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Dynamics in the Macroeconomy and the U.S. Agricultural Trade Balance

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ABSTRACT

The effects of the exchange rate and the income and money supply of the United States and its major trading partners on the U.S. agricultural trade balance are examined using an autoregressive distributed lag (ARDL) model. Results suggest that the exchange rate is the key determinant of the short- and long-run behavior of the trade balance. It is also found that the income and money supply in both the United States and the trading partners have significant impacts on the U.S. agricultural trade in both the short- and long-run.

Keywords**:** Agricultural trade balance, autoregressive distributed lag model, exchange rate, income, macroeconomy, money supply

HIGHLIGHTS

The United States has been a net exporter of agricultural products for several decades. On average in the 1980s, the United States had an agricultural trade surplus of $16 billion. Moreover, due to the rapid growth of U.S. exports relative to imports during the early 1990s, the agricultural trade surplus reached a record high of $27 billion in 1996. However, this positive balance of trade has dwindled significantly over the past 10 years. U.S. agricultural imports have risen by approximately 64%, from $36 billion in 1997 to $59 billion in 2005. Meanwhile, exports have fluctuated from a low of $48 billion in 1999 to a high of $63 billion in 2005. As a result, the trade surplus has shrunk to $4 billion in 2005. The U.S. Department of Agriculture has projected that the current trade surplus will become negative within a couple of years.

The main objective of this study is to explore macro-agricultural trade linkages to identify the driving forces behind the shrinking agricultural trade balance. For this purpose, we use an autoregressive distributed lag (ARDL) model to examine the short- and long-run effects of various macroeconomic variables on U.S. agricultural trade with its top 30 trading partners. These countries account for approximately 78% of U.S. agricultural exports and approximately 85% of U.S. agricultural imports.

The results show that the exchange rate plays a key role in determining the short- and long-run behavior of U.S. agricultural trade with its major trading partners. It is also found that income and money supply of the United States and its trading partners have significant effects on the agricultural trade balance in both the short- and long-run. Moreover, the variables relating to the domestic economy are found to have significant impacts on U.S. agricultural imports.

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Jungho Baek and Won W. Koo*

INTRODUCTION

Over the last 40 years, U.S. agriculture has been one of the few economic sectors showing a positive trade balance. On average in the 1980s, the United States had an agricultural trade surplus of $16 billion. Moreover, due to the rapid growth of U.S. exports relative to imports during the early 1990s, the agricultural trade surplus reached a record high of $27 billion in 1996. However, this positive balance of trade has dwindled significantly over the past 10 years. U.S. agricultural imports have risen by approximately 64%, from $36 billion in 1997 to $59 billion in 2005. Meanwhile, exports have fluctuated from a low of $48 billion in 1999 to a high of $63 billion in 2005. Accordingly, the trade surplus has shrunk to $4 billion in 2005 (Figure 1). The U.S. Department of Agriculture (USDA) has projected that the current trade surplus will become negative within a couple of years.

Agricultural economists have long recognized the importance of macroeconomic variables' influence (e.g., exchange rates and growth in home and/or foreign real income) on the U.S. agricultural trade balance. For example, a rise in U.S. income relative to foreign real income leads to growth in demand for U.S. agricultural imports, which in turn will deteriorate the trade balance (Figure 2). Or, a real depreciation of the U.S. dollar tends to increase U.S. agricultural exports through increased competitiveness of U.S agricultural prices, thereby increasing the trade surplus (Figure 3). As such, it is important to explore macro-agricultural trade linkages to identify the driving forces behind the shrinking agricultural trade balance.

Within the international trade literature, the relationship between macroeconomic variables and a country's balance of trade has been studied extensively. For example, Doroodian et al. (1999) used time-series analysis (i.e., Shiller lag model) to investigate the factors influencing the U.S. trade balance. Bahmani-Oskooee and Ratha (2004) adopted an autoregressive distributed lag (ARDL) model to examine the dynamics of the U.S. trade balance and macroeconomic factors (i.e., exchange rates). In the agricultural trade literature, on the other hand, studies to date have concentrated mostly on how macroeconomic variables (i.e., money supply and exchange rates) affect the U.S. agricultural exports and/or prices (Chambers 1981, 1984; Chambers and Just 1981; Gardner 1981; Batten and Belongia 1986; Bessler and Babula 1987; Bradshaw and Orden 1990; Orden 2002). For example, Chambers and Just (1981) used both a structural model (i.e., three stage least squares) and a time-series model (i.e., dynamic multiplier analysis) to determine macroeconomic factors affecting U.S. exports. Bradshaw and Orden (1990) employed the Granger causality test to analyze exchange rate effects on U.S. agricultural exports and prices. However, dynamic interrelationships between macroeconomic variables and the U.S. agricultural trade balance have been neglected.

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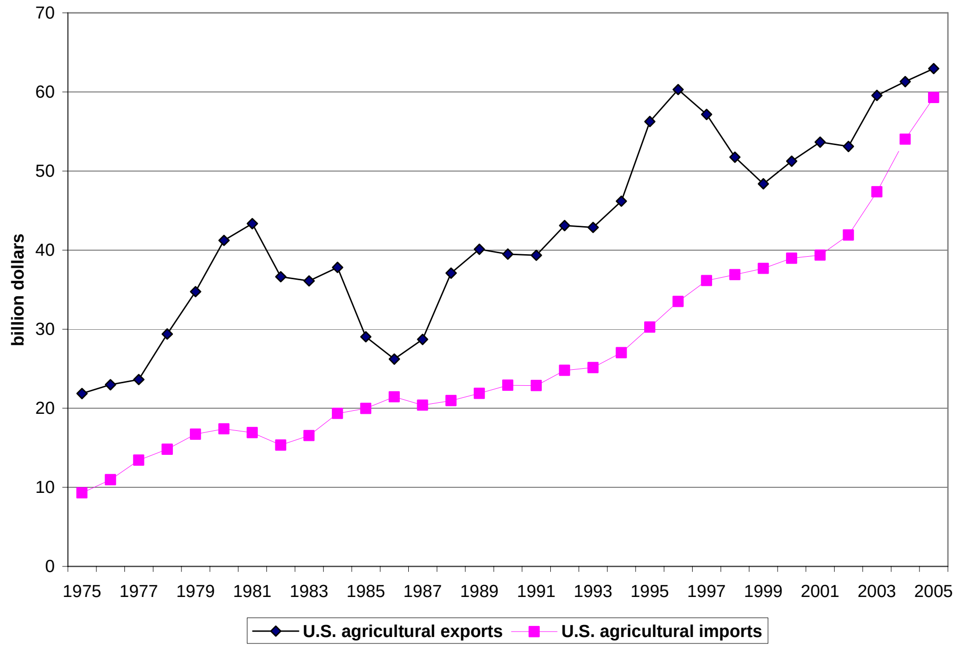

Figure 1. U.S. agricultural exports and imports
Source: Economic Research Service, U.S. Department of Agriculture

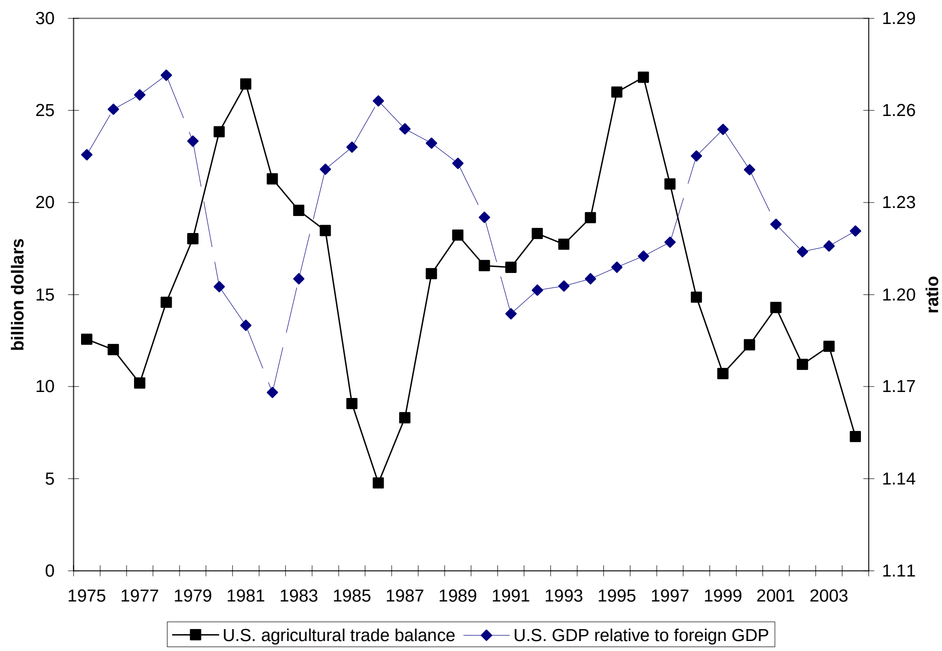

Figure 2. U.S. trade balance in agriculture and U.S. GDP relative to foreign GDP
Source: International Financial Statistics, International Monetary Fund
Note: U.S. agricultural trade balance is expressed as trade surplus.

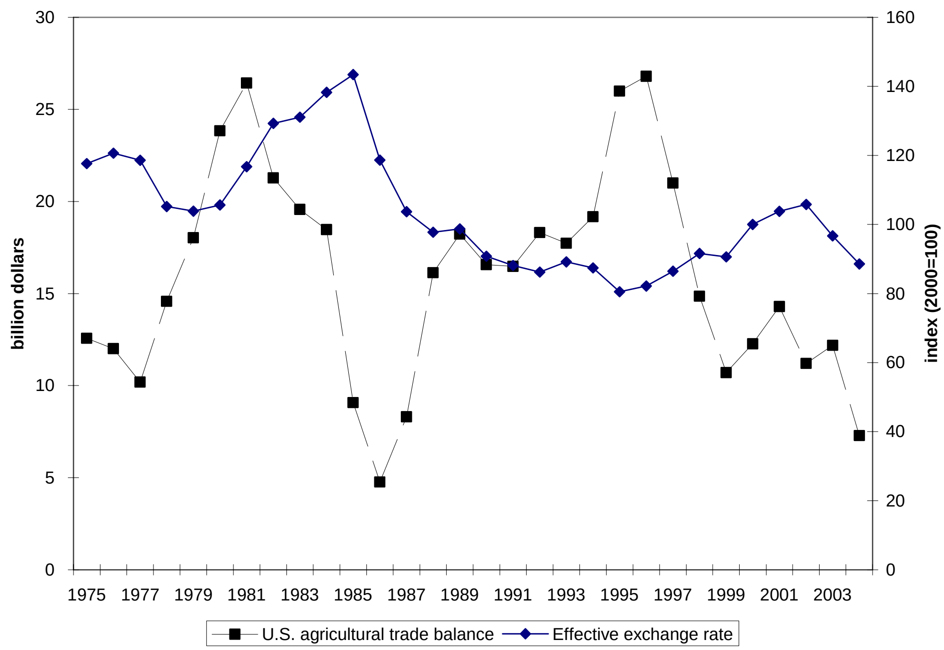

Figure 3. U.S. trade balance in agriculture and effective exchange rate
Source: International Financial Statistics, International Monetary Fund
Note: U.S. agricultural trade balance is expressed as trade surplus.

The objective of this study is to examine the short- and long-run effects of various macroeconomic variables on the agricultural trade balance between the United States and its top 30 trading partners. These countries account for approximately 78% of U.S. agricultural exports and approximately 85% of U.S. agricultural imports (Table 1).

We employ an autoregressive distributed lag (ARDL) model developed by Pesaran and Shin (1999) and Pesaran et al. (2001). This approach has some econometric advantages over standard cointegration methods (e.g., Engle and Granger 1987; Johansen 1995). Specifically, the traditional approaches concentrate on cases in which the underlying variables are of equal order of integration [e.g., integrated of order one, or $I(1)$]. This inevitably involves a certain degree of pre-testing and introduces a further degree of uncertainty into the analysis of level relationships (Pesaran et al. 2001, p.289). To overcome these weaknesses, Pesaran et al. (2001) developed an alternative approach to testing for the existence of cointegration (levels) relationships which is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, or mutually cointegrated. Unlike conventional cointegration tests, therefore, the ARDL model is relieved of the burden of establishing the order of integration among variables and of pre-testing for unit roots, and it avoids problems associated with non-stationary time-series data (i.e., spurious regression). In addition, an error-correction model (ECM) can be derived from the ARDL model through a simple linear transformation. The ECM captures the short-run dynamics while restricting the long-run equilibrium. The ARDL model thus estimates the short- and long-run parameters of the model simultaneously.

Table 1. U.S. agricultural trade (2000-04 average)

	Exports (million $)	*Imports (million $)*	*Total (million $)*	*Share (%)*
Canada	8,697	10,123	18,820	18.8
Mexico	7,491	5,885	13,376	13.4
Japan	8,722	383	9,105	9.1
China	3,256	1,106	4,362	4.4
Netherlands	1,241	1,744	2,985	3.0
Korea	2,636	156	2,792	2.8
Italy	535	1,856	2,391	2.4
Australia	354	1,970	2,324	2.3
Taiwan	2,012	177	2,189	2.2
Indonesia	861	1,096	1,957	2.0
France	389	1,557	1,946	1.9
Germany	995	826	1,821	1.8
United Kingdom	1,061	576	1,637	1.6
Brazil	296	1,302	1,598	1.6
Colombia	499	1,034	1,533	1.5
Spain	710	784	1,494	1.5
Thailand	609	843	1,452	1.5
New Zealand	115	1,303	1,418	1.4
Chile	117	1,152	1,269	1.3
Philippines	758	474	1,232	1.2
Hong Kong	1,122	78	1,200	1.2
Turkey	754	318	1,072	1.1
Costa Rica	227	838	1,065	1.1
Ireland	245	819	1,064	1.1
Guatemala	325	710	1,035	1.0
India	282	746	1,028	1.0
Egypt	967	41	1,008	1.0
Belgium	587	205	792	0.8
Malaysia	358	390	748	0.7
Dominican Rep.	485	260	745	0.7
Sub-Total	46,709	38,751	85,460	85.4
World-Total	55,781	44,321	100,102	100.0

Note: Share represents % shares of each country's total trade in world total trade.
Source: Economic Research Services, U.S. Department of Agriculture

In the next section, the theoretical framework of the agricultural trade balance model is presented. This is followed by a discussion of the empirical model and by a description of the dataset used in the analysis. Finally, the empirical results are discussed, followed by some conclusions.

THEORETICAL FRAMEWORK

The theories dealing with the relationship between macroeconomic variables and the trade balance can be classified into three categories: elasticity, absorption, and monetary approaches (Whitman 1975). Based on a partial equilibrium version of a standard two-country (domestic and foreign), two-goods (exports and imports) model, the elasticity approach places its emphasis on the effects of the relative price (domestic *versus* foreign) changes on individual microeconomic behavior. More specifically, the domestic and foreign demand for imports can be defined as follows:

(1) $M^d = M^d(P_m)$ and $M^{d^*} = M^{d^*}(P_x^*)$,

where M^d (M^{d^*}) is the quantity of domestic (foreign) imports; and P_m (P_x^*) is the domestic (foreign) currency price of imports (exports). In addition, P_m (P_x^*) is defined as $P_m = NE \times P_m^*$ ($P_x^* = \frac{P_x}{NE}$), where NE is the nominal exchange rate and P_m^* (P_x) is the foreign (domestic) currency price of domestic imports (exports). Similarly, the domestic and foreign supply of exports can be specified as follows:

(2) $X^s = X^s(P_x)$ and $X^{s^*} = X^{s^*}(P_m^*)$,

where X^s (X^{s^*}) is the quantity of domestic (foreign) exports; and P_x (P_m^*) is the domestic (foreign) currency price of exports (imports). Given equations (1)-(2) and the market equilibrium conditions for exports and imports ($M^d = X^{s^*}$ and $M^{d^*} = X^s$), the trade balance (TB) in domestic currency is then:

(3) $TB = P_x X^s - P_m M^d = EX - IM$,

where EX and IM are the value of exports and imports, respectively. The elasticity approach suggests that the changes in the exchange rate (relative price between domestic and foreign) determine the trade balance through changes in the demand and supply of exports and imports.

The absorption approach focuses its analysis on identifying the linkage between changes in macroeconomic aggregates (i.e., national income and absorption) and changes in the trade balance. The trade balance (TB) in this approach is defined as:

(4) $TB = Y - A = EX - IM$,

where Y is the gross domestic product (GDP); and A is the domestic absorption (expenditure). The absorption approach indicates that the trade balance is determined by the difference between GDP (how much is produced) and absorption (how much is consumed domestically). For improvement of the nation's trade balance, therefore, an increase in the national income (GDP) must surpass a rise in domestic consumption.

Given the belief that the trade balance is essentially a monetary phenomenon, on the other hand, the monetary approach places its emphasis on the effects of changes in the supply and demand of money on the trade balance (Frenkel and Johnson 1977). The trade balance in this approach is specified as follows:

(5) $TB = \Delta FR$,

where ΔFR is the change in the foreign-reserve holdings of the central bank. According to this approach, for example, a surplus (deficit) in the trade balance leads to a rise (decline) in foreign reserves, thereby resulting in an excess domestic demand for money (excess domestic supply of money). Additionally, the change in the domestic money supply (ΔM) is defined as:

(6) $\Delta M = \Delta DC + \Delta FR$,

where ΔDC is the change in the domestic credit. Given equations (5)-(6), the trade balance (TB) in domestic currency is then:

(7) $TB = \Delta FR = \Delta M - \Delta DC$.

The monetary approach thus suggests that the trade balance is determined by changes in the money supply (i.e., the foreign-reserve holdings).

Finally, if we take all variables as *ex post* identities, all three schools of thought are essentially identical as follows (Mundell 1968):

(8) $EX - IM = Y - A = TB = \Delta FR = \Delta M - \Delta DC$.

For example, the elasticity approach can be considered as the absorption (Keynesian) approach in the sense that, with only Keynesian assumptions of unemployment and wage-price rigidity in domestic market, it can be assumed that a real devaluation would change the relative price between domestic and foreign goods in the domestic and foreign markets, thereby promoting substitutions in production and consumption. Or, the monetary approach can be reconciled with the absorption approach, in which the demand for money relative to its initial supply determines domestic absorption relative to income (Whitman 1975, pp. 506-507).

EMPIRICAL FRAMEWORK

To examine the interaction between agricultural trade balance and macroeconomic factors, we extend the standard two-country model of trade (Rose and Yellen 1989) to represent the relationship between the United States and its major trading partners. This relationship is specified as follows:

(9) $TB = TB(Y, Y^*, M, M^*, ER)$,

where TB is the U.S. agricultural trade balance with its major trading partners; Y (M) is the real U.S. income (money supply); Y^* (M^*) is the weighted average of the foreign income (money supply) calculated on the basis of the trade share of the trading partners in agricultural commodities for the United States; and ER is the weighted average of real exchange rate index between the U.S. dollar and the currencies of its major trading partners.

It should be emphasized that equation (9) empirically encompasses the elasticity, absorption, and monetary approaches. For example, the elasticity approach views a change in the exchange rate as the determinant of the trade balance. The absorption approach identifies changes in real domestic income (relative to absorption) as the main factor contributing to the trade balance. Finally, the monetary approach stresses that the balance of payments implies a change in the growth in money supply.

To illustrate the ARDL modeling approach, equation (9) is then expressed in a log linear form as follows:

(10) $\ln TB_t = \alpha + \beta_1 \ln Y_t + \beta_2 \ln Y_t^* + \beta_3 \ln M_t + \beta_4 \ln M_t^* + \beta_5 \ln ER_t + \varepsilon_t$

With regard to the signs of the coefficients in equation (10), it is expected that $\beta_1 < 0$ ($\beta_2 > 0$), since an increase in the real U.S. income (weighted average of real income of the major trading partners) leads to a rise in U.S. imports (exports), thereby deteriorating (increasing) the trade balance. In addition, a rise in U.S. money supply leads to an increase in the level of real balances. Accordingly, individuals perceive their wealth to increase, causing the level of expenditures to increase relative to income and the trade surplus to decrease (Johnson 1972). As a result, it is expected that $\beta_3 < 0$ ($\beta_4 > 0$). Finally, as to the effect of exchange rate, it is expected that $\beta_5 > 0$, since a rise in the exchange rate (depreciation of the U.S. dollar) increases exports and decreases imports, thereby improving the trade balance.

The ARDL approach involves estimating the error correction version of the ARDL model for variables under estimation (Pesaran et al. 2001). From equation (10), the ARDL model of interest can be written as follows:

(11)
$$\Delta \ln TB_t = \alpha_0 + \sum_{i=1}^{p} \varepsilon_i \Delta \ln TB_{t-i} + \sum_{i=1}^{p} \phi_i \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta \ln Y_{t-i}^* + \sum_{i=1}^{p} \gamma_i \Delta \ln M_{t-i} + \sum_{i=1}^{p} \eta_i \Delta \ln M_{t-i}^*$$
$$+ \sum_{i=1}^{p} \mu_i \Delta \ln ER_{t-i} + \lambda_1 \ln TB_{t-1} + \lambda_2 \ln Y_{t-1} + \lambda_3 \ln Y_{t-1}^* + \lambda_4 \ln M_{t-1} + \lambda_5 \ln M_{t-1}^* + \lambda_6 ER_{t-1} + u_t$$

where Δ is the difference operator; p is lag order; and u_t is assumed serially uncorrelated. Equation (11) is called the error correction version related to the ARDL, since the terms with the summation signs ($\sum$) represent the short-run dynamics between the trade balance and its main determinants, while the second part (terms with λs) corresponds to the long-run (cointegration) relationship. The null hypothesis in equation (11) is defined as $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0$, indicating the non-existence of the long-run relationship.

DATA

The main objective of this study is to examine the dynamic effects of various macroeconomic variables on the agricultural products trade between the United States and its major trading partners. For this purpose, we identify the United States' 30 most important trade partners. China is excluded due to unavailability of certain data, reducing the number of countries to 29. Note that trade weights (w_i) are calculated based on the average 2000-2004 trade share of each partner among the top 29 trading countries as follows:

$$(12) \qquad w_i = \frac{EX_i + IM_i}{\sum_{i=1}^{n}(EX_i + IM_i)}$$

where $EX_i (IM_i)$ is the U.S. agricultural exports (imports from) to the partner country i , $i = 29$ countries. Quarterly data are collected for the period of 1975:q4-2004:q4.

The total values of exports and imports for agricultural commodities between the United States and its major trading partners are collected from the Foreign Agricultural Trade of the United States (FATUS) from the Foreign Agricultural Service (FAS-USDA). The U.S. trade balance is then expressed as the ratio of exports to imports (trade surplus). The real income of the United States and its trading partners is measured as real GDP index (2000=100) and is taken from the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). The money supply of the United States and its major trading partners is measured as high-powered money (monetary base) and is obtained from the IFS. The high-powered money that is under control of the monetary authorities is comprised of currency (banknotes and coins) and commercial banks' reserves with the central bank. Hence, it is a narrow definition of money supply, only including the most liquid forms of money (Miles 1979; Bahmani-Oskooee 1985; Doroodian et al. 1999). The nominal exchange rates between the U.S. dollar and the currencies of its major trading partners are collected from the Economic Research Service (ERS-USDA) (originally collected by the IFS). The consumer price indices (CPIs, 2000=100) in the United States and its trading countries obtained from the IFS are used to derive real money supply and exchange rates. Finally, all variables are converted to natural logarithms.

Before estimating the model, there are two issues to be addressed. The first issue relates to the calculation method of the weighted average of foreign income and money supply. These two variables are calculated using the following geometric mean formula:

$$(13) \qquad Y_t^* (M_t^*) = \prod_{i=1}^{n} [S_{it}]^{w_i} ,$$

where Y_t^* (M_t^*) is the weighted average of the foreign income (money supply); S_{it} is the real income (money supply) of partner country i during period t (measured by the U.S. dollar); n is the number of the U.S. trading partners (29 countries); and w_i is the weighted value of the U.S. agricultural trade to its trading partners derived from equation (12).

The second issue pertains to the calculation method of the weighted average of real exchange rate index between the U.S. dollar and the currencies of its major trading partners. For this purpose, following the IMF methodology, the nominal exchange rate index (NE_t) is first calculated as follows:

$$(14) \qquad NE_t = \prod_{i=1}^{n} [\Delta E_{it}]^{w_i} ,$$

where n is the number of the U.S. trading partners (29 countries); $\Delta E_{it} = \dfrac{E_{it}}{E_{it-1}}$ is the change rate of the U.S. dollar in currency of partner country i from $t-1$ to t; $E_{it} = 1/R_{it}$, R_{it} is the nominal exchange rate of the U.S. dollar per units of foreign currency during period t. Then, the weighted average of the real exchange rate index (RE_t) is derived from deflating NE_t with the respective CPIs as follows:

$$(15) \qquad RE_t = NE_t \times \prod_{i=1}^{n} \left[\frac{CPI_t}{CPI_{it}^*} \right]^{w_i} ,$$

where CPI_t is the U.S. CPI during period t; CPI_{it}^* is the CPI of partner country i during period t. Since the weighted average of the real exchange rate index is calculated in terms of the U.S. dollar per units of foreign currency, a decline (rise) in the exchange rate index indicates a real appreciation (depreciation) of the U.S. dollar.

EMPIRICAL RESULTS

Preliminary Analysis

The ARDL modeling procedure starts with determining the appropriate lag order (p) in equation (11). For this purpose, we use the Akaike Information Criterion (AIC) and Lagrange multiplier (LM) statistics for testing the hypothesis of no serial correlation against orders 1 and 3 (Table 2). The AIC indicates that $p = 1$ is the most appropriate lag length for the trade balance model. However, the LM statistics show that the null of no serial correlation can be rejected for $p = 1$ and even $p = 2$, which gives the second highest AIC statistic. We then select lag 3 ($p = 3$), which provides the third highest AIC statistic as well as the acceptance of no serial correlation.

Table 2. Statistics for selecting the lag order and F-statistics for testing cointegration among variables of the U.S. agricultural trade balance model

Lag order	*AIC*	$\chi^2_{SC}(1)$	$\chi^2_{SC}(3)$	F *-statistic*
1	-1.78	4.76**	19.36**	5.05
2	-1.98	7.92**	9.13**	3.89
3	-2.40	0.73	0.76	9.25
4	-2.45	2.87	3.69	5.36
5	-2.41	0.85	3.67	4.32
6	-2.43	0.60	4.86	4.64

Note: ** denotes significance at the 5% level; AIC represents Akaike Information Criterion for a given lag length; $\chi^2_{SC}(1)$ and $\chi^2_{SC}(3)$ are LM statistics for testing no serial correlation against orders 1 and 3; and the F -statistics for 10% and 5% critical value bounds are (2.26, 3.35) and (2.62, 3.79), respectively. The critical values are from Table CI in Pesaran et al. (2001).

With the selected lag order ($p = 3$), we then test the existence of a level relationship (cointegration) among six variables. For this purpose, the null hypothesis of non-existence of the long-run relationship, namely ($\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0$) in equation (11) is tested, irrespective of whether the regressors are purely $I(0)$, purely $I(1)$, or mutually cointegrated. This can be implemented using an F - test with two sets of asymptotic critical values tabulated by Pesaran et al. (2001) in which all the regressors are assumed to be purely $I(0)$ or purely $I(1)$. This is known as a bounds testing procedure, since the two sets of critical values provide critical value bounds for all possibilities of the regressors into $I(0)$, purely $I(1)$, or mutually cointegrated. More specifically, if the computed F - statistic lies outside the upper critical value, then the null hypothesis of no long-run relationship can be rejected, indicating that the variables are cointegrated. If the computed F - statistic falls below the lower level of the critical bounds, on the other hand, the null hypothesis cannot be rejected, supporting lack of cointegration. With $p = 3$, for example, the F -statistic is 9.25, which lies outside the upper level of the 5% critical bounds (Table 2). As such, this result supports the existence of the cointegrated trade balance equation when using $p = 3$.

Results of Long- and Short-Run Analysis

After determining the lag length and existence of the level relationship, we estimate the long-run trade balance model in equation (10) to identify the cointegration relationship among variables. The results show that all estimates are statistically significant at least at the 10% level and have the expected signs (Table 3). A positive coefficient of the real exchange rate index on the trade balance suggests that, in the long-run, a rise in the index (depreciation) causes an increase in U.S. exports and a decrease in U.S. imports, thereby increasing the trade surplus. A negative (positive) coefficient of the domestic (trading partners) real income on the trade balance implies that an increase in real domestic (trading partners) income leads to a rise in U.S. agricultural imports (exports) through the increased purchasing power of U.S. (trading partners) consumers, thereby decreasing (increasing) the trade surplus. In fact, with an increase in the U.S. relative income over the last decades, U.S. agricultural imports rose steadily (Figures 1 and 2).

Table 3. Estimated long-run coefficients of the U.S. agricultural trade models

Variable	*Trade Balance* (TB_t)	*Exports* (EX_t)	*Imports* (IM_t)
Exchange rate (ER_t)	0.43 (2.81)**	0.91 (4.74)**	-0.19 (-1.83)*
U.S. income (Y_t)	-4.14 (-8.50)**	-0.71 (-1.17)	1.15 (3.54)**
Foreign income (Y_t^*)	0.17 (1.76)*	0.34 (2.81)**	-0.20 (-3.04)**
U.S. money supply (M_t)	-0.76 (-3.48)**	0.92 (1.47)	0.57 (3.93)**
Foreign money supply (M_t^*)	0.15 (2.82)**	-0.23 (-2.84)**	0.17 (4.67)**
Constant	31.45 (9.56)**	2.32 (2.67)**	-11.27 (-5.14)**

Note: ** and * denote significance at the 5% and 10% levels, respectively.

Particularly, processed products ─ wine, beer, nuts, fresh fruits and vegetables ─ have been the largest share of the increase in U.S. imports during the 1994-2004 period; about 45% of agricultural imports in 2004 was processed products, a rise from the 37% in 1994. During the same period, U.S. imports of horticultural products have substantially increased from Canada, Mexico, Australia, New Zealand, Chile, and a number of European countries (Mattson and Koo 2005). Finally, a negative (positive) coefficient of the domestic (trading partners) money supply on the trade balance indicates that an increase in the U.S. (trading partners) money supply leads to deterioration (improvement) of the trade surplus through an increase (decrease) in the level of real balances.

For the short-run analysis, the ARDL approach is used to estimate equation (11). These estimates provide evidence on the short-run dynamics that exist between the trade balance and its main determinants. For this purpose, the estimated residual from equation (10) is used as error-correction terms in equation (11) (Table 4). The results show that changes in the real exchange rate have a significant effect on the U.S. agricultural trade balance in the short-run. In addition, both the domestic and foreign variables are found to be highly significant, suggesting that the real income and money supply also have significant short-run effects on the U.S. agricultural trade balance. The coefficient of the error-correction term (ec_{t-1}) is negative and significant at the 5% level, which indicates the short-run adjustment process of the trade balance to the long-run equilibrium, and justifies the choice of $p = 3$. For example, the coefficient of ec_{t-1} in the trade balance model is -0.18, which suggests that the trade balance adjusts approximately 18% to the long-run equilibrium in one quarter. In other words, with a shock to the U.S. agricultural trade, it takes more than five quarters (1/0.18=5.6 quarters) to correct long-run disequilibria.

Table 4. Estimated short-run coefficients of the U.S. agricultural trade models

	Trade Balance (ΔTB_t)		*Exports* (ΔEX_t)		*Imports* (ΔIM_t)	
	coefficient	t-statistic	coefficient	t-statistic	coefficient	t-statistic
ΔTB_{t-1}	-0.18	-2.36**				
ΔTB_{t-2}	-0.44	-5.08**				
ΔEX_{t-1}			-0.47	-5.57**		
ΔIM_{t-1}					-0.24	-2.30**
ΔIM_{t-2}					-0.29	-3.31**
ΔER_t	1.10	2.69**	0.73	2.84**	-0.34	-1.11
ΔY_t	-1.11	-2.14**	0.77	0.68	1.16	2.12**
ΔY_t^*	0.44	1.70*	0.62	2.23**	0.02	0.08
ΔY_{t-1}^*	0.52	2.20**	0.58	2.06**		
ΔY_{t-2}^*	0.55	2.52**				
ΔM_t	-0.75	-2.02**	-1.21	-1.44	0.08	0.30
ΔM_{t-1}	-1.34	-3.68**			0.49	1.75*
ΔM_{t-2}					0.58	1.96**
ΔM_{t-3}					0.93	3.31**
ΔM_t^*	0.20	1.41	0.29	1.84*	-0.02	-0.19
ΔM_{t-1}^*	0.31	2.31**	0.70	3.32**		
ΔM_{t-2}^*	1.04	5.75**				
ec_{t-1}	-0.18	-2.11**	-0.37	-4.49**	-0.28	-2.49**
Constant	0.01	1.31	-0.01	-0.99	-0.01	-0.22

Note: ** and * denote significance at the 5% and 10% levels, respectively; ec_{t-1} refers to the error-correction term; and Δ indicates the first difference of a variable.

Finally, it should be noted that the trade balance model analyzing exports and imports together is not able to directly identify what variable is impacting exports or imports. For completeness, therefore, we also estimate the effects of macroeconomic variables on exports and imports separately (Tables 3 and 4). For this purpose, weights of the U.S. exports (imports) are calculated based on the average 2000-2004 exports' (imports') share of the trading partners, which are then applied to the recalculation of the foreign variables and exchange rate index in equations (13) through (15). The results show that U.S. agricultural exports have significant relationships with the exchange rate and foreign variables (income and money supply) in both the short- and long-run. On the other hand, all five variables are found to have significant long-run effects on U.S. agricultural imports, while only the domestic variables are found to have short-run effects on U.S. agricultural imports. Hence, the findings suggest that the exchange rate and foreign variables play key roles in determining U.S. agricultural exports, while the domestic variables mainly determine U.S. agricultural imports.

CONCLUSIONS

In this paper, we explore both the short- and long-run dynamics of the U.S. agricultural trade with its major trading partners over the past three decades. The effects of the exchange rate, and income and money supply of the United States and its trade partners on the U.S. agricultural trade balance are investigated in the framework of the ARDL approach.

The results show that the exchange rate plays a key role in determining the short- and long-run behavior of U.S. agricultural trade with its major trading partners. We also find that income and money supply of the United States and its trade partners have significant effects on the agricultural trade balance in both the short- and long-run. Moreover, the variables relating to the domestic economy are found to have significant impacts on U.S. agricultural imports.

The important implication of our findings is that the most significant factor affecting the U.S. agricultural trade balance in both the short- and long-run is the strength of the economy. This is because data on exchange rate and GDP are generally convenient tools for measuring the strength of the U.S. economy. For example, a stronger economy causes the U.S. dollar to appreciate, effectively driving up U.S. export prices, which leads to a decline in U.S. agricultural exports, resulting in deterioration of the trade balance. Likewise, a rise in real income stimulates U.S. agricultural imports and diminishes the trade surplus. Moreover, our findings provide some clues for understanding the declining U.S. agricultural trade surplus since the mid-1990s. The strong dollar and rising relative income due to the remarkable economic expansion in the late 1990s enabled U.S. consumers to purchase more foreign agricultural products, particularly processed products, which could be a major reason for the slow growth of U.S. agricultural exports relative to U.S. agricultural imports.

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