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Dynamic Interrelationships between the U.S. Agricultural Trade Balance and the Macroeconomy

Jungho Baek and Won W. Koo

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 U.S. agricultural trade in both the short and long run.

Key Words: agricultural trade balance, autoregressive distributed lag model, exchange rate, income, macroeconomy, money supply

JEL Classifications: C32, F14, Q17

Over the past 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, because of 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 50%, from $36 billion in 1997 to $54 billion in 2004. Meanwhile, exports have fluctuated from a low of $48 billion in 1999 to a high of $61 billion in 2004. Accordingly, the trade surplus has shrunk to $7 billion in 2004 (Figure 1). The U.S. Department of Agriculture (USDA) has projected that the current trade surplus will become negative within a couple of years. In fact, during the first 6 months of 2005, the values of U.S. exports and imports almost equaled each other at approximately $30 billion.

Agricultural economists have long recognized the importance of macroeconomic variables influence (e.g., exchange rates and growth in home and in 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 demonstrates the negative relationship between U.S. income and the trade balance in agriculture. Likewise, as shown in Figure 3, a real depreciation of the U.S. dollar tends to increase U.S. agricultural exports through increased competitiveness in U.S. agricultural

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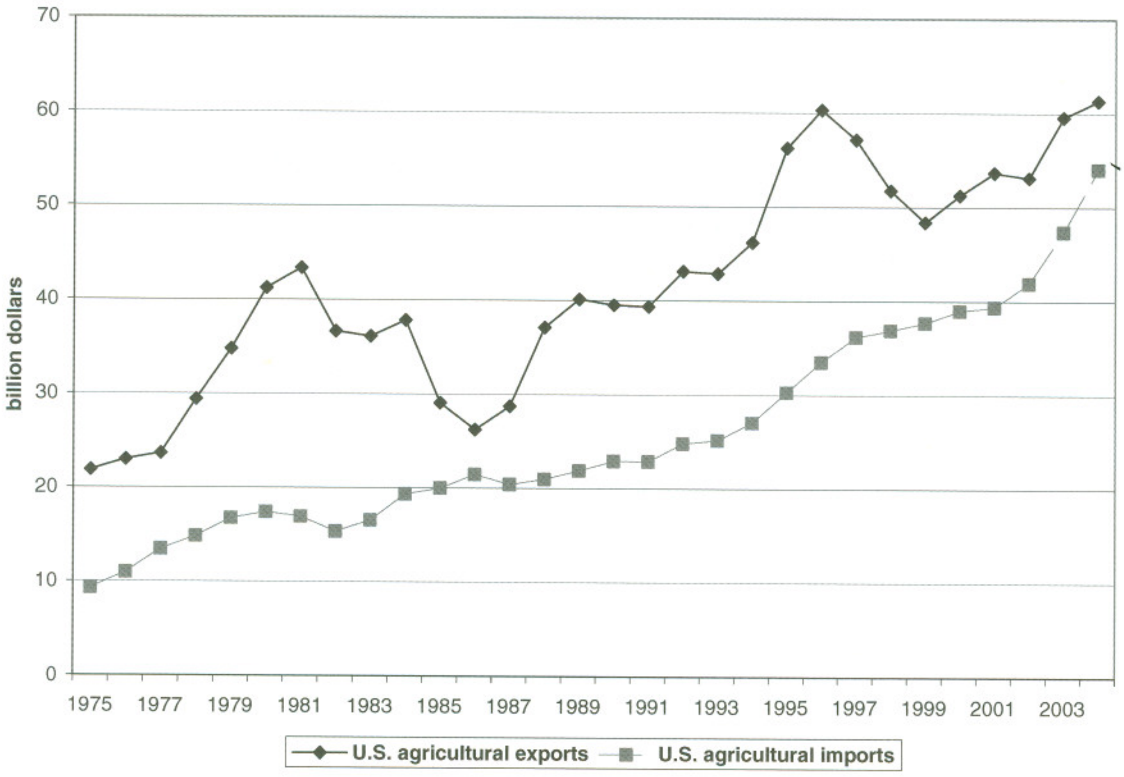

Figure 1. U.S. Agricultural Exports and Imports (Source: United States Department of Agriculture, Economic Research Service)

prices, thereby increasing the trade surplus. 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, Jung, and Boyd use time-series analysis (i.e., Shiller lag model) to investigate the factors influencing the U.S. trade balance. Bahmani-Oskooee and Ratha adopt 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 (Batten and Belongia; Bessler and Babula; Bradshaw and Orden; Orden; Chambers 1981, 1984; Chambers and Just; Gardner). For example, Chambers and Just use 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 employ the Granger causality test to analyze exchange-rate effects on U.S. agricultural exports and prices. However, dynamic interrelationships between macroeconomics variables and the U.S. agricultural trade balance have been neglected.

In this article, we 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 (except China). These countries account for approximately 81% of U.S. total trade in agricultural commodities (Table 1). We employ an autoregressive distributed lag (ARDL) model developed by Pesaran

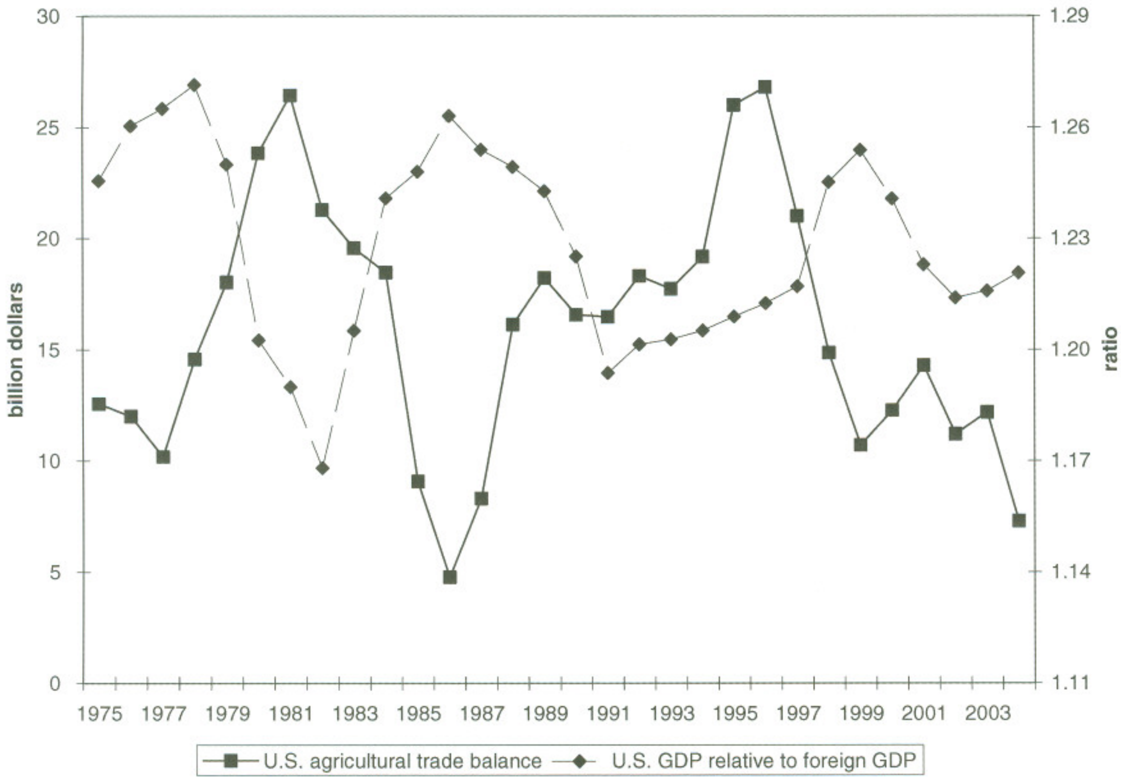

Figure 2. U.S. Trade Balance in Agriculture and U.S. GDP Relative to Foreign GPD (Source: International Financial Statistics, International Monetary Fund; Note: U.S. agricultural trade balance is expressed as trade surplus)

and Shin and by Pesaran, Shin, and Smith. This approach has certain econometric advantages in comparison to standard cointegration methods (e.g., Engle and Granger; Johansen). More 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 pretesting and introduces a further degree of uncertainty into the analysis of level relationships (Pesaran, Shin, and Smith, p. 289). To overcome these weaknesses, Pesaran, Shin, and Smith develop 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 pretesting for unit roots, and it avoids problems associated with nonstationary time-series data (i.e., spurious regression). In addition, the ARDL model takes sufficient numbers of lags to capture the data generating process in a dynamic framework of a general to specific modeling. Finally, 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.

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 data set used in the analysis. The empirical results are discussed followed by some conclusions.

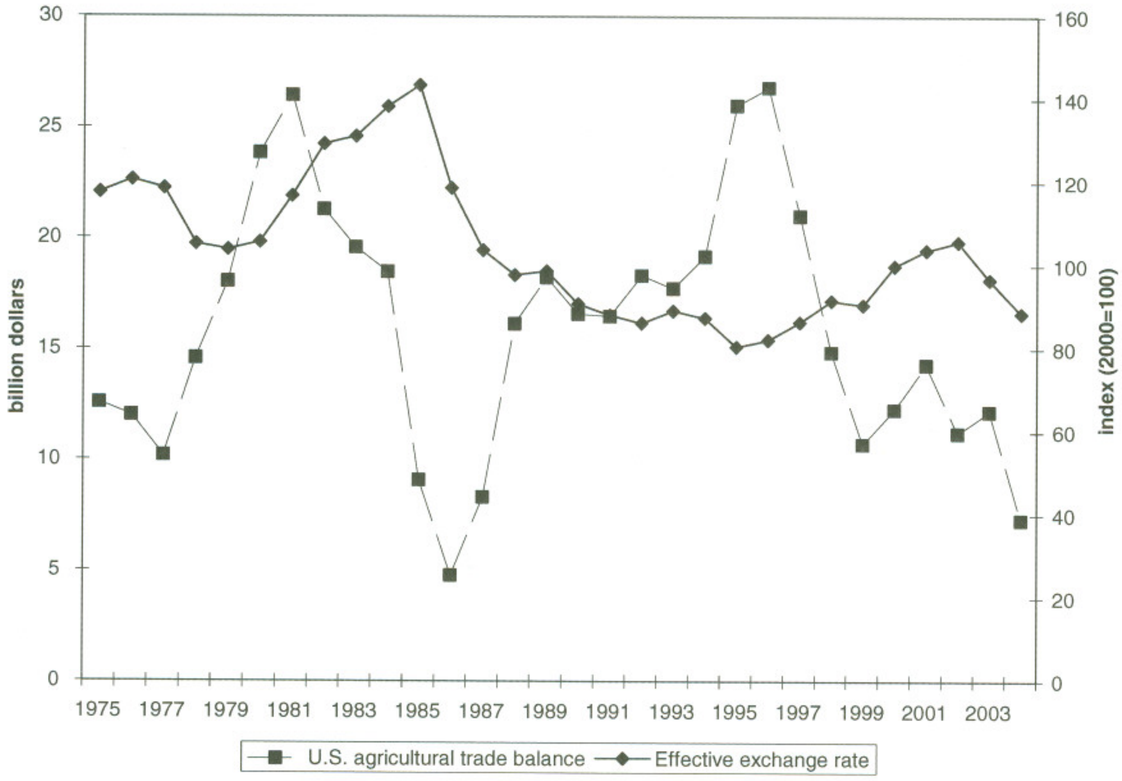

Figure 3. U.S. Trade Balance in Agriculture and Effective Exchange Rate (Source: International Financial Statistics, International Monetary Fund; Note: U.S. agricultural trade balance is expressed as trade surplus)

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). 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. This is known as Marshallian demand-and-supply analysis (Dornbusch). 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 domestic imports (exports). Additionally, $P_m(P_x^*)$ is defined as $P_m = NE \times P_m^*$ ($P_x^* = P_x/NE$), 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 domestic exports (imports). Given Equations (1) and (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

Table 1. United States Agricultural Trade: 2000–2004 Average

Country	Exports (Million $)	Imports (Million $)	Total (Million $)	Share[a] (%)
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

Source: United States Department of Agriculture, Economic Research Service (USDA/ERS).

[a] Share represents % shares of each country's total trade in world total trade.

thus 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.[1]

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. This is known as (a variant of) Keynesian multiplier analysis (Alexander).[2]

[1] To show the effects of exchange-rate change on the trade balance, this approach differentiates Equation (3) with respect to the exchange rate, translates the results into elasticity form, and thus establishes the following elasticity condition: a country's devaluation can improve a trade balance when the sum of domestic and foreign price elasticities of demand (in absolute value) exceeds one (Marshall-Lerner condition).

[2] The reason is that both approaches stem from the following basic national-income accounting identity: $Y = C + I + EX - IM$, where C is consumption, and I is investment. Setting $C + I = A$ thus yields $Y - A = EX - IM$. In addition, this approach asserts that A (absorption) is directly influenced by both fiscal and monetary policy.

According to this approach, the TB in domestic currency is defined as

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

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.[3]

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). The trade balance in this approach is specified as follows:

$$(5) \quad TB = \Delta FR,$$

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

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

where ΔDC is the change in the domestic credit. Given Equations (5) and (6), the TB in domestic currency is then

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

The monetary approach thus suggests that the trade balance is determined by changes in the money supply (i.e., the foreign-reserve holdings).[4]

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

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

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 the 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, pp. 506–507).

[3] The absorption approach identifies two direct effects of changes in macroeconomic policies on the trade balance: the expenditure-substituting and income effects. For example, a real devaluation lowers the relative price of domestic goods in domestic currency, thereby resulting in an increase in net exports. It thus causes a shift in demand from foreign goods toward domestic goods, which increases domestic production and thus the trade balance (expenditure-substituting effect). At the same time, a rise in net exports leads to an increase in domestic income, which tends to induce more imports through the marginal propensity to absorb (consume), thereby deteriorating the trade balance (income effect). As such, the net effect of a real devaluation on the trade balance depends on the combination of these two effects.

[4] For example, a real devaluation increases import prices and raises the price level of domestic goods, thereby resulting in a reduction of supply of money stock (excess demand of money). Under this circumstance, individuals tend to restore their real money balances and holdings of financial assets by reducing their spending and consuming less, which improves money account and thus the trade balance. However, when the desired balance is restored to their financial holdings, individuals tend to increase their expenditures, leading to a deterioration in the trade balance. As such, the monetary approach argues that changes in macroeconomic factors (i.e., exchange rates) have only a transitory effect on the trade balance. For that reason, this approach says little about the effects of changes in macro-trade balance linkages and the transmission mechanisms on those relationships (Whitman).

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) to represent the relationship between the United States and its major trading partners. This relationship is specified as follows:

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

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 (see the data section for calculation method of the weighted average of income, money supply, and exchange rate).

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.[5]

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

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

[5] The absorption approach points out that fiscal policy (e.g., government spending) also can affect the trade balance through changes in income. Because data are unavailable, however, we cannot consider this effect in our analysis.

With regard to the signs of the coefficients in Equation (10), it is expected that $\beta_1 < 0$ ($\beta_2 > 0$) because an increase in 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 surplus. This expected relationship is consistent with the absorption approach. The effect of the money variable on the trade balance is not certain (Miles). Johnson argues that a rise in the 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. In this case, it is expected that $\beta_3 < 0$ ($\beta_4 > 0$). However, Miles (pp. 604–605) argues that this relationship may not be observed for the following three reasons: (1) nominal money balances may be a small fraction of the individuals' wealth, (2) money may not be perceived as net wealth by individuals, and (3) the response of expenditures to wealth changes could not be significant. Finally, regarding the effect of exchange rate, it is expected that $\beta_5 > 0$ because 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, Shin, and Smith). From equation (10), the ARDL model of interest can be written as follows:

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

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 because the terms with the summation signs ($\sum$) represent the short-run dynamics between the trade balance and its main determinants, whereas the second part (terms with λ) 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 nonexistence of the long-run relationship.

Finally, it should be noted that, because the ARDL model is based on a single-equation approach, it may not be able to correct the potential endogeneity of the explanatory variables (i.e., exchange rates) and thus yield insufficient estimates of the short- and long-run relationships. In our case, however, because the size of the agricultural sector is small relative to the entire economy in the United States and its major trading countries, the exchange rate, income, and money supply are expected to behave exogenously in the agricultural sector. As such, this economic relationship justifies the use of a single-equation approach to estimate Equation (11).[6]

Data

As noted in the introduction, the main purpose 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, using average 2000–2004 trade weights, we identify the U.S. 30 most-important trade partners. Note that weighted values of the U.S. agricultural trade to its trading partners (w_i) are calculated based on the average 2000–2004 trade share of each partner among the top 29 trading countries as follows:

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

where EX_i (IM_i) is the U.S. agricultural exports (imports from) to the partner country i; $i = 29$ countries because China is not included in the calculation of our weights because of the unavailability of the data. Quarterly data are collected for the period from the fourth quarter of 1975 to the fourth quarter of 2004.

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) in the USDA.[7] The U.S. trade balance is then expressed as the ratio of exports to imports (trade surplus). The reasons for using the trade balance as the ratio are (1) to reduce the degree of sensitivity to the units of measurement and can be interpreted as real trade balance, (2) to narrow the range of the variable to make it less susceptible to

[6] For comparison, the Johansen cointegration method is also applied to Equation (9). The results show that there is one stable, long-run equilibrium relationship among the six variables. The weak exogeneity tests further indicate that all variables except the trade balance are weakly exogenous at the 5% level. The finding implies that these variables do not adjust to deviations from any equilibrium state defined by the cointegration relation but are rather determined outside the model system. This also validates the use of a single-equation approach.

[7] The FATUS is a standard USDA aggregation of several thousand Harmonized Tariff Schedule (HTS) codes (>4,000 import and >2,000 export in 10-digit codes) into 213 agricultural groups most used by the public. The U.S. Trade Internet System of Foreign Agricultural Service (known as FAS Online) in the USDA provides the U.S. agricultural trade data from 1989 forward. Historical FATUS data between 1975 and 1988, on the other hand, are available electronically from the Economic Research Service (ERS) by personal request. The FATUS defines exports and imports for agricultural goods to include live animals, meat, and products of livestock, poultry, and dairy; hides and skins (but not leather products); animal fats and greases; food and feed grains and grain products; oilseeds and oilseed products; fruits, nuts, and vegetables and products of these; juices, wine, and malt beverages (not distilled spirits); essential oils; planting seeds; raw cotton, wool, and other fibers (not manufactured products of these); unmanufactured tobacco (not manufactured tobacco products); sugar and sugar products; coffee, cocoa, tea, and products of these; rubber and allied products; and stock for nurseries and greenhouses, spices, and crude or natural drugs.

outlying or extreme observations, and (3) to transform the model into a logarithmic form without being concerned about possible negative values. The real income of the United States and its trading partners is measured as the 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 comprises currency (banknotes and coins) and commercial banks' reserves with the central bank. Hence, it is a narrow definition of money supply, including only the most liquid forms of money (Bahmani-Oskooee; Doroodian, Jung, and Boyd; Miles). 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) (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 in 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 formula (geometric mean):

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

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); $\Delta E_{it} = E_{it}/E_{it-1}$ is the change rate of the U.S. dollar in currency of partner country i from $t-1$ to t; and $E_{it} = 1/R_{it}$, where 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, and CPI_{it}^* is the CPI of partner-country i during period t. Because 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).[8] Note that, because the specification of Equation (11) is based on the assumption that ε_t is serially uncorrelated, it is

[8] To ensure comparability of results of different choices of p, all regressions are computed over the same sample period, 1977:q3–2004:q4, with the first seven observations reserved for the construction of lagged variables. In addition, it is found that lagged changes of ER_t and Y_t are insignificant (either singly or jointly) in all estimators. To avoid unnecessary overparameterization, therefore, we reestimate the regressions without these lagged variables, but include lagged changes of all other variables (TB_t, Y_t^*, M_t, and M_t^*).

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[a]	χ_{SC}^2 (1)[b]	χ_{SC}^2 (3)[b]	*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. 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, Shin, and Smith.

[a] AIC is Akaike Information Criterion for a given lag length.

[b] χ_{SC}^2 (1) and χ_{SC}^2 (3) are LM statistics for testing no serial correlation against orders 1 and 3.

important to balance between choosing a p sufficiently large to mitigate the residual serial correlation problems and one sufficiently small to avoid being overparameterized, particularly in view of the limited time-series data that are available (Pesaran, Shin, and Smith, p. 308). 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 [χ_{SC}^2 (1)) and 3 (χ_{SC}^2 (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.

With the selected lag order ($p = 3$), we then test the existence of a level relationship among six variables. For this purpose, the null hypothesis of nonexistence 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.[9] 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 because 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 can not 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).[10] As such, this result supports the existence of cointegrated trade balance equation when using $p = 3$. Note that Equation (11) is estimated with and without a linear trend to see whether a deterministic linear trend is required. However, our finding is more conclusive when the *F*-test is applied to Equation (11) without a linear trend.

[9] To determine the nature of our data, we also test the presence of a unit root in the six variables in Equation (9) using a battery of unit root tests—the Augmented Dickey-Fuller (ADF) test (1979), the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (1992), and the Dickey-Fuller generalized least squares (DF-GLS) test (Elliot et al. 1996). The results show that all the variables are nonstationary $I(1)$ processes.

[10] The 5% critical value bounds is (2.62, 3.79), which is obtained from Table CI in Pesaran, Shin, and Smith.

Table 3. Estimated Long-Run Coefficients of U.S. Agricultural Trade Models

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

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

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 past decades, U.S. agricultural imports rose steadily (Figures 1 and 2). 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% share 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). Finally, a negative (positive) coefficient of the domestic (trading partners) money supply on the trade balance is consistent with Johnson; 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. Notice that, in the long run, the domestic variables are more pronounced than foreign variables in determining the trade balance. For example, as the domestic income (money supply) increases by 1%, the trade surplus deteriorates by approximately 4.2% (0.8%). On the other hand, the trade surplus increases by only 0.17% (0.15%), given a 1% increase in the foreign income (money supply).

Then, we adopt the ARDL approach to estimate Equation (11).[11] These estimates provide evidence on the short-run dynamics that seem to exist between the trade balance and its main determinants. For this purpose,

[11] The estimated orders of an ARDL (p, p_1, p_2, p_3, p_4, p_5) model in the six variables (TB_t, Y_t, Y_t^*, M_t, M_t^*, ER_t) are selected by a general-to-specific search, spanned by lag length p = 0, 1, 2, 3 using the AIC criterion, which results in the choice of an *ARDL* (3, 0, 3, 2, 3, 0) (see Pesaran and Shin for details).

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} [a]	−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. Δ indicates the first difference of a variable.
[a] ec_{t-1} refers to the error-correction term.

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 ensures the short-run adjustment process of the trade balance to the long-run equilibrium, as well as 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 1 quarter. In other words, with a shock to the U.S. agricultural trade, it takes more than 5 quarters (1/0.18 = 5.6 quarters) to correct long-run disequilibria.

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 and by how much. For completeness, therefore, we also estimate the effects of macroeconomic variables on exports and imports separately (Tables 3 and 4).[12] 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, whereas only the domestic variables are found to have short-run effects on U.S. agricultural imports. Notice that, in the long run, the domestic variables are more important than the foreign variables in determining the U.S. imports. Given a 1%

[12] 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) to (15).

increase in the domestic income (foreign income), for example, the imports increase (decrease) by approximately 1.2% (0.2%). Hence, the findings suggest that the exchange rate and foreign variables play key roles in determining U.S. agricultural exports, whereas the domestic variables mainly determine U.S. agricultural imports.

Conclusion

In this article, 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 the income and money supply of the U.S. 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 the U.S. agricultural trade with its major trading partners; that is, the strong U.S. dollar in the late 1990s and early 2000s indeed led to a deterioration of the agricultural trade balance. We also find that the income and money supply of the U.S. 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. Therefore, our findings provide some clues for understanding the declining U.S. agricultural trade surplus since the mid-1990s. That is, the strong dollar and rising relative income and balances 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.

It should be pointed out, however, that it is also important to recognize other policy factors (shocks) that significantly affect the U.S. agricultural economy, such as farm programs and changes in the global trading system (e.g., World Trade Organization [WTO] and North American Free Trade Agreement [NAFTA]). For example, the WTO has brought into sharp focus the elimination of the trade-distorting policies (e.g., domestic subsidies) of developed countries (i.e., the European Union [EU], Japan, and the United States), which may cause an outward shift in the world supply for U.S. imports and deteriorate the trade balance. As one of the U.S. agricultural trade programs stipulated by the U.S. farm bill, on the other hand, the Export Enhancement Program (EEP) allows USDA to provide bonuses to make U.S. commodities more competitive in the world market. This may cause an upward shift in the world demand for U.S. exports and improve the trade balance.

Finally, because the interest of this study is limited to the effects of macroeconomic aggregates on the aggregated U.S. agricultural trade balance, the responses of agricultural trade in major crops or categories of products to changes in macroeconomic factors are not examined. U.S. agricultural trade is increasing or decreasing at varying rates with different commodities. In addition, the type of agricultural products being traded has also changed over the past 3 decades. As such, models that rely on disaggregate trade data could complement our aggregate analysis. This issue should be addressed in future research.

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