exports tend to decrease and imports tend to increase. When a country's currency falls in relative value, exports tend to be increased and imports decreased. When a currency's value is rising internationally, domestic prices of imported goods tend to decrease and foreign prices of the same goods tend to increase. When a currency's value is falling, domestic prices of imported goods tend to increase while international prices tend to decrease.

Such a relationship between exchange rate and price can be explained by the law of one price. The LOP maintains that the domestic price of a commodity will be equal to the foreign price of the same commodity through the exchange rate. The specification of the price equation begins with identity which links the domestic price of a commodity to the import prices:

$$(1) \qquad P_d = EP_m$$

where P_d is the domestic price in importing country, P_m is the import price of the commodity imported from a country, and E is the exchange rate expressed in units of domestic currency per unit of the exporting country's currency. Thus, equation (1) becomes basically a statement of the law of one price. In international trade, transactions are mainly dealt with the US dollar. The price equation (1) can be rewritten as follows:

$$(2) \qquad P_d = \frac{E_d}{E_m} P_m$$

where E_d and E_m are the exchange rate expressed in units of domestic currency and in units of exporting country's currency per unit of a key currency (i.e., the US dollar), respectively. The price equation (1) and (2) can be written in terms of percentage changes:

$$(3) \qquad \frac{dP_d}{P_d} = \frac{d(EP_m)}{EP_m}$$

$$(4) \qquad \frac{dP_d}{P_d} = \frac{dE_d}{E_d} - \frac{dE_m}{E_m} + \frac{dP_m}{P_m}$$

Equation (4) says that the percentage change in importing country's domestic price is equal to the percentage change in the exchange rate in expressed units of domestic currency per unit of US dollar plus the percentage change in the import price expressed in exporting country's currency minus the percentage change in the exchange rate expressed in units of exporting country's currency per unit of US dollar. To test the law of one price, the following equation will be applied:

$$(5) \qquad \ln P_d = \alpha_0 + \alpha_1 \ln P_m^* + \varepsilon$$

$$(6) \qquad \ln P_d = \beta_0 + \beta_1 \ln E_d + \beta_2 \ln E_m + \beta_3 \ln P_m + \varepsilon$$

where P_m^* is import price expressed in importing country's currency, i.e., Korean Won.

If the law of one price holds in the free market, α_1 will equal to 1 and α_0 will equal to 0 in equation (5). α_1 implies the level of how much import prices transmit to domestic price. Less than perfect price transmission will be indicated by the value α_1. For convenience, equation (5) will be considered as price transmission equation in this paper. In equation (6), β_1 and β_3 will equal to 1, β_2 will equal -1 in value, and β_0 will equal to zero if the LOP holds. β_1 and β_2 imply the level of how much exchange rates pass to domestic price through international financial markets. β_3 implies the level of how much import prices transmit to domestic price. Less than perfect price transmission and exchange rate pass-through would be indicated by values β_1, β_2, and β_3 of less than 1 in absolute values. That is, if the law of one price does not hold, then β_1, β_2, and β_3 will differ from 1 in absolute values, since exchange rates and import price movements are not completely transmitted to the domestic market. For convenience, equation (6) will be considered as the exchange rate pass-through equation in this paper.

III. Methodology and Data

The direct estimations of equation (5) and (6) may create problems. The error term (ε) can be shown a highly positive autocorrelation, since the exchange rates are allowed to float. Failing to account for the presence of trend in time series data on price and exchange rates will make statistical inference misleading. Conventional tests of the LOP typically have an equilibrium relationship between two markets in which price changes in one market reflect the proportional changes in other market. Such conventional regression tests suffer from several weakness. If prices are nonstationary and have a trend together, conventional statistical procedures cannot be used to provide reliable hypothesis tests because the parameter estimates are consistent, but the estimated standard errors are not. Therefore, it may be impossible to apply explicit hypothesis tests for the estimated parameters of conventional regression models.

This paper uses the concept of cointegration to test whether or not the law of one price holds. The concept of cointegration is that, if there is a long-run relationship between two or more nonstationary variables, deviations from this long run path are stationary. This is a method of defining the long-run relationship amongst a group of time series variables. For this method, two steps must be done in testing for cointegration. The first step is to test for the order of integration of the series. This can be done using unit root tests. Several approaches are available to test for the existence of unit roots. In this analysis, two approaches are used, the Dickey-Fuller (DF) test and the augmented Dickey-Fuller (ADF) test.

The second step is to test for whether or not there exists a long-run relationship among variables or there exists cointegrating vectors. The concept of cointegration is that deviations from this long run path are stationary. If there is such a long-run relationship, the variables are said to be cointegrated. That is, if the law of one price holds in the long run, the variables will be cointegrated.

The formal definition of cointegration of two variables was developed by Engle and Granger (1987). An alternative procedure has been proposed for testing for multivariate cointegration approach developed by Johansen. The multivariate cointegration test procedures of Johansen and Juselius (1990) can identify the whole set of cointegrating relationships compared with the often-used Engel and Granger method, which can not distinguish between the existence of one or more cointegrating vectors. Johansen and Juselius's procedures generate test statistics that their likelihood ratio test statistics are asymptotically χ^2 distributions.

Johansen and Juselius begin with the vector autoregression (VAR):

(7) $$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \cdots + \Pi_k X_{t-k} + \mu + \varepsilon_t \quad (t = 1,\cdots,T)$$

where X_t is a $p \times 1$ vector, i.e., $X_t = [X_{1t}, X_{2t},\cdots,X_{pt}]'$, ε_t is drawn from a p-dimensional i.i.d. normal distribution with covariance Ω. The Π_i are $p \times p$ matrices of coefficients, μ is a $p \times 1$ vector of constants. Equation (7) can be reparameterized as

(8) $$\triangle X_t = \Gamma_1 \triangle X_{t-1} + \Gamma_2 \triangle X_{t-2} + \cdots + \Gamma_{k-1} \triangle X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t$$

where
$\Gamma_i = -(I + \Pi_1 + \cdots + \Pi_i) \quad (i = 1,\cdots,k\text{-}1)$,
and
$\Pi = -(I - \Pi_1 - \cdots - \Pi_k)$

This equation (8) becomes an error-correction model if the components of X_t are cointegrated. The Johansen and Juselius procedure investigates whether the coefficient matrix Π contains information about long-run relationships among the variables of the system. They focus on matrix Π of (8) and particularly on its rank. Since there are p variables which constitute the vector X_t, the dimension of Π is $p \times p$ and its rank can be at most equal to p. It follows from Johansen that under some general conditions:
(i) If the rank of matrix Π is equal to p, the vector process X_t is stationary;
(ii) If the rank of matrix Π is equal to 0, the vector process is specified in terms of first differences of the variables;
(iii) If the rank of matrix Π is equal to $r<p$, it will occur if X is $I(1)$. Then, Π contains r cointegrating variables and there exists a representation of Π such that:

(9) $$\Pi = \alpha \beta'$$

where α and β are both $p \times r$ matrices. Matrix β is called the cointegrating matrix and has the property that $\beta' X_t \sim I(0)$, while $X_t \sim I(1)$. The variables in X_t are cointegrated with the cointegrating vectors $\beta_1, \beta_2,\cdots, \beta_r$ being particular columns of the cointegrating matrix β. That is, β provides the property that the elements in $\beta' X_t$ are stationary even though X_t is non-stationary. Hence, in a $p \times 1$ VAR model, there can be at most $r = p$-1 cointegrating vectors. That is, the coefficients β and $\beta' X_t$ represent the long-run relationship between variables and deviations from the long-run relationship. The greater the number of cointegrating vectors, the more stable the relationship. α is the speed of adjustment of the deviations from the long-run relationships.

The essential problems are in the determination of r, that is in identifying the number of cointegrating vectors, and in estimating the cointegrating matrix β. Johansen (1988) shows the rank of Π is determined by two likelihood ratio tests. The tests are the trace test and the maximal eigenvalue test. Both tests have nonstandard distributions that depend on the number of variables in the system (p). Even though the distributions are nonstandard, Johansen and Juselius (1990) suggest a χ^2 with r degrees of freedom. For the empirical analysis, the law of one price will hold in the long-run, if there exist r cointegrating vectors in this paper. The procedures described in Johansen (1988) can be used.

All the data in this paper is based on monthly series from January of 1989 to December of 1994. The unit values are constructed from quantity and c.i.f (cost, insurance, freight) value data, which at the port of import describes valuation of a product to include all the costs, known as transfer costs. Monthly nominal exchange rates used in this paper are published regularly by International Monetary Fund (IMF) in the *International Financial Statistics*(*IFS*). They include Korean Won/US dollar, Australian dollar/US dollar, and New Zealand dollar/US dollar. The data on Korean price levels are wholesale price indices obtained from monthly issues of the *IFS*. Korean beef wholesale prices obtained from the *Materials on Price, Demand, and Supply of Livestock Products*, NLCF, Korea. There are 72 monthly observations for the United States and Australia. However, observations for New Zealand are 56 from May of 1990 to December of 1994, because Korea did not import beef from New Zealand for some period.

IV. Empirical Results

Before cointegration tests, the hypothesis of a unit root is tested. The

Dickey-Fuller and the augmented Dickey-Fuller test statistics are the $\hat{\rho}_\mu$ and $\hat{\tau}_\mu$. The null hypothesis of a unit root is rejected for values of $\hat{\rho}_\mu$ that are negative and significantly different from zero using the critical values tabulated by Dickey and Fuller. The tests for each of the exchange rate and various price series are presented in Table 1. The test is conducted for the levels and first differences of each series (DF test) and for the levels and four lags of the first-differences of each series (ADF test). In every case of exchange rate, the test results for both DF and ADF show that the null hypotheses of a unit root are not rejected. Thus, we can conclude that the exchange rates are non-stationary. In the case of the US price in terms of the US dollar, the null hypothesis of a unit root can be rejected for both tests. It means that the level of this series is stationary. In all cases, except for the US price expressed in the US dollar, the null hypothesis is not rejected by both tests.

TABLE 1 The DF and ADF unit root tests

	$\hat{\rho}_\mu$		$\hat{\tau}_\mu$	
	DF	ADF(4)	DF	ADF(4)
Exchange Rates				
Korean won/US dollar	-1.233	-1.032	-0.213	-2.068
Aus dollar/US dollar	-5.784	-4.534	-1.820	-1.339
NZ dollar/US dollar	-0.104	-1.146	-0.045	-0.421
Prices				
Korean Won price				
Domestic price	-9.237	-5.978	-1.971	-1.070
USA	-10.729	-11.752	-2.327	-2.075
Australia	-8.744	-8.547	-2.124	-2.051
New Zealand	-4.416	-6.822	-1.385	-1.966
Import prices in each country's currency				
USA	-19.990*	-35.133*	-3.586*	-3.913*
Australia	-8.192	-10.031	-1.953	-2.102
New Zealand	-3.753	-4.616	-1.368	-1.505

The critical values for $\hat{\rho}_\mu$ and $\hat{\tau}_\mu$ at 0.05 level are -13.3 and -2.93 for n=50. The critical value at 0.01 level are -18.9 and -3.58, respectively.

* Rejections at significant 1% level.

The relationship between the unit import beef price in terms of Korean Won and the domestic beef price for beef produced in Korea is tested in this section. The law of one price for each country was analyzed using the price transmission equation (5). Many of the previous studies on the law of one price and commodity prices can in fact be unreliable because either they have failed to explore the time series properties, i.e., the nonstationarity, of the variables analyzed or they have inappropriately applied various transformations on these variables, i.e., first differencing. Granger and Newbold (1974) argued that many variables are nonstationary in their levels and appear to be near-random walks. Although stationarity can be induced by differencing, the first-differencing is not always the proper solution. Moreover, in many cases what matters are the relations among the levels of the variables, which would be lost through relations among first differences.

The nonstationarity invalidates the use of the conventional *t*-values since it makes the classical asymptotic theory inapplicable. However, even though individual variables may not be stationary, linear combinations of them can be. In this case the variables are said to be cointegrated. Thus, the theory of cointegration gives a method to reconcile the findings of nonstationarity with the possibility of the relationships among the levels of economic variables. The law of one price is an example of a steady-state relationship: although deviations from the equilibrium may occur in the short run, the exchange rate and prices should be proportional in the long run. If the exchange rate and prices are nonstationary, a linear combination of them which is stationary, i.e., that holds in the long run, may be found. This linear combination will correspond to the law of one price identity.

If the prices show evidence of nonstationarity because of the presence of a unit root, one of the methods to test the law of one price as a long run relationship is to test for cointegration among the series. The above approach was used to analyze some exchange rates and commodity prices in order to verify the law of one price.

Note that the variables in equation (5) are in logarithms. Given that P_d and P_m are nonstationary, the multivariate cointegration testing procedures are used to test the law of one price for the prices in the Korean beef market. To determine the lag length of the VAR system, we used the likelihood ratio (LR) criterion.[1] We start with one lag system and test up to the four lags using likelihood ratio tests. Using this criterion the chosen lag lengths are two, three, and one for the US, Australia, and New Zealand, respectively.

The LR statistics for testing the hypothesis that there are at most r cointegrating vectors are given below. Table 2 contains the results of the multivariate cointegration tests. For the US price, it suggests that the null hypothesis that there are no cointegrating vector is rejected, since 16.92>14.07 and 20.29>15.41 for both maximal eigenvalue and trace test, respectively. However, the null hypothesis that the cointegrating vector is less than or equal to 1 is accepted. Therefore, for the US price, there exists at least one cointegrating vector. This implies that the law of one price for the viewpoint of price transmission in the long run holds in the case of the US price in Korean beef market. Table 3 shows the β' matrix and α matrix. β' can be standardized (divided by 1.2251). According to the estimated α, both prices adjust slowly but price of the US beef adjusts very quickly compared to the Korean domestic price.

For Australia and New Zealand, the null hypothesis that there is no cointegrating vector can not be rejected. The maximal eigenvalue and trace tests indicate identical conclusions. The results for Australia and New Zealand indicate that there is no cointegrating relation. Such a finding fails the law of one price as it implies that a stable long-run equilibrium relationship does not exist between the two prices.

The relationship among exchange rates and prices is tested. The exchange rate pass-through for Australia and New Zealand's price is analyzed using the equation (6). To determine the lag lengths of the VAR systems, we also use the likelihood ratio criterion. Using this criterion the chosen lag length one for Australia and New Zealand. Table 4 shows the test results of the relationships among the exchange rates and prices. The results from the Johansen tests of cointegration conducted by eigenvalue and trace tests for Australia and New Zealand suggest one cointegrating vector for both countries. Thus, a long-run equilibrium relationship among the exchange rates and

---

[1] The likelihood ratio test statistic is

$$LR = -2[L_0 - L_1] = n[\ln|\Omega_0| - \ln|\Omega_0|] \sim x_q^2$$

where L and Ω are the maximized log likelihood with lag p and the variance-covariance matrix of the residuals from the VAR systems. The degrees of freedom, q, is $k^2(p_0\text{-}p_1)$, when the system has k variables, p_0 and p_1 lags.

TABLE 2 Cointegration testing results for the price transmission equaions

Null	Alternative	USA	Australia	New Zealand	95% c.v.
Number of cointegrating vectors *r*					
		maximal eigenvalue test			
r = 0	r = 1	16.92*	8.13	10.57	14.07
r<=1	r = 2	3.37	1.37	1.18	3.76
		trace test			
r = 0	r >= 1	20.29*	9.50	11.75	15.41
r<=1	r = 2	3.37	1.37	1.18	3.76

* represents rejection of nulll hypothesis.

TABLE 3 The estimated cointegrating vectors for the US price transmission equaion

Variables	Cointegrating vectors	
	β	α
Korean domestic price	1.2251	-0.0017
	(-1.0000)	
US import price	-1.5156	0.1865
	(1.2371)	

prices is established, indicating neither VAR models in first differences nor in levels is appropriate. Table 5 shows the long-run relationship for Australia and New Zealand.

According to the estimated α matrix in Table 5, Korean domestic price adjusts 9.3 times, Australian dollar/US dollar adjusts 4.5 times, and import price expressed in Australian dollar adjusts 6.0 times faster than Korean Won/US dollar to any deviation. In the case of New Zealand, Korean domestic price adjusts 5.4 times, NZ dollar/US dollar adjusts 2.1 times, and import price expressed in New Zealand dollar adjusts 2.0 times faster than Korean Won/US dollar.

TABLE 4 Cointegration testing results for the exchange rate pass-through equations

Null	Alternative	Australia	New Zealand	95% c.v.
Number of cointegrating vectors *r*				
		maximal eigenvalue test		
r = 0	r = 1	29.37*	40.62*	27.07
r<= 1	r = 2	21.04*	18.43	20.97
r<= 2	r = 3	3.53	3.25	14.07
r<= 3	r = 4	1.03	0.74	3.76
		trace test		
r = 0	r >= 1	54.97*	63.04*	47.21
r<= 1	r >= 2	25.60	22.42	29.68
r<= 2	r >= 3	4.57	3.99	15.41
r<= 3	r = 4	1.03	0.74	3.76

* represents rejection of nulll hypothesis.

TABLE 5 The estimated cointegrating vectors for exchange rate pass-through equations

Variables	Australia		New Zealand	
	β	α	β	α
Korean domestic price	-1.3374 (-1.0000)	0.1409	-1.2586 (-1.0000)	0.1108
Korean Won/US dollar	1.8682 (1.3969)	-0.0152	3.3290 (2.6450)	-0.0205
Aus or NZ dollar/US dollar	-2.3920 (-1.7886)	0.0680	-2.3603 (-1.8753)	-0.0426
Aus or NZ import price	-0.9119 (-0.6818)	0.0919	0.8580 (0.6817)	-0.0402

V. Summary and Conclusions

This paper found that the relationships between exchange rates and prices represent different behavior according to the country. First, the cointegration test was used to test whether the law of one price with the price transmission equation holds. For the US, the result suggests that there exists at least one cointegrating vector. In the case of US price in the Korean beef market this implies that the law of one price holds in the long run. However, for Australia and New Zealand, the null hypothesis that there is no cointegrating vector was not rejected. The results for Australia and New Zealand indicate that there is no cointegrating vector and, thus, that there are stochastic trends between the import prices and Korean domestic price. Such a finding is unfavorable to the law of one price as it implies that there exists no stationary long-run equilibrium relationship between the two prices.

Second, the cointegration test was used to test whether the law of one price with the exchange rate pass-through equation holds. For the US, the results of this paper show that import price expressed in US dollars appears to be stationary. This result indicates a lack of empirical support for the cointegration test using the exchange rate pass-through equation as a long-run relationship. The results from the Johansen tests of cointegration conducted by eigenvalue and trace tests for Australia and New Zealand suggest one cointegrating vector for both countries. Thus, a long-run equilibrium relationship among the exchange rates and prices is established. It implies that there exists a long-run equilibrium relationship among exchange rates and prices. It also indicates that neither the VAR model in first differences or in levels is appropriate.

From these two cointegration tests, we can interpret the results in the following manner: the Korean domestic beef price in the long run is linearly dependent on US beef prices expressed in Korean Won. Changes in the Korean beef price will be adjusted by the changes in the exchange rate and the US import price in the long run. However, the changes in the Korean Won/US dollar exchange rate may not be the same as the proportional changes in US import price in absolute values. For Australia and New Zealand, the Korean domestic beef price in the long-run may be independent of Australian beef price or New Zealand beef price expressed in Korean Won. However, the four variable systems (including 2 more variables of exchange rates, the Korean Won/US dollar and Australian dollar or New Zealand/US dollar) have one cointegration vector for both countries. This implies that a variable may have a linear relationship with one of the other variables. The remaining three variables may be independent of each other. Primarily, since the price transmission equations do not have cointegrating vectors for both countries, it is difficult to predict the direction of each variable in the long-run. It sometimes violates the theory of price formation.

Several reasons can be offered for failure of the law of one price in the Korean beef market. First, the current beef import quota system (which is the minimum amount to be imported from any country, at a given quota, and within given period) may not influence price formations. This can not use all available information to incorporate into prices. Second, different qualities imported from different countries reduce the substitutability of commodities between countries and, thus, these commodities have different prices. Hence, competition may be imperfect. Third, changes in the exchange rate depend on monetary and fiscal policies, and the financial markets in a given country. The changes in exchange rates are not fully incorporated into the price of specific products.

In summary, this paper has focused on the relationships between exchange rates and prices. The paper used methods which appear to have important implications for the tests of the relationships of the relationships between prices. With more recent data it should be possible to update the results that are more useful and to interpret the situation suggested by the theory.

REFERENCES

Ardeni, Pier Giorgio. "Does the law of one price really hold for commodity prices?" *American Journal of Agricultural Economics* 71(1989):661-669.

Babula, Ronald A., Fred J. Ruppel, and David A. Bessler. "U.S. corn exports: the role of the exchange rate." *Agricultural Economics* 13(1995):75-88.

Bredahl, Maury E., William H. Meyers, and Keith J. Collins, "The elasticity of foreign demand for U.S. agricultural products: the importance of the price transmission elasticity." *American Journal of Agricultural Economics* 62(1980):58-63.

Charemza, Wojciech W. and Derek F. Deadman. *New Directions in Econometric Practice*. England: Edward Elgar, 1992.

Crouhy-Veyrac, Liliane, Michel Crouhy, and Jacques Melitz. "More about the law of one price." *European Economic Review* 18(1982):325-344.

Dickey, D. A. and W. A. Fuller. "Distribution of the estimators for autoregressive time series with a unit root." *Journal of the American Statistical Association* 74(1979):427-431.

Engle, Robert F. and C. W. J. Granger. "Co-integration and error correction: representation, estimation and testing." *Econometrica* 55(1987):251-276.

Goodwin, Barry K. "Multivariate cointegration tests and the law of one price in international wheat market." *Review of Agricultural Economics* 14(1992):117-124.

Goodwin, Barry K., Thomas J. Grennes, and Michael K. Wohlgenant. "A revised test of the law of one price using rational price expectations." *American Journal of Agricultural Economics* 72(1990):682-693.

Granger, C.W.J. and P. Newbold. "Spurious regression in econometrics." *Journal of Econometrics* 2(1974):111-120.

International Monetary Fund. *International Financial Statistics*, various year.

Jabara, Cathy L. and Nancy E. Schwartz. "Flexible exchange rates and commodity price changes: the case of Japan." *American Journal of Agricultural Economics* 69(1987):580-590.

Johansen, Soren. "Statistical analysis of cointegration vectors." *Journal of Economic Dynamics and Control* 12(1988):231-254.

Johansen, Soren and Katarina Juselius. "Maximum likelihood estimation and inference on cointegration - with applications to the demand for money." *Oxford Bulletin of Economics and Statistics* 52(1990):169-210.

Karbuz, Sohbet and Adusei Jumah. "Cointegration and commodity arbitrage." *Agribusiness* 11(1995):235-243.

National Livestock Co-operatives Federation. *Materials on Price, Demand, and Supply for Livestock Products*. Seoul, Korea, various issues.

Officer, Lawrence H. "The law of one price: Two levels of aggregation." in

International Financial Markets and Agricultural Trade, ed. Thomas Grennes, p. 10, Boulder, CO: Westview Press, Inc., 1990.

Officer, Lawrence H. "The law of one price cannot be rejected: two tests based on the tradable/nontradable price ratio." *Journal of Macroeconomics* 8(1986):159-182.

Pesaran, M. Hashem and Bahram Pesaran. *MICROFIT 3.0: User Manual.* Oxford University Press, 1991.

Protopapadakis, A. and H. R. Stoll. "The law of price in international commodity market: a reformulation and some formal tests." *Journal of International Money and Finance* 9(1986):335-360.