THE DERIVED DEMAND FOR IMPORTED WHEAT IN GHANA

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ABSTRACT

The goal of this paper is to provide the U.S. wheat industry with empirical estimates of the sensitivity of Ghana's derived demand for wheat differentiated by country of origin. Divisia index elasticities for the U.S. and the rest of the world (ROW) are 0.500 and 1.686 respectively, indicating that as total imports increase, imports from the ROW should increase by the larger percent. Own-price elasticities for the U.S. and the ROW are -0.567 and -0.778 respectively indicating that the demand for wheat from both sources is inelastic. Cross-price elasticities indicate that U.S. wheat and ROW wheat are substitutes.

INTRODUCTION

Economic reforms in Sub Sahara Africa (SSA) are changing the perception international businesses have about the potential for this region to be economically profitable. The removal of exchange controls, liberalizing investment regimes, privatizing state-owned enterprises, eliminating subsidies and price controls, and instituting tighter government discipline have led to an economic environment more open to global trade and foreign investment [14]. Furthermore, the relationship between developed nations and SSA is shifting from one of developmental aid to foreign direct investment. Given that this region represents well over a half billion consumers and if economic reforms continue to have a positive effect on growth, countries that seek to remain competitive in international markets must improve their relationship with SSA [13].

The importance of SSA to the U.S. as a means of maintaining international competitiveness in exports markets is decisively clear. However, the question thus arises, how have U.S. exports competed in SSA markets in the past and what is America's current position? How are U.S. products viewed relative to similar products produced domestically or in other foreign countries? What relationships is the U.S. establishing or have established that are geared toward improving trade between the U.S. and SSA. As the U.S. market share of world exports is lost to the European Union and the Asian economies, the African market is becoming a market that can no longer be ignored by the U.S.

Of the countries in SSA, one particularly important to the U.S. is the country of Ghana. Since 1983 Ghana has pursued economic reform policies aimed at encouraging private sector development and reducing government involvement. Although the private sector has been weak in the past, economic reform has resulted in two-thirds of the 300 state-owned enterprises to be sold to private owners.

Additionally real economic growth has been from 4 to 5 percent per year in recent years [15].

An important market in SSA for the U.S. is the market for wheat in Ghana. Virtually all of Ghana's wheat consumption is through imports from primarily the US, Canada, Argentina, and the EU. Currently 90 percent of all wheat is imported from the U.S. with the remaining 10 percent being imported from the other sources previously mentioned [10]. In 1998, Ghana imported 278,334 metric tons of wheat for an overall value of 35.6 million dollars, up 39 percent when compared to 1997. This made Ghana the fourth largest wheat importer in the Sub-Saharan Region. Ghana is also the second largest importer of U.S. wheat in the Sub-Saharan region [6] [9].

Although there is some local production, domestically produced wheat accounts for less than a tenth of a percent of total available supply. Given Ghana's status as a significant wheat importer within the Sub-Saharan Region, and given its importance to the disappearance of U.S. wheat exports to that region, it is clear that if the U.S. is to remain competitive in SSA it must maintain its market share of Ghana's wheat imports. As economic reforms in Ghana continue, many countries are changing their perception of doing business in Ghana and seeking to increase overall trade. Given these concerns the question arises, how competitive is U.S. wheat in Ghana when compared to wheat produced in other countries?

In assessing competitiveness the following questions arise. As U.S. wheat prices change, what affect does this have on Ghana's demand for U.S. wheat? What affect dose this have on Ghana's demand for wheat imported from countries other than the U.S.? Additionally, as wheat prices in other countries change, what effect does this have on the demand for U.S. wheat? Lastly, as wheat consumption increases in Ghana, will the U.S. be the primary beneficiary or will other wheat exporting countries benefit most? The major goal of this paper is to answer the above questions by providing the U.S. wheat industry with empirical estimates of the sensitivity (elasticities) of Ghana's derived demand for imported wheat, differentiated by country of origin, with respect to price changes and total import changes. These estimates are used to assess the relative competitiveness of wheat imported from the U.S. to wheat imported from other source countries. Past studies that assessed the demand for imports differentiated by source country of production have used a utility or consumer approach to obtain import demand equations. However, given that imported wheat is used to produced other goods such as bread and flour, is purchased by firms and not consumers, and that a significant amount of transformation and/or value added takes place after it reaches Ghana, this study will estimate demand from a production approach where imports are inputs into production processes.

Specific goals are: (1) To econometrically estimate the derived demand for imported wheat in Ghana where imports are differentiated by country of origin; (2) To utilize the empirically estimated import demand parameters to provide empirical measures of the sensitivity of demand to changes in total imports, own price, and the prices of cross country substitutes.

CONCEPTUAL FRAMEWORK

This study assesses the competitiveness of wheat imports into Ghana from the U.S. compared to whey imported from other countries such as the EU and Canada. Following an Armington specification, similar wheat products such as EU wheat and US wheat are both individual goods that are part of the product group wheat, but different based on their source country of production. There are a number of reasons why similar products are viewed as different based on their source country of origin. Wheat from different sources may actually be physically different. For example, the U.S. primarily exports hard wheat to Ghana while the EU exports soft wheat [10]. The crux of this assumption is that within an importing country, a particular product imported from a given source is considered a substitute for that same product from another source. However, because of the physical and perceived differences attributed to the product due to its origin, these products are imperfect substitutes.

In this paper it is assumed that wheat is imported through firms that exclusively import. Although, there are firms within Ghana that import wheat as well as transform wheat into other products, it is assume that there is a separate entity within the firm that deals primarily with the procurement of imported products. In addition to providing imported products to other firms, these firms also provide the services that are associated with importing. These services include, search and acquisition, transportation, logistics, and storing. A major characteristic of this firm type is that it deals primarily in imported goods. This suggests that the procurement of imported goods by firms is a unique process separate from the procurement of similar products produced domestically. Even if the firm is a subsidiary or branch of a larger firm that purchases domestic and foreign produced inputs, it is not unlikely that the subsidiary that is responsible for imported inputs deals primarily in this activity. This is because the acquisition of foreign produced goods is more involved than purchasing domestically produced goods.

If we assume a production function for these firms, then the output of these firms is the imported goods that are sold to other firms and the inputs are the imported goods from the various exporting countries. If we minimize cost subject to this function, the system of input demand equations resulting from the optimization procedure will be a system of import demand equations. If we assume product differentiation across source countries, then each import demand equation represents the demand for a product from a particular source.

OVERVIEW OF THEORY

Using the methodology of Laitinen (1980) [11], the differential derived demand model will be used to estimate Ghana's import demand for wheat. The differential derived demand model is derived from the differential approach to the theory of the firm where firms maximize profit in a two-stage procedure. In the first stage, firms determine the profit maximizing level of output to produce and in the second stage firms minimize the cost of producing the profit maximizing level of output. Davis and Jensen (1994) [5] notes that this procedure is consistent with a one-step or direct profit maximization procedure.

In the second stage the differential derived demand model is derived, which will be used to estimate the system of source specific import demand equations. This model is specified as

$$\bar{f}_{it} D x_{it} = \theta_i D X_t + \sum_{j=1}^{n} \pi_{ij} \ D w_{jt} + \varepsilon_{it} . \tag{1}$$

$Dx_t = \log(x_t)-\log(x_{t-1})$ and $Dw_t = \log(w_t)-\log(w_{t-1})$ are the log change in quantity and price respectively from period t-1 to t, where x_i and w_i are respectively the quantity and price of Ghana's imported wheat from source country i. $\bar{f}_{it} = (f_{it} + f_{it-1})/2$, where f_i is the *ith* exporting country's share of total cost (Ghana's total expenditures on wheat imports). DX is the finite version of the Divisa input index, where $DX_t = \sum_{i=1}^{n} \bar{f}_{it} D x_{it}$. π_{ij}'s are the price coefficients and θ_i is the marginal share of the *ith* input in marginal cost. Both are parameters to be estimated [11] [16].

A key feature of the DFAM is that production theory can be tested or imposed upon the system to determine if the data is consistent with theory. The properties, homogeneity and symmetry are imposed and tested, and negative semi-definiteness is checked by inspection of the eigenvalues of the price coefficient matrix. The homogeneity property in the DFAM model is satisfied when $\sum_j \pi_{ij} = 0$. Symmetry is satisfied when $\pi_{ij} = \pi_{ji}$.

When applied to the estimation of the derived demand for wheat imports into Ghana, equation (1) is the *ith* derived demand equation for imported wheat into Ghana from exporting country i, where $i \in$ (US, ROW). ROW is the rest of the world, which in this instance is an aggregation of all imports of wheat into Ghana not imported from the U.S. The Divisa input index is now an index of total wheat imports into Ghana. f_i is the total cost of wheat from source country i divided by the total cost of all wheat imported into Ghana. w_i's are the prices for imported wheat charged by the exporting countries. x_i is the quantity of wheat imported into Ghana from the *ith* exporting source.

Estimation of the system of equations represented by equation (1) is accomplished using the LSQ procedure in the econometric program package Time Series Processor (TSP), version 4.4. The LSQ procedure in TSP when estimating the seemingly unrelated regression problem uses the multivariate Gauss-Newton method to estimate the parameters in the system. This procedure generates parameter estimates, standard errors, and probability values; also, a goodness of fit measure for each equation (R^2), the Durbin Watson statistic for each equation, and the log likelihood function value for the system [8].

Since the DFAM is a singular system, an equation must be deleted from the system when using the LSQ procedure. The equation deleted is the ROW equation, which is the least important equation to the system. However, parameter estimates for this equation are recovered by re-estimating the system with another equation deleted and this one replaced. This is possible because parameter estimates are invariant to the equation deleted when using maximum likelihood estimation [1].

The system goodness of fit measure used is the measure presented by Bewley (1986) [4]:

$$R_W^2 = 1 - \frac{1}{1 + W^*/(T-k)(n-1)} \tag{2}$$

where W^* is the Wald statistic that forces all the coefficients in the system to zero. T is the number of observations, n is the number of equations in the full system, and k is the number of regressors in each equation.

The test for AR(1) in the DFAM model is accomplished using the likelihood ratio (LR) test where the DFAM with AR(1) imposed is the unrestricted model and the DFAM without AR(1) is the restricted model. In this study, the estimate of the autocorrelation parameter ρ will be obtained using full maximum likelihood estimation where ρ will be common across equations. This procedure is found in Berndt and Savin (1975) [3], Green et al. (1978) [7] and Beach and MacKinnon (1979) [2]. If autocorrelation cannot be rejected, then the autocorrelated DFAM will be used to test for economic properties and forecasting.

The DFAM allows for homogeneity, symmetry, and negative semi-definiteness to be tested, imposed, or checked. The homogeneity property is satisfied when $\sum_j \pi_{ij} = 0$, which implies that $\pi_{in} = -\pi_{i1} - \pi_{i2} - \cdots - \pi_{in-1}$. Imposing this restriction on equation (1) yields [12]

$$\bar{f}_{it} D_{it} = \theta_i DX_t + \sum_{j=1}^{n-1} \pi_{ij} \ (D w_{jt} - D w_{nt}) + \varepsilon_{it} \,. \tag{3}$$

Equation (3) is estimated using the LSQ procedure in TSP. The resulting log likelihood value is obtained from the estimation procedure and used in a LR test to determine if the homogeneity constraint is valid. The symmetry constrained ML estimator can be obtained using the LSQ procedure in TSP as well. This is accomplished by imposing homogeneity and then restricting the symmetric parameters equal. To illustrate, the *ith* price coefficient in the *jth* equation will be restricted to equal the *jth* price coefficient in the *ith* equation. Once these restrictions are imposed, estimates are obtained using the LSQ procedure.

The property of negative semi-definiteness is validated by inspection of the eigenvalues of the price coefficient matrix. This property is verified when all of the eigenvalues are less than or equal to zero. If any values are questionable, judgement is made based on the standard errors of the price coefficient estimates.

Mean –based elasticities will be calculated using the constrained parameters resulting from the estimation procedure. These elasticities are as follows.

$$\varepsilon_{xw} = \frac{Dx_i}{Dw_j} = \frac{\pi_{ij}}{f_i} \tag{4a}$$

Equation (4a) is the conditional own and cross price elasticity. This will be evaluated at the mean factor share. From equation (4a) we will know the percentage change in the quantity demanded of imported wheat from the *ith* source country resulting from a 1 percent change in the price of that same product from source country *j*.

$$\varepsilon_{xX} = \frac{Dx_i}{DX} = \frac{\theta_i}{f_i} . \tag{4b}$$

Equation (4b) is the Divisa index elasticity, which reflects the effects of a change in the Divisa index on imports from the various source countries. Given that this index is proportional to total imports, this elasticity reflects the effects of total import changes on source-specific imports.

The Commodity Trade Statistics section of the United Nations provided the data used in this study. Imported quantities are in metric tons and values are in \$1000US. Source countries are the U.S. and the ROW. Given that there was no other countries that exported to Ghana for the entire period considered all other exporting countries are aggregated as the ROW. The time period for the data set was from 1962 to 1998. The value of imports was on a cost, insurance, and freight (CIF) basis, which include the cost of the product, the insurance paid, and the transportation cost. Commodity prices were calculated by dividing the value of the commodity imported by the quantity, which results in a per-unit cost per kilogram measure. The rest of the world quantities and values were calculated by subtracting from the total quantity and value imported the quantity and value from the U.S. respectively.

EMPIRICAL RESULTS

The first step in the estimation procedure was to test for the presence of autocorrelation in the system. Since estimation of the DFAM requires that we take the first difference of the log of the variables, this is often a correction for autocorrelation; however, autocorrelation may still exist. A likelihood ratio (LR) test was used to test for the presence of AR(1) in the estimated system. Likelihood ratio test indicated the null hypothesis of no autocorrelation could not be rejected at the 0.05 significance level.

In addition to autocorrelation, LR tests were also used to test if the data satisfied the economic properties, homogeneity and symmetry. The results of these tests are summarized in Table 1. LR tests indicate that the property of homogeneity could not be rejected at the .05 significance level. Given that there are only two countries in the model, when homogeneity is imposed, symmetry is automatically satisfied. Therefore no test was needed.

The property of negative semidefiniteness was verified by inspection of the eigenvalues of the price coefficient matrix. This property is validated when all of the eigenvalues are less than or equal to zero. All eigenvalues were non-positive. Eigenvalues that had zeros up to the third decimal place were considered to be zero.

Table 2 displays the fully constrained (homogeneity and symmetry imposed) parameter estimates for Ghana’s derived demand for imported wheat. All price parameter estimates are highly significant and the signs of the own-price estimates are negative, as expected. The cross-price coefficient which represents the relationship between U.S. wheat and wheat from the ROW indicate that imports from these two s sources are considered to be substitutes in Ghana. All of the estimates for the marginal factor shares are highly significant for each equation and are all positive indicating that as total imports increase, imports from each source country should increase as well. However the marginal factor share for the ROW (0.7107) is

Table 1 Likelihood ratio test results for economic constraints

Model	Log-likelihood Value	LR*	$P[\chi^2_{(j)} \leq LR^*] = .95$
Unrestricted	-10.625		
Homogeneity	-10.749	.248	5.99(2)[a]

[a] The number of restrictions are in parenthesis.

Table 2 DFAM parameter estimates for imports of wheat in Ghana

	Price Coefficients, π_{ij}		Marginal Factor Shares, θ_i
Exporting Country	US	ROW[a]	
US	-.3281 (.1269)***	.3281 (.1269)***	.2893 (.0737)***
ROW		-.3281 (.1269)***	.7107 (.0737)***
System $R^2 = .99$			

[a] ROW= rest of the world.
[b] Asymptotic standard errors are in parentheses.
*** Significant level = .01

Table 3 Ghana Divisia and price elasticities of the derived demand for imported wheat

	Elasticities			
Exporting Country	Divisia Import	Conditional Own-Price	Conditional Cross-Price	
			US	ROW[a]
US	*0.500* (.127)	*-0.567* (.219)		*0.778* (.301)
ROW	*1.686* (.174)	*-0.778* (.301)	*0.567* (.219)	

[a] ROW = rest of the world.
[c] *Italics* indicate that the elasticity was significant by at least .01.
[c] Asymptotic standard errors are in parentheses.

significantly higher than marginal factor share for the U.S. (0.2893). This indicates that as total imports of wheat increase in Ghana, the greater quantity will be imported from the ROW. This is likely due to increase demand for products that require soft wheat as an ingredient, which results in increased derived demand for soft wheat. Given that the U.S. primarily exports hard wheat, the ROW satisfied this increased demand.

Divisia index and price elasticities evaluated at the mean are presented in Table 3. The Divisia index elasticities for U.S. and the ROW are 0.500 and 1.686 respectively. These elasticities indicate that as that as total imports of wheat into Ghana increases, imports from the ROW should increase by the larger percent, over 3 times the percentage increase for the U.S. This should not be surprising since the U.S. in recent years have accounted for over close to 90 percent of all wheat imported into Ghana. This indicates that a small increase in imports in terms of quantity may actually represent a significant increase in imports in terms of percent. However, as mentioned before, the quantity of ROW wheat imports into Ghana is likely to increase with increases in Ghana's total wheat imports, significantly more so than U.S. wheat imports. Own-price elasticities for the U.S. and the ROW are -0.567 and -0.778 respectively. This indicates that the demand for wheat from both sources is inelastic. However the derived demand for ROW wheat is relatively more elastic when compared to the U.S. Both elasticity estimates indicate that expenditures on each product should increase as prices increase. Given the U.S.'s market share of Ghana's wheat market (90 percent), which indicates some monopoly power, inelastic demand implies negative marginal revenue. This suggests that it is possible to increase profits for U.S. firms by increasing the price of U.S. wheat. Cross-price elasticities indicated that wheat imported from the U.S. and the ROW is substitutes in Ghana. Although cross-price elasticities for the U.S. and the ROW are not exactly identical, standard errors suggest that the cross-price elasticities are statistically identical. Therefore no significant differences in cross-price effects will likely occur (Table 3).

SUMMARY AND CONCLUSION

This study is an attempt to assess the competitiveness of U.S. wheat exported to Ghana when compared to wheat exported from other countries. Overall the own-price elasticities for both the U.S. and the ROW indicate that Ghana's demand for imported wheat is inelastic, which is a good implication that increases in world prices due to trade deregulation will result in greater wheat expenditures in Ghana. The Divisia Import elasticities indicate that as total wheat imports increase the largest percentage increase in source-specific imports will be from the ROW. According to the USDA, wheat imports into Ghana will continue to grow at a phenomenal rate. If this is the case, imports from the ROW will likely increase as well and by a larger amount in terms of both quantity and percentage when compared to the U.S. However, given the U.S. dominance in Ghana's wheat market, the U.S. will likely remain the dominant supplier.

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