

**VECTOR AUTOREGRESSIVE MODELING OF AGRICULTURAL COMMODITY TRADE:
THE CASE OF AFRICA'S EXPORTS TO THE UNITED STATES**

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Abstract

It is pertinent to note that trade in agricultural commodities still dominates the export scene of the African economies. Moreover, the agricultural sector constitutes a significant part of the whole economy and employs a considerable proportion of the labour force. Furthermore, increasing agricultural exports is an intermediate step toward restoring external balance of payments equilibrium, a central component of most economic structural adjustment programmes (ESAP) initiated in the 1980s and 1990s. Against this backdrop, the major objective of this research is to increase our understanding of the specification and estimation of agricultural commodity trade models as well as to provide veritable tools for trade policy analysis. More specifically, the study aims at building a set of dynamic, theory-based econometric models which are able to capture both short-run and long-run effects of income and price changes, and which can be used for prediction and policy simulation under alternative assumed conditions

In this study, the methodology to be adopted will be a relatively unrestricted, data determined, econometric modeling approach based on the vector autoregressive process, which is very popular for modeling multiple time series. Further, econometric models will be constructed for SSA's agricultural exports to the United States (U.S). In an attempt to provide a broad-based commodity coverage, this study will also explore whether the chosen modeling approach is able to capture the essentials of the behavioural relationships underlying the SSA-US trade flow.

The study will show that vector autoregressive processes are well suited for the study of agricultural trade flows, which are typically non-stationary time series. Furthermore, the research will reveal the importance of inspection of the time series properties and the examination of both short- and long-run adjustment when studying trade functions. Finally, it is crucial to note that the different dynamic responses will often be critical to the outcomes of the types of trade policies considered.

Key words: agricultural trade, Africa, US, econometric models, vector autoregressive modeling.

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1.0 Introduction and Problem Statement

The African agricultural sector depends on the markets of the industrialised countries. In fact, the sector is continually being influenced by the activities of the World Trade Organisation (WTO) in general and the US in particular. The US represents one of the world's largest markets for raw materials and agricultural products. This makes the economy a very attractive one and always sought-after market for exports through out the world. Furthermore, in 2004, the US-Africa two-way trade increased by 37 per cent over 2003, with considerable increases in African exports of agricultural products and value-added products such as apparel and footwear (USTR, 2005). The share of agriculture in total exports from sub-Saharan Africa (SSA) to the US varies widely from 0 per cent for relatively large oil exporters, such as Angola and Gabon, to more than 95 per cent in countries such as Liberia. Agricultural exports are relatively high performing economies including South Africa and Mauritius form about 5 per cent of the total exports to the US. It is important to note that despite the small share of agriculture in the South African total exports, the country remains the second largest exporter of agricultural products from SSA to US, after Cote d' Ivoire, which accounts for at least one-third of these exports. Other major agricultural exporters are Malawi, Ghana, Kenya, and particularly Madagascar.

On November 4, 2002, U.S. a free trade agreement (FTA) was negotiated with the five member countries of the Southern African Customs Union (SACU). These nations—Botswana, Lesotho, Namibia, South Africa and Swaziland—comprise the largest U.S. export market in sub-Saharan

Africa, with \$2.5 billion in U.S. exports in 2002. SACU and the United States held successful rounds of FTA negotiations in June, August, and October 2003. This FTA— the first ever between the United States and sub-Saharan African countries — offers an opportunity to craft a groundbreaking agreement that will serve as a model for similar efforts in the developing world. The SACU countries are strong economic reformers and leading AGOA beneficiaries. They have seen the positive role that trade can play in promoting economic growth and development and, through the FTA negotiations, are taking an important step toward deeper economic engagement with the United States. Through an FTA with SACU, U.S. businesses will gain preferential access to their largest export market in sub-Saharan Africa. On the contrary, by building on the success of AGOA, the SACU countries would secure the kind of guaranteed access to the American market that supports long-term investment and economic prosperity. The FTA would also reinforce ongoing regional economic reforms and lower the perceived risk of doing business in southern Africa.

It is pertinent to note that the US continues to grant preferential market access to developing and least developed countries through Generalised System of Preferences (GSP) and the Trade and Development Act of 2000, which includes the African Growth Opportunity Act (AGOA). In fact, as a result of African Growth Opportunity Act (AGOA), almost all imports from sub-Saharan Africa (SSA) are eligible to enter the US duty-free. Furthermore, in 2004, over 98 per cent of US imports from AGOA-eligible countries entered duty-free. US imports of non-fuel commodity from Africa increased by more than \$26billion in merchandise duty-free under AGOA in 2004, an 88 per cent increase from 2003, largely due to increase in oil imports. Non-oil exports in Africa are largely agricultural in nature. Thus, non-oil AGOA imports totaled \$3.5billion in 2004, up from 22 per cent in 2003. It is pertinent to note that apparel and agricultural products accounted for more than half of non-oil AGOA imports (USTR, 2005). On the other hand, US merchandise exports to SSA were \$8.6billion in 2004, up from

25 per cent in 2003, with significant gains in agricultural goods, machinery and transportation equipment. Of note is the fact that the growth in US merchandise exports to SSA was more than twice the growth in US merchandise to the rest of the world.

However, the purpose of this study is to combine recent theories of the structure of trade and applied econometrics in order to provide a good representation of dynamic behavioural relationships underlying agricultural trade flows between Africa and the US. More specifically, the aim is to capture both short-run and long-run effects of income and price changes on Africa major agricultural commodity exports to the US, and which can be used for prediction and policy simulation under alternative assumed conditions. Furthermore, the study attempts to increase our knowledge of the behavioural relationships underlying agricultural commodity markets between Africa and the US. It is divided into three main parts. Empirical analysis of the study is based on econometric models that capture the dynamics underlying trade and price formation in commodity markets, and it is conducted by means of recently developed econometric concepts.

The first section is the introduction, while the second section formulates a general theoretical framework based on theories of trade in the presence of imperfectly competitive markets. Then, demand functions for US' agricultural imports from Africa are estimated by applying a theory-based, dynamic econometric modeling framework. These demand functions relate the level of imports to real income, price, and exchange rate.

2.0 The Theoretical Framework and Research Methodology

Imperfect competition arising from product differentiation underlies the modeling from framework of the study. The estimation of import demand systems is derived from the Armington's (1969) model, where it is assumed that the same goods of different origins are imperfect substitutes within an importing country's commodity market. Furthermore, in order to reduce to number of parameters to be estimated the model assumes a constant elasticity of substitution (CES) for each product pair. Following the model, the importing decision is split into two stages. The solution to the utility maximisation problem for the first level of decision yields the overall demand schedules for commodity imports M of importer j , given a commodity import price P and a level of constant dollar income Y , and is expressed as:

$$M_j^d = K_1 Y_j \left(\frac{P_j}{D_j} \right) \epsilon_M^P \quad (1)$$

Where K_1 is a constant with expected sign $K_1 > 0$; D is the deflator; and ϵ_M^P is the price elasticity of import demand for good M . The income elasticity is equal to unity.

Once the level of expenditures Y_j for the imported commodity M has been determined, the solution to the utility maximisation problem of how much of the commodity to purchase from alternative suppliers - let say an exporter of interest i and its competitors m , which refer each of the $n-1$ other foreign supplying countries, to market j whose corresponding export prices are P_{ij} and P_{mj} - may be expressed as:

$$X_{ij}^d = K_2 M_j \left(\frac{P_{ij}}{p_j} \right) \epsilon_M^P \quad (2)$$

Where X_{ij}^d is the quantity of the good exported from country i to country j , K_2 is a constant, P_{ij} is the price of the good imported from country i to country j , P_j is the average price of the good imported from country j ; and ϵ_M^P is the relative price elasticity of export demand.

Consider now the introduction of a tariff whose per-unit value is a specified amount into the import demand equation (1). The tariff raises the price of the commodity to $(1+t)P$ in the geographic market j . The resulting import demand schedule is:

$$M_j^d = K_1 Y_j \left(\frac{(1+t)P_j}{D_j} \right) \epsilon_M^P \quad (3)$$

Thus, provided the price elasticity of import demand, ϵ_M^P , is absolutely larger than -1.0 , buyers spend less after the tariff. If ϵ_M^P is absolutely less than -1.0 , buyers spend more. In either case, they pay higher price and purchase less than they did without the tariff.

If export demand is proportional to the change in import demand in the geographic market and relative prices remain unaltered: that of the country of interest I and its competitor m is $(1+t)P_i/(1+t)P_m$, the export demand schedules for the country i in the long-run dynamic equilibrium relationship implicit in equation (2) is:

$$X_{ij}^d = a_2 M_j \left(\frac{(1+t)P_{ij}}{(1+t)P_j} \right) \epsilon_x^P \quad (4)$$

In other words, a change in the quantity demanded of the commodity because of the tariff would cause a proportional change in the demand for the commodity supplied from foreign sources. However, in some cases export demand is not proportional to the change in import demand in the geographic market when relative prices remain unchanged. A hypothesis will be tested.

2.2 Export demand specification

In terms of the general stochastic difference specification, the export demand relationship in (2) is expressed as:

$$\ln X_{ijt}^d = \beta_0 + \beta_1 \ln M_{jt} + \beta_2 \ln M_{j,t-1} + \beta_3 \ln \left(\frac{P_{ij}}{P_j} \right)_t + \beta_4 \ln \left(\frac{P_{ij}}{P_j} \right)_{t-1} + \beta_5 \ln X_{ij,t-1}^d + V_{2t} \quad (5)$$

where the expected signs of the coefficients are $\beta_1, \beta_2 > 0$; $\beta_3, \beta_4 < 0$; and $0 < \beta_5 < 1$. The results of the cointegrating regressions suggest that the demand for exports of an African country i ($\ln X_{id}$) has a steady-state response to the import demand of the US ($\ln M_{USD}$), and a transient response to the relative price of the US market ($\ln P_i / \ln P_{US}$). The following transformation of (9) incorporates an VAR driven by import demand M_j :

$$\Delta \ln X_{ijt}^d = \beta_0 + \beta_1 \Delta \ln M_{jt} + Y_2 \ln \left(\frac{P_{ij}}{P_j} \right)_t + Y_3 \ln \left(\frac{P_{ij}}{P_j} \right)_{t-1} + Y_4 \ln \left(\frac{X_i^d}{M_j} \right)_{t-1} + Y_{2t} \quad (6)$$

where $\gamma_2 = b_3$, $\gamma_3 = (\beta_3 + \beta_4)$, and $\gamma_4 = (\beta_5 - 1)$. The expected signs of the coefficients are $\beta_1, \gamma_2 > 0$, $\gamma_3 < 0$, and $-1 < \gamma_4 < 0$. The relative price term in the foregoing specification have been so transformed as to nest the ‘differences’ formulations of the variable in the levels form of the equation. The disequilibrium adjustment mechanism in the fourth term, $\gamma_4 \ln (X_{ij}/M_j)_{t-1}$, measures ‘errors’ (divergences) from the long-run equilibrium and corrects for previous non-proportional responses in the long-run dynamic growth of export demand. Since in dynamic equilibrium $\Delta \ln M_{jt} = g_2$, $\Delta \ln X = g_3$ and $\Delta \ln (P_{ij}/P_j)_t = 0$, it follows that the solution of (10), in terms of the original values of the variable, is:

$$X_{ij}^d = K_2 M \left(\frac{P_{ij}}{P_j} \right)^{-Y_3/Y_4} \quad (7)$$

Where $K_2 = \exp. \{[-\beta_0 + (1 - \beta_1)g_2]/Y_4\}$. Therefore, export demand is assumed to have a unitary elasticity with respect to the level of import demand in the geographic market. The price elasticity of export demand is expressed as $\epsilon^{MG} = -\gamma_3/\gamma_4$. The import growth elasticity, denoted ϵ^{MG} , is defined as a percentage change in export demand brought about by a 1 per cent change in the growth rate of import demand, and is expressed as:

$$\epsilon^{MG} = \frac{\partial X_{ij}^d}{\partial g^2} \frac{1}{X_{ij}^d} = \frac{1 - \beta_1}{Y_4} \quad (8)$$

3.0 Empirical Analysis of the Africa's Agricultural Exports to the US: Data and Econometric Methodology

The empirical analysis of the study will be conducted with a sample of annual data that cover Africa's major commodity exports to the US from 1981 to 2004. Volume and value data on trade flows over the period 1981-2004 are obtained from US International Trade Commission (USITC) Statistical Office. Volume data is compiled in metric tons, and value data in thousands of dollars. The total exports from SSA to US (or equivalently the US imports for consumption from SSA) are disaggregated into agricultural and non-agricultural exports. The transaction value is the value at which goods were sold by the exporter, and includes the cost of transportation and insurance, and freight to the frontier of the importing country (c.i.f valuation).

The unit prices of US imports (P_{US}), and unit prices of exports by an individual sub-Saharan African country (P_i), are derived by dividing value by volume. The gross domestic product (GDP) index and the consumer price index (CPI) are used as a measure of economic activity (Y_{US}) and price deflator (D_{US}) of the US, respectively. The source of the data is the International Financial statistics data base of the International Monetary Fund (IMF).

Estimating long-run relationships such as equations (1) and (2) are likely to pose some problems because the variables used in the analysis typically exhibit multicollinearity and non-stationarity. The problems are often dealt with by taking first differences of all the variables before any

estimation is done. Nonetheless, taking first differences is a major drawback because the low frequency (long-run) variation of the data is removed. Thereby, only short-run effects are explained by the model (Banerjee et al. 1993).

In this paper it is argued that since time series data used in trade analysis are often non-stationary unit root processes, econometric modeling of commodity demand should be based on methods, which explicitly take this feature of the data into account, namely vector autoregression (VAR). There are several main advantages in using a VAR, which is an advanced and more efficient techniques than the error correction modeling (ECM). First, it is possible to clearly distinguish between short-run and long-run effects since both first differences and levels of the variables enter the VAR. Second, the speed of adjustment toward the long-run relationship can be directly estimated. Finally, the VAR has a sound statistical foundation in the theory of cointegration developed by Engle and Granger (1987).

At the formal level stationarity can be checked by finding out if the time series contains a unit root. Tests for unit roots are performed using the augmented Dickey-Fuller (1981) tests. It is found that with the exception of price variables the null hypothesis of a unit root could not be rejected for the levels of the variables but was rejected for the first differences of the variables. Having established that the time series of the variables are integrated of order $I(1)$, the augmented Dickey-Fuller (1981) and Phillips and Ouliaris (1990) cointegration tests are undertaken, and the nature of any co integrating vectors explored.

3.1 Estimation results

The export demand functions

The elasticity estimates of export demand equations for the agricultural exports of SSA to the US are reported in this sub-section. The signs and magnitudes of the estimated coefficients are significantly in line with theoretical expectations and the diagnostic test statistics are quite satisfactory. Relative prices and error correction terms are strongly significant with an adjustment coefficients ranging from -0.06 to -0.71 . Furthermore, the models explain the changes in the volume of SSA agricultural exports to the US rather accurately. Goodness of fits is acceptable with an R^2 in a range between 0.68 and 0.88.

The models also pick up quite well the turning points and rapid rises in export demand. All tests for model adequacy yield satisfactory results. As expected, relative price movements affect significantly the trade flows of agricultural commodities, implying that exporter's market share has been influenced by price competitiveness. For the combined commodity exports of the region, the trade-weighted average relative price elasticity of export demand by the US (which is equivalent to the elasticity of substitution for market share in the US) is equal to -3.5 in the short run and -5.7 in the long run.. The short-run relative price elasticity of export demand range from -0.4 to -6.0 , and the long-run elasticity from -1.2 to -7.5 .

Therefore, care should be exercised in generalisations about the price elasticity of demand for the SSA's agricultural exports. The observed differences in relative-price coefficients by trade flow reflect the dynamic aspect of the US agricultural trade, in which particular trade flows rise and fall in price competition.

The adjustment of export demand from one level of foreign import demand to another is determined by the error correction term. The error correction terms for all the trade flow equations are strongly significant with an adjustment coefficient showing wide variations from -0.06 to -0.71 .

However, if the estimated coefficient of the import response variable is significantly greater than unity, it is a good indication for an exporting country that its exports can expand more than others and its share increase as US market grows. Among the selected commodity trade flows, coconut oil from Indonesia and palm oil from Malaysia have clearly more than proportional response to changes in the level of US import.

4.0 Conclusion

This paper has attempted to increase our understanding of the specification and estimation of agricultural commodity trade models. More specifically, the aim was to build a set of dynamic, theory-based econometric models which are able to capture both short-run and long-run effects of income and price changes, and which can be used for prediction and policy simulation under alternative assumed conditions. A relatively unrestricted, data determined, econometric modeling approach based on the vector autoregressive mechanism (VAR) was used, in order to emphasis the importance of dynamics of trade functions. Econometric modeling approach based on the VAR was used, in order to emphasis the importance of dynamic of trade functions.

The results indicate the importance of inspection of the time series properties and the examination of both short-and long-run adjustment when studying trade functions. Furthermore, the study has shown that concepts such as co-integration and error correction specification are well suited

for the study of trade flows, which are clearly non-stationary time series. The vector autoregressive mechanism is found to provide a good representation of the data-generating process of agricultural commodity flows from SSA to the US.

The overall results for the estimated export demand functions for the agricultural commodities covered by the study suggest that there is a statistically significant demand response to income changes in the US. The results also demonstrate the inelastic nature of price responses in the US demand for the SSA agricultural exports. The policy implication of this fact is that trade policy measures in the form of tariff and non-tariff barriers are not very significant in changing the quantity of SSA agricultural exports to the US.

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