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UGANDA COFFEE SUPPLY RESPONSE AND EXPORT DEMAND: AN ECONOMETRIC ANALYSIS

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ABSTRACT

Econometric methods were used to estimate the supply and demand functions for Uganda's coffee using time series data for the period 1971–91. Eight major importing countries for Uganda's coffee: U.S., U.K., Japan, France, Italy, Spain, Germany, and the Netherlands were considered in export demand analysis. The models generated were able to capture over 70 % of the variation in output for *robusta* coffee and 50 % for *arabica* coffee. Farmers were responsive to producer price incentives and the structural adjustment programmes instituted in Uganda had a positive impact on coffee production. Short run and long run elasticities were between 0.052 and 0.314 for *robusta* coffee and 0.088 and 0.526 for *arabica* coffee, respectively. The demand for Uganda's coffee is a function of a number of factors and varies from one consuming country to another. The study draws the conclusion that improved producer prices is one of the important factors in maintaining or increasing Uganda's coffee production. This may be achieved through reduced costs and improved yields resulting from adoption of improved coffee technology.

Key Words: Coffee, export demand, supply response, Uganda

RÉSUMÉ

Des méthodes économétriques étaient utilisées pour l'estimation des fonctions d'offre et demande pour le café ougandais, en utilisant des données en séries pour la période 1971-91. Huit pays principaux d'importation du café ougandais: les Etats-Unis, le Royaume-Uni, le Japon, la France, l'Italie, l'Espagne, l'Allemagne et les Pays-Bas étaient inclus dans l'analyse de la demande d'exportation. Les modèles générés pouvaient déceler plus de 70 % de la variation pour le café *robusta* et 50 % pour le café *arabica*. Les agriculteurs ont répondu favorablement aux variations des prix producteurs et les programmes d'ajustement structurel ougandais influençaient la production de café d'une façon positive. Des élasticités à court et à long terme étaient entre 0,052 et 0,314 pour le café *robusta* et 0,088 et 0,526 pour le café *arabica*, respectivement. La demande de café ougandais est fonction de plusieurs facteurs et varie d'un pays à l'autre. On peut conclure de cette étude, que des meilleurs prix producteurs forment un des facteurs les plus importants pour la maintenance ou l'augmentation de la production de café ougandais. Ceci peut être atteint en réduisant les coûts et en stimulant la productivité par l'introduction des technologies améliorées.

Mots Clés: Café, des fonctions d'offre et demand, Ouganda

INTRODUCTION

Coffee (*Coffea*) is the most important foreign exchange earner for Uganda. In the 1980s it contributed over 90 percent of the export earnings, and currently contributes over 60 percent, the export diversification strategy notwithstanding (The Republic of Uganda—Background to the Budget, 1992/93).

Since the 1970s, Uganda's economy has faced both domestic and international constraints that have had negative effects on coffee production and export. Poor economic incentives to producers and general economic mismanagement resulted in neglect of coffee gardens, aggravating the problem of poor yields and quality due to the old age of the existing coffee trees

Over the years, Uganda has been facing stiff competition and losing market share in the international coffee market. Producers like Indonesia, India, Thailand, the Philippines, among others, have increased their production levels and consequently taken an increasing share of the international coffee trade, stimulating pressure for lower prices on the World market. There has also been a decline in the rate of increase in demand in consuming countries and a shift to milder, high quality *arabicas* (Akiyama and Varangis, 1989). Following the suspension of the International Coffee Agreement (ICA) export quota system in July 1989, there has been a slump in coffee prices especially for *robusta*. The resulting free international market situation has made coffee trade more competitive. This competitiveness is based on factors such as production and marketing costs, product quality and the macro-economic policy environment.

Consequently, the Uganda Government has adopted policy measures aimed at improving competitiveness, profitability and viability of coffee production and export. In addition to overall macroeconomic management (e.g. exchange rate re-alignment and liberalisation), the government has implemented sub-sector specific policies that include encouraging farmers to replant old coffee gardens with new improved high-yielding clonal robusta coffee, liberalisation of producer prices and marketing operations, complete abolition of the export tax, restructuring of the Coffee Marketing Board (CMB) to a limited commercial company (CMBL) and establishing a new body, the Uganda Coffee Development Authority (UCDA) to take over the regulatory functions within the sub-sector.

Given the above policy framework, there is need to estimate the coffee supply responsiveness in terms of producer response to price incentives so as to assess the impact of the policies being implemented. It is also important to determine the demand for Uganda's coffee exports in light of the changing international policies and consumption patterns. The results of the study will help to guide the future direction of change in terms of both economic policies and scientific research or developments for the sub-sector.

The objectives of this research therefore were: (a) to estimate coffee producers' supply response to price incentives; (b) to analyse export demand of Uganda's coffee in the international coffee market, and the factors affecting demand; and (c) to draw some policy recommendations based on the empirical findings from the above two objectives.

METHODOLOGY

Econometric models were specified and estimated using time series data for the period 1971-91. These data were collected from a number of sources that included Agricultural Secretariat - Bank of Uganda; Ministry of Agriculture, Animal Industry and Fisheries; Ministry of Commerce, Co-operatives and Industry; Ministry of Finance and Economic Planning; Coffee Marketing Board Limited; World Bank - Country Office; and the Department of Agricultural Economics, Makerere University. Analysis of supply response was made for robusta and arabica coffee separately. Demand functions were estimated for eight leading importers of Uganda's coffee who account for over 84 percent of total exports. These were U.S, U.K, Netherlands, France, Spain, Japan, Italy, and Germany.

Coffee Supply Functions

The functions were specified in logarithmic form because they gave best fits for the data and conform with theoretical expectations: growth of production follows non-linear and exponential trends, and linear growth should not be anticipated. This derives from the biological nature of agricultural production in Uganda.

The farm supply function was broken down into two parts:- Output function and yield function. Output function expresses the total supply response resulting from price changes as they affect both acreage planted and the yield. The yield function isolates the effect of price changes on yield.

(a) The output supply function was specified as follows (with expected signs in parentheses):

$$LnQ_i = \alpha_\phi + \alpha_1 LnQl_i + \alpha_2 LnPl_i + \alpha_3 LnD_1Pl_i + \alpha_4 Pl_c + U_{i1} \quad (1).$$
$$(+)\ (+)\ \ (+)\ \ (-)$$

Where:

Q_i = quantity of robusta/arabica coffee produced in the current year in metric tons.

Ql_i = quantity of robusta/arabica coffee produced in the previous year in metric tons.

Pl_i = real robusta/arabica coffee producer price per metric ton, lagged by one year.

D_1 = structural adjustment programme dummy which takes a value of 1 for 1981-91 (structural adjustment period), and 0 otherwise.

Pl_c = real market prices per metric ton of competing crops lagged by one year (Pl_C = Pmzl for maize and Pbnl for beans).

U_{i1} = error term.

Since one of the objectives of the study was to determine the price effects under the two policy regimes (pre-adjustment and adjustment), the structural adjustment programme dummy was entered multiplicatively with the coffee price. Thus the coefficients α_2 and $(\alpha_2 + \alpha_3)$ measure the price effects under the pre-adjustment and adjustment policy regimes, respectively. As equation 1 was specified in logarithms, α_2 and $(\alpha_2 + \alpha_3)$ were the short run own price elasticities for pre-adjustment and ajustment periods respectively, and α_4 was the cross-price elasticity. The corresponding long run elasticities were α_2/λ; $(\alpha_2 + \alpha_3)/\lambda$; and α_4/λ; λ being the coefficient of adjustment and is specified as $\lambda = (1-\alpha_1)$, where α_1 is the coefficient of the lagged dependent variable.

(b) Yield function

Yield equations were estimated because the current policy in Uganda is to replace old coffee bushes with high yielding material. It is therefore important to determine how responsive yields are to prices as this may determine the success of that policy. The specification was as shown below (expected signs are in parentheses below the coefficients):

$$LnY_i = \theta_\phi + \theta_1 LnYl_i + \theta_2 LnPl_i + \alpha_3 LnD_1Pl_i + \alpha_4 LnPl_c + U_{i2} \quad (2)$$
$$(+)\ (+)\ \ (+)\ \ (-)$$

Where:

Y_i = yield of *robusta/arabica* coffee in metric tons per hectare realised in the current year.

Yl_i = yield of *robusta/arabica* coffee in metric tons per hectare realised in the previous year.

U_{i2} = error term.

Other variables are as defined for equation 1 above. Price elasticities were also determined as in (a) above.

Export Demand Functions

The major importers' demand functions for Uganda's coffee were specified in logarithms (with expected signs in parentheses) as:

$$LnQ_{xj} = \beta_\phi + \beta_1 LnP_{xj} + \beta_2 LnGNP_j + \beta_3 LnRER_j + \beta_4 LnP_{cj} + \beta_5 D_2 + U_j \quad (3)$$
$$(-)\ (+)\ \ (+)\ \ (-)\ \ (+)$$

Where:

Q_{xj} = quantity of Uganda's *robusta/arabica* coffee exports in metric tons to country j.

P_{xj} = *robusta/arabica* coffee export unit value in U.S. dollars per metric ton weighted by country j's export price index.

GNP_j = real GNP of country j in U.S. dollars (income proxy).

RER_j = real effective exchange rate between Uganda and country j, expressed in Uganda Shillings per U.S. dollar.

P_{cj} = export price of a substitute commodity in country j ($P_{cj} = Pbz_j$ for Brazilian coffee, $Pclb_j$ for Colombian coffee, and Pt_j for tea) in U.S. dollars per metric ton.

D_2 = Dummy for ICA export quota system. (D_2 = 1 for 1971–72, 1981–85, and 1988–89, years of export quota system operation; and 0 otherwise).

U_j = Error term.

j = The U.S., U.K., Japan, France, Germany, Italy, Spain, and the Netherlands; which are the major importers of Uganda's coffee.

Since export price is not domestically determined, it would not be appropriate to adjust it to local currency. This would be justified if producer price, usually quoted in local currency, was one of the variables in equation 3. As equation (3) was expressed in logarithms, β_1, β_2, β_3, and β_4 were also interpreted as elasticities.

Estimation Procedures

In estimating the coefficients of the coffee supply and export demand functions presented above, the Ordinary Least Squares (OLS) multiple regression techniques were utilized. No simultaneous equation specifications were required: Uganda satisfies the small country condition that is a price taker in the international market. Thus, Uganda can not influence international coffee prices, and yet changes in foreign demand can influence exports only through changes in world prices (Turnovsly, 1968; Bond, 1985). In correcting the fitted equations for auto-correlation, the Preis-Wistein iterative procedure was applied. The naive price expectations model was used in the analysis because it is parsimonious in parameters. No alternative specifications of price expectations were tested because they are profligate in parameters, given the length of the data series.

RESULTS AND DISCUSSION

Farm Supply Response. The best selected results from estimating output and yield equations for both robusta and arabica are presented below. Figures in parentheses are t-statistic values, R^{-2} is the adjusted coefficient of determination, and D.W is the Durbin—Wartson statistic.

Output Equations

Robusta:

$$LnQr = 5.939 + 0.435LnQrl + 0.174LnPrl + 0.019LnD_1Prl - 0.089LnPmzl$$
$$(3.169)^{***} \quad (2.133)^{**} \quad (2.693)^{**} \quad (2.221)^{**} \quad (-1.027)$$

$R^{-2} = 0.70$; D.W = 1.96.

Arabica:

$$LnQa = 5.091 + 0.212LnQal + 0.376LnPal + 0.026LnD_1Pal - 0.127LnPbnl$$
$$(2.500)^{**} \quad (0.745) \quad (2.140)^{**} \quad (1.588) \quad (-1.022))$$

$R^{-2} = 0.53$; D.W = 1.82.

Yield Equations

Robusta:

$$LnYr = 0.737 + 0.452LnYrl + 0.158LnPrl + 0.017LnD_1Prl - 0.101LnPmzl$$
$$(1.048) \quad (2.580)^{**} \quad (3.158)^{***} \quad (2.129)^{**} \quad (-1.288)$$

$R^{-2} = 0.72$; D.W = 1.97.

Arabica:

$$LnYa = 3.103 + 0.292LnYal + 0.104LnPal + 0.033LnD_1Pal - 0.145LnPbnl$$
$$(1.991)^{*} \quad (0.984) \quad (1.998)^{*} \quad (1.821)^{*} \quad (-1.071)$$

$R^{-2} = 0.44$; D.W = 1.79.

Generally, the results conform to a priori expectations. Results from both output and yield equations indicate that farmers' response to producer prices is statistically significant and positive for both robusta and arabica coffee. The coefficient for multiplicative term of the structural adjustment dummy and coffee price is also positive and statistically significant in all the cases except for arabica output equation. Thus, the structural adjustment policy regime had a net improvement in producer price incentives in Uganda. The government from time to time used to adjust producer prices to reflect costs of production and market prices and also marketing and institutional arrangements have improved. Moreover, the government's commitment to overall macroeconomic management and controlling inflation helped to sustain producer prices in real terms. With the liberalisation of coffee prices and marketing since 1990, further improvement in producer price incentives is expected.

Price Elasticities. Table 1 shows the short run and long run price elasticities for the pre-adjustment and adjustment period derived from the analysis. The results show that arabica output is more responsive to producer price than robusta output. The converse is observed for yield price elasticities. A comparison of short run and long run price elasticities from both output and yield functions for the two policy regimes indicates that they are higher for the structural adjustment period. Thus, the structural adjustment programmes improved the responsiveness of coffee producers to prices. The cross price elasticities for competing crops were statistically insignificant and very low and therefore they are not presented in Table 1. The results confirm the intercropping behaviour of coffee farmers: both coffee and the crops grown with it simultaneously benefit some input from activities. The long run acreage price elasticities are derived by subtracting yield price elasticities from output prices elasticities in the long run (taking acreage to be given in the short run) since we know that Output = Yield x Area. When the derived long run acreage price elasticities are computed for the adjustment period, the respective values for arabica and robusta are 0.314 and 0.023.

A comparison of yield and derived acreage price elasticities for the adjustment period shows that in the long run, the supply response for robusta coffee would mainly be achieved through increases in yield, while for arabica coffee this would be through increases in acreage. Thus, the government's current policy of replanting old robusta coffee with improved high-yielding clonal material is a policy development in the right direction.

Estimates of Export Demand of Ugandan Coffee in International Markets. Table 2 shows estimates of export demand for Uganda's robusta and arabica coffee for the eight major importers considered in this study.

The estimated price elasticities have the correct negative sign and are less than unity (inelastic) in all cases, except for France for *arabica* coffee where the coefficient is elastic (greater than unity). The results were statistically significant for the U.S, Japan, Italy and Spain for *robusta* coffee, and for the U.S and Germany for arabica coffee.

The cross price elasticities suggest that Brazilian coffee is a substitute (competing

TABLE 1. Estimates of coffee supply elasticities in Uganda, 1971–91.

		Pre-adjustment Period		Adjustment Period	
		SRE	LRE	SRE	LRE
	Type of Coffee				
Output:	*Robusta*	0.174	0.308	0.193	0.342
	Arabica	0.376	0.477	0.402	0.508
Yield:	*Robusta*	0.158	0.288	0.175	0.319
	Arabica	0.104	0.147	0.137	0.194
Area: (derived)	*Robusta*	–	–	–	0.023
	Arabica	–	–	–	0.314

SRE and LRE denote the short run and the long run elasticities, respectively.

TABLE 2. Ugandan robusta and arabica coffee export demand estimates, 1971–91.

Country	Constant	LnPrj	LnRERj	LnGNPj	LnPclbj	LnPbzj	LnPtj	Trend	D2	R^{-2}	D.W
***ROBUSTA* COFFEE:**											
U.S.A.	21.860	-0.954	0.238	-0.621	–	1.569	–	–	0.571	0.85	2.49
	(1.960)*	(-5.782)***	(4.466)***	(-1.261)	(7.574)***	(7.029)***					
U.K.	6.436	-0.028	0.058	0.065	0.607	–	–	–	0.252	0.79	2.07
	(1.145)	(-0.105)	(2.133)**	(0.242)	(1.769)*	(2.134)**					
Japan	21.241	-0.648	-0.148	-0.607	0.577	–	–	–	–	0.42	2.03
	(6.799)***	(-1.819)*	(-1.771)*	(-4.250)***	(1.219)						
France	5.485	-0.104	-0.296	–	0.679	–	–	0.074	–	0.56	2.19
	(2.747)**	(-0.192)	(-1.764)*	(0.792)	(1.585)						
Germany	-17.524	-0.317	–	1.246	–	–	–	–	0.748	0.26	1.96
	(-1.550)	(-0.995)	(2.314)**	(2.186)**							
Italy	6.009	-0.750	0.204	0.231	–	–	0.353	–	–	0.62	2.38
	(1.139)	(-4.192)***	(3.735)***	(0.864)	(1.151)						
Spain	24.540	-0.443	-0.474	-0.762	–	–	–	–	-0.395	0.79	1.89
	(2.172)**	(-2.155)**	(-5.758)**	(-1.337)	(-1.415)						
Netherlands	-5.737	-0.506	-0.981	0.359	–	–	2.096	–	0.428	0.37	1.90
	(-0.210)	(-0.820)	(-2.647)**	(0.248)	(1.973)*	(1.063)					
***ARABICA* COFFEE:**											
U.S.A.	206.767	-0.659	-0.761	-9.089	–	–	–	–	1.279	0.51	1.39
	(4.135)***	(-1.858)*	(-3.370)***	(-4.010)***	(3.070)***						
U.K.	79.868	-0.044	0.414	-3.622	–	–	–	–	1.316	0.73	2.09
	(3.649)***	(-0.136)	(3.923)***	(-3.383)***	(3.991)***						
France	28.028	-1.119	0.187	-0.809	–	–	–	–	0.193	0.42	2.01
	(0.916)	(-1.120)	(1.088)	(-0.542)	(0.395)						
Germany	49.379	-0.584	0.347	-1.980	–	–	–	0.886	0.260	0.54	1.56
	(3.099)***	(-1.901)*	(1.898)*	(-2.481)**	(2.615)**	(1.068)					
Italy	54.161	-0.342	0.135	-2.111	–	–	–	–	-2.056	0.32	2.35
	(1.975)*	(-0.652)	(0.739)	(-1.556)	(-3.230)***						
Netherlands	-16.219	-0.513	–	0.918	–	1.978	–	–	0.726	0.27	1.56
	(-1.220)	(-0.960)	(1.355)	(2.936)***	(1.624)						

R^{-2} was adjusted for degrees of freedom. Figures in parentheses are t-statistic values. ***; **; and * indicate significant at 1; 5; and 10 percent levels of significance, respectively.

commodity) for Ugandan robusta in the U.S, while for U.K, Japan and France, Colombian coffee seems to be a close substitute. For Italy and the Netherlands, tea is considered as a close substitute. In the case of *arabica* coffee, Colombian coffee and Brazilian coffee are superior in the markets considered except for Netherlands where Uganda's arabica coffee can substitute for Brazilian coffee.

The income elasticities were positive but statistically insignificant for *robusta* coffee in the U.K, Italy and Netherlands. Only Germany had a positive and statistically significant income elasticity. For *arabica* coffee, only the Netherlands had a positive income elasticity. The positive income elasticity coefficients for these countries suggest that Uganda's *robusta* and *arabica* coffee are considered as normal goods in these countries. The magnitudes of the income elasticity coefficient indicate that while Germany has an income elastic demand for Ugandan coffee, the remaining three countries have an income inelastic demand.

The negative income elasticity for the U.S, Japan and Spain for robusta coffee and all countries considered except Netherlands for *arabica* coffee tend to suggest that Ugandan coffee is an inferior good for these countries. However, this may not be the case of an inferior good but a reflection of the fact that imports of Ugandan coffee in these countries constitute a declining proportion of rising income either because the saturation point of this commodity has been reached and there is apparent shift in tastes and preferences, or imports from other countries have taken Uganda's share of their coffee markets. Also, some blending techniques which call for smaller quantities of coffee beans of a particular type could explain the negative income elasticity (Abaelu, 1968; Hughes, 1969; Oni, 1970). In the U.S in particular, coffee demand has been shifting toward consumption of high quality milder *Arabicas* and gourmet coffees, such as *expresso* and *capuccino*. For *arabica* coffee, negative income elasticities imply that despite a shift in tastes in favour of *arabica* coffees in some major consuming countries, Uganda's *arabica* does not measure up to quality standards demanded by those countries (Akiyama and Varangis, 1989).

Exchange rate elasticities obtained were statistically significant and less than unity in almost all the cases. With reference to *robusta* coffee, the expected positive sign was obtained for the U.S, U.K, and Italy. For *arabica* coffee positive values were obtained for U.K, France, Germany and Italy. The positive exchange rate elasticities for these countries suggest that a sustained devaluation of the Ugandan shilling would contribute to an increase in coffee export demand. The negative exchange rate elasticities obtained for other countries could be due to the reduced expenditure-switching effect of devaluation in the short run that leads to a worsening of the trade balance which only improves over time as export and import volumes adjust.

The estimated coefficient for the dummy for ICA export quota system was positive in most respects except for Spain (for *robusta* coffee) and Italy (for *arabica*). These results demonstrate the benefits Uganda obtained from the export quota system of the ICA. Firstly, the quota limitations prevented a glut of the international coffee market and therefore prices were kept artificially high. Secondly, quota limitations reduced the degree of competition since producing and exporting countries were assigned quotas. Therefore, under the current free-market situation, a poor competitor is likely to lose market share.

CONCLUSIONS AND POLICY IMPLICATIONS

Several conclusions derive from the study. Coffee farmers are responsive to producer prices and therefore if prices increase they respond by raising production. Price elasticities indicate that in the long run *robusta* coffee production will increase primarily as a result of increasing production per unit area (yield) while for *arabica* coffee production growth will result more from expanding acreage.

EEC markets still have great potential to expand the import of Ugandan *robusta* coffee. This is especially true for Germany, Netherlands, Italy, U.K and France. On the other hand, U.S and Japanese markets offer poor prospects due to changing consumption patterns in favour of milder *arabicas* for the U.S and stiff competition for Japan. Unless quality is improved, the prospects for Ugandan *arabica* coffee in the world market will continue to be poor.

Uganda is likely to lose market share in the international coffee market in the absence of the

ICA export quota system due to stiff competition and lower prices.

The policy implications deriving from this study are as follows:

1. Since farmers respond positively to price incentives, any measures that increase producer price incentives will result in increased coffee production. Therefore the current liberalised coffee purchasing arrangements should result in increased efficiency and higher producer prices, hence stimulating coffee production.

2. The challenge to research is to develop *arabica* coffee cultivars which are adapted to slightly lower altitudes so as to raise acreage under this crop.

3. Overall, increased research into high yielding and improved quality coffee exports would lead to increased production and export demand.

4. In the marketing of coffee exports a strategy of targeting those market's where consumption trends are still positive should be adopted.

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REFERENCES

Abaelu, J.N. 1968 A quarterly Analysis of the United States import demand for varieties of green coffee. *American Journal of Agricultural Economics* 50 (2): 232–242.

Akiyama, T. and Varangis, P.N. 1989. Impact of the International coffee agreement export quota system on the World's coffee market. The World Bank, Policy, Planning and Research Working Paper, No. 148.

Bond, M.E. 1985. Export demand and supply for groups of non-oil developing countries. International Monetary Fund, *Staff Papers* 32 (1): 57–77.

Hughes, J.J. 1969. Note on the U.S. Demand for Coffee. *American Journal of Agricultural Economics* 51 (4): 912–914.

Jaeger, W. and Humphreys, C. 1988. The effects of reforms on agricultural incentives in Sub-Saharan Africa. *American Journal of Agricultural Economics* 70: 1036–1043.

Khan, M.S. 1974. Import and export demand in developing countries. International Monetary Fund, *Staff papers* 21 (4): 678–693.

Oni, S.A. 1970. The demand for Nigerian Cocoa: A statistical analysis of regional markets and projections. *Nigerian Journal of Economics and Social Studies* 12(1): 61–71.

Republic of Uganda. 1992. *Background to the Budget.* Ministry of Finance and Economic Planning, Kampala.

Turnovsly, S.J. 1968. International trading relationships for a small country: the case of New Zealand. *Canadian Journal of Economics* 1: 772–790.

Wickens, M.R. and Greenfield, J.N. 1973. The econometrics of agricultural supply : an application to the World coffee market. *The Review of Economics and Statistics* 55 (4): 433–440.