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Optimal Pricing of Primary Commodities in Developing Countries: A Model From Sub-Saharan Africa

Abstract: In most developing countries, especially in sub-Saharan Africa, prices received by farmers are not optimal in the sense that they do not optimize government revenues. In this paper a dynamic model for optimal pricing of primary commodities is developed. The model and results demonstrate that optimal prices depend on marginal cost of the commodity stock, the exporting country's supply elasticity, the importing country's demand elasticity, the social rate of time discount. Therefore when the model is cast in a static framework, or the foreign elasticity of demand is not accounted for, the result could be biased.

INTRODUCTION

Virtually all African economies depend on a single or few primary export commodities. Despite the crucial role of primary commodities, government policies in many countries have slowed down their expansion and have in many instances contributed to their decline (Franco, 1981; Lutz and Scandizzo, 1980; Bale and Lutz, 1981). Policies have taken various forms, including the setting of producer prices below the international market price levels, direct or indirect taxation of commodity exports, and overvaluation of national currencies. In most developing countries prices received by farmers are not optimal in the sense that they do not optimize government revenues. Tax rates are often imposed on a cost-plus basis which does not take into account the foreign demand and export supply relationships in the world market.

Today, many developing nations face the challenge of how to set producer prices so as to maximize government revenues and without overly taxing producers. Governments must impose a tax on agricultural exports in order to generate revenues. However, inappropriate imposition of the tax can have deleterious effects on producers' welfare.

The purpose in this study is to develop a model for the optimal pricing of primary commodities in developing countries, taking into account the excess supply and demand relationships as well as the social rate of time discount and commodity storage costs. The model is applied to the cocoa subsector in Côte d'Ivoire and Ghana, two countries in Africa that depend heavily on the export of cocoa, and where the cocoa export trade is regulated through marketing boards (Gbetibouo and Delgado, 1984).

THE MODEL

Two models are considered: (a) the static approach and (b) the dynamic approach.

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The Static Approach

The basic idea behind optimum taxation is that a nation facing a less than perfectly elastic demand curve can exploit its international market power via tax or export control to offset the combined deadweight losses caused domestically. As it faces the rest of the trading world, such a nation can select an optimal tax for its own benefit.

Mathematically, government total revenue R is defined as:

$$(1) \quad R = (P_w(Q) - P_d(Q))Q$$

Where $P_w(Q)$ and $P_d(Q)$ denote the inverse excess demand and supply curves, respectively. Totally differentiating Equation (1) gives:

$$(2) \quad dR = P_w^* dQ + Q^* dP_w/dQ^* dQ - P_d^* dQ - Q^* dP_d/dQ^* dQ = 0$$

This is equivalent to (after rearranging terms):

$$(3) \quad P_w + P_w^*(1/E_d) - P_d - P_d^* (1/E_s) = 0$$

Where $E_d = (dQ/dP_w)(P_w/Q)$ and $E_s = (dQ/dP_d)(P_d/Q)$ are the excess demand and supply elasticities. $P_w(1+1/E_d)$ is the marginal revenue (MR_f) and $P_d(1+1/E_s)$ is the marginal cost. Solving for the optimal producer price P_d^* gives:

$$(4) \quad P_d^* = (1+1/E_d)(P_w^* E_s/(E_s+1))$$

If the optimum export tax rate is expressed as a proportion of the world price P_w then Equation (4) can be written as:

$$(5) \quad P_w(1-T^*) = (1+1/E_d)(P_w^* E_s/(1+E_s))$$

The optimum tax rate becomes,

$$(6) \quad T^* = 1-[(1+1/E_d)(E_s/(1+E_s))]$$

Most often, prices are fixed by the marketing boards and do not vary with Q. In this case, the optimum tax rate is:

$$(7) \quad T^* = -1/E_d \text{ and } P_d^* = P_w - T^*$$

It is clear from Equation (7) that when the excess demand curve is perfectly elastic $(E_d = \infty)$, the optimum tax rate is zero.

A Generalized Intertemporal Approach

So far the problem has been cast in a static framework. Governments normally manage stocks and have a long-run view of the welfare of their communities. The model proposed here has as its objective the maximization of the present value of the revenues derived from imposing an export tax subject to changes in the commodity stock over time.

Formally, the control problem over an infinite horizon can be stated as follows:

$$(8)\quad \mathrm{Max}(W) = \int_0^{\infty} e^{-rt}\,(Q,S))dt$$

subject to:

$$(9)\quad R(Q,S) = (P_w(Q)Q - P_d(Q)Q) - C(S)$$

$$(10)\quad \dot{S} = -\dot{Q} = 0 \quad \text{if } \dot{S} = 0$$

$$(11)\quad Q,S > 0$$

Where, W is the measure of present value of government revenues; r is the social discount rate. $R(Q,S)$ represents the net government revenue and is defined as the difference between gross revenues from tax rate and the cost of managing the stock, $C(S)$, Equation (9). Equation (10) describes the changes in the commodity stock over time. Equation (11) gives the non-negativity conditions for the commodity stock, and the amount of commodity to be exported.

Assuming an interior solution, the current value Hamiltonian associated with the control problem described by Equations (8)–(11) is given by Equation (12):

$$(12)\quad H = P_w(Q)Q - P_d(Q)Q - C(S) + \lambda Q$$

where, λ is the current value costate associated with the equation of motion, Equation (10). Assuming an interior solution, the maximum principle requires that Equations (13)–(15) hold.

$$(13)\quad dH/dQ = Q(dP_d/dQ) + P_w - P_d - (dP_d/dQ)Q - \lambda = 0$$

$$(14)\quad r\lambda - \dot{\lambda} = H_s = -C_s$$

$$(15)\quad \lim_{t \to \infty} e^{-rt}\lambda(t)S(t) = 0$$

Equation (13) indicates that at any point in time, the quantity to be exported, Q, should be chosen so that the marginal revenue from imposing the tax is equal to the marginal cost of exporting Q plus the opportunity cost of holding the commodity stock (λ). Here, λ, measures the future benefits forgone by a decision to export quantity Q today. In other words, it is a measure of the marginal cost of 'harvesting' Q at time t rather than saving it for future generations. Equation (14) implies that the commodity stock services should be employed up to the point where the marginal benefit of the stock is equal to the social cost of the capital. The right hand side of Equation (14) represents the marginal benefit of the commodity stock while the left measures the cost of employing one unit of the commodity stock at any point in time. The cost includes both an interest charge $(r\lambda)$ and a capital gain $(-\dot{\lambda})$. Finally Equation (15) is the transversality condition.

Totally differentiating Equation (13) with respect to time and combining it with Equation (14) yields an expression for the time rate of change along the optimal path.

$$(16)\ \dot{Q} = Q\frac{r(P_w(1 + 1/E_d) - (P_d(1 + 1/E_s) + C_s}{P_w/E_d - P_d/E_s} = 0$$

where C_s is the marginal cost of the commodity stock.

In a steady state, the rate of change in the commodity stock is necessarily zero. Setting $\dot{S}_t = \dot{Q}_t = 0$ in equation (16), a steady state commodity stock S^* is uniquely defined by

$$(17)\ (P_w(1+1/E_d)-P_d(1+1/E_s))=C_s$$

Solving for P_d^* in Equation (17) gives:

$$(18)\ P_d^* = (1+1/E_d)(P_wE_s/(1+E_s) + C_s E_s/(r(1 + E_s))$$

The optimum tax rate is obtained by solving $P_d^* = P_w(1-T^*)$

$$(19)\ T^* = 1-(1+1/E_d)(E_s/(1+E_s))-C_s^*E_s/(rP_w(1+E_s))$$

It can be observed from Equations (18) and (19) that the optimal producer price and the export tax differ from those obtained under the static framework by the factor $C_s^*E_s/(rP_w(1+E_s))$. Comparative statics results can be obtained by taking the partial derivatives of P_d^* and T^* with respect to C_s and r.

$$(20)\ dP_d^*/dC_s = -E_s/(r(1+E_s))<0$$

$$(21)\ dT^*/dC_s = E_s/rP_w(1+E_s))>0$$

$$(22)\ dP_d/dr = C_sE_s/(r(1+E_s)<0 \text{ and}$$

$$(23)\ dT^*/dr = C_sE_s/(rP_w(1+E_s)>0$$

Two conclusions can be drawn from the analysis. (a) The optimum producer price depends on the marginal cost of commodity stock, the exporting country's supply elasticity, the import demand elasticity, and on the social rate. When the problem is cast in a static framework or when the foreign elasticity of demand is not taken into account, the results are biased. (b) An increase in the marginal cost of the stock leads to a decrease in the optimal producer price and an increase in the maximum tax rate. The social rate of time discount has the opposite effects. A higher value of *r* leads to a decrease in the optimal producer price and an increase in the optimal tax rate.

In the case where domestic price is fixed,

$$(24)\ T^* = -1/E_d - C_s/rP_w$$

It is clear from the results that a shortsighted trade policy that neglects commodity stock-flow relationships and the social rate of time discount will result in a serious over-taxation of the export sector. Too high a tax rate would result in considerable welfare losses through restrictions in the volume of trade, and shortfalls over time in export earnings.

Table 1 *Optimal Pricing in the Short and Long-run: Ghana and Côte d'Ivoire, Case I ($/ton)*

	Ghana				Côte d'Ivoire			
	P_w	P_d	P^*_{ds}	P^*_{dl}	P_w	P_d	P^*_{ds}	P^*_{dl}
1964	491.49	369.160	434.17	466.92	475.81	285.7	266.46	406.33
1965	380.48	369.60	336.34	361.45	349.21	322.34	195.56	298.22
1966	363.48	246.04	321.32	345.31	427.42	238.30	239.36	365.02
1967	453.73	194.04	401.09	431.04	533.33	284.63	298.67	455.46
1968	508.36	233.24	449.39	490.18	643.59	282.90	360.42	549.63
1969	684.35	251.86	604.96	650.13	823.53	251.87	461.18	703.29
1970	802.18	288.12	709.13	762.07	673.43	289.80	377.12	575.11
1971	603.82	161.70	533.77	573.63	670.07	325.30	375.24	572.24
1972	533.98	229.32	472.04	507.28	556.60	331.97	311.69	475.34
1973	788.24	318.92	696.80	748.83	875.52	352.52	490.30	747.69
1975	1489.13	478.82	1316.39	1414.67	1301.76	790.27	728.98	1111.70
1976	1366.77	510.97	1208.22	1298.43	1534.36	704.25	859.24	1310.34
1977	2290.70	638.72	2024.98	2176.16	2544.94	765.14	1425.16	2173.37
1978	3061.50	483.87	2706.36	2908.43	2920.90	1196.17	1635.70	2494.45
1979	3555.56	668.12	3143.12	3377.78	3196.49	1243.78	1790.03	2729.80
1980	3350.71	1452.00	2962.02	3183.17	2797.10	1328.61	1566.42	2388.78
1981	2063.38	1452.00	1824.03	1960.21	1675.64	1043.84	938.36	1430.99
1982	1596.69	1356.00	1411.47	1516.85	1530.33	892.19	856.98	1306.90
1983	1517.57	396.00	1394.57	1498.69	1474.51	718.77	825.73	1259.23
1984	2330.42	400.00	2060.09	2213.89	2027.61	729.77	1135.46	1731.58
1985	2078.31	480.00	1837.23	1974.39	2133.08	991.93	1194.53	1821.06
1986	2353.93	622.60	2080.87	2236.24	2177.56	1239.30	1219.43	1859.64
1987	2382.00	422.105	2105.68	2262.90	2382.00	1498.13	1335.82	2048.52
1988	1783.00	420.00	1576.17	1693.85	1783.00	1333.00	998.48	1533.38
1989	1795.00	396.00	1409.98	1515.25	1595.00	1333.00	893.20	1371.70
1989	1795.00	396.00	1409.98	1515.25	1595.00	1333.00	893.20	1371.70

Prices: P_w international; P_d domestic; P^*_{ds} short-run optimal domestic; P^*_{dl} long-run optimal domestic.

CALCULATION OF THE OPTIMAL PRICES AND EXPORT TAX RATES

In order to compute the optimal producer price and tax rate, import demand and excess supply elasticities were calculated using data from the top five exporters, including Côte d'Ivoire, Brazil, Ghana, Malaysia and Nigeria. Together these countries in 1988, exported 80 percent of the world cocoa to the top 4 importers; Germany, USA, The Netherlands and Italy. Results for optimal prices are reported in Table 1. In the short and long-runs, the optimal prices derived for Côte d'Ivoire are higher than the actual prices, in general, suggesting that farmers have been over taxed. Optimal producer prices are about 1.2 times greater than actual prices. Toward the end of the 1980s, however, the government objective of raising revenue became more rational than before in the short-run.

It is quite obvious that Ghana has been facing net social loss as optimal prices depart significantly from actual prices. By re-examining Table 1, it can be noticed that the estimated optimal prices are about 1.5 times greater than actual prices, for all years, and the gap was quite high in the 1980s. This clearly suggests that cocoa farmers were being over taxed in Ghana as well. Table 2 provides summary results of the optimal and actual tax rates for the period 1964–1988. A distinction is made between short-run and long-run. When government depends heavily on taxes for its revenue, it taxes on the basis of short-run elasticities. Otherwise, long-run elasticities are used. We see from Table 2 that when a government depends heavily on taxes for its revenue (short-run) and has a larger share (case I) the tax optimal tax rate is lower than the one which is heavily dependent on taxes (short-run) but has a small share of the market (case II). This is in line with our a priori expectations from the theoretical model. While the actual tax rates were about 48 and 60 percent in Côte d'Ivoire and Ghana, the suggested long-run optimal tax rates are about 14 and 5 percent for the two countries, respectively. The long-run case is the situation where the government has sources of revenue other than from cocoa.

Table 2 *Import Demand Elasticities Facing Côte d'Ivoire and Ghana and Their Optimal Export Taxes, 1964–1988, Cases I and II*

	Import demand elasticities		Actual taxes	Export tax (percent)			
Country	Short-run	Long-run		Short-run		Long-run	
Côte d'Ivoire				Case I	Case II	Case I	Case II
	–2.27	–6.84	48	44.0	62.5	14.0	54
Ghana	–8.56	–21.13	60	11.6	81	5.0	72

Notes: Case I: case of less than perfectly elastic situation; Case II: case of a highly elastic situation.

Table 3 presents the optimal tax rates using the dynamic model for Côte d'Ivoire alone. It shows that the tax rate varies with time. Also, the optimal tax rates are lower that the actual tax rates for the period 1980 to 1985. However during the last four years from 1986 to 1989, the actual tax rates were lower than the optimal. One should recall that the political situation in Cote d'Ivoire was a bit unstable and the world prices were going down. Therefore it was not politically feasible to reduce the prices that were given to the farmers. The only option that was left to the government was to reduce the actual tax that was perceived. The partial conclusion here is that if policy makers ignore the time factor, the discount rate and the stock-flow relationship, there would be risk of overtaxing producers.

Table 3 *Optimal Tax Rates: Dynamic Case (Percent): Côte d'Ivoire*

Year	Actual	Optimal
1980	61.08	45.0
1981	52.48	45.0
1982	47.70	46.5
1983	45.69	47.0
1984	51.27	46.0
1985	53.49	46.0
1986	43.08	47.0
1987	37.11	47.0
1988	25.23	47.0
1989	16.42	47.0

CONCLUSIONS

The results of the policy modelling exercise strongly suggest that, in general, the price and taxing behaviour of the two countries did not optimize net revenue. One issue that should be of interest to policy makers is the impact of the time factor in their taxation decisions. Since the estimate of the optimal tax is based on the price elasticity of demand and the price response of the commodity from other exporters, policy makers should take into account both short- and long-term demand and supply elasticities. This is especially true when there is a large gap between the two.

A comparison of the estimated optimal export tax rates for Côte d'Ivoire and Ghana with their current taxes show that when the government depends heavily on the tax for its revenue, it taxes on the basis of the short-run elasticities. This tax rate is much higher than if the long-run elasticities were used, which is usually the case when the taxes are a small proportion of government revenue. But the higher tax rate makes the country susceptible to loss of market share over time because it reduces the incentive to its own producers (while raising world prices) and encourages the substitution of the commodity by other producers. Actual export tax rates by Ghana on cocoa were much higher than the optimal rates even when based on short-run elasticity estimates. This may well have contributed to the reduction in the country's share of the world market.

Regardless of the reasons for the non optimal pricing and taxation behaviour, the policy framework presented in this study is of potential use to primary commodity producing countries as a yardstick against which to measure feasible policies. It should provide a basis for sound economic arguments to induce policy changes in the direction of optimal producer price.

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GENERAL DISCUSSION — Yoav Kislev, Chairman *(Hebrew University of Jerusalem, Israel)*

Romeo M. Bautista provided the following reply to questions by the chairman and the discussant concerning taxation as an objective of government intervention. It is true that government interventions in developing countries are motivated by the need to raise revenue, among other important and well recognized objectives that also include income redistribution. However, as the title suggests, the paper is more narrowly concerned with the evaluation of the effects of government interventions on export price variability as it affects producer income and welfare. The political economy questions raises are interesting but are beyond the scope of the paper. One would like to see research in this area, more firmly based on intimate knowledge of the workings of developing country governments.

Dr Bautista argued that it is odd that the discussant found the conclusions of the paper to be 'good', but criticizes them for not being novel since the benefits of less government interventions have been known for some time. Criticism should be directed to the analysis done, not the conclusions reached. He noted that the calculated producer incomes are based not on 'instantaneous' supply response to price changes (as the discussant assumed) but on a distributed lag a la Koyck–Nerlove. Even if world commodity prices are distorted, policy analysis for 'small countries', to be useful, has to make use of expected or long-run world prices. It is not always the case that government intervention serves to reduce domestic price instability. Producers of copra (coconut) in the Philippines, for example, have faced a higher degree of price instability due to government intervention at the same time that the average copra price has been made lower (relative to no government intervention).

It was pointed out that the Egyptian government had heavily subsidized inputs to cotton producers, providing finance and sharing more than 50 percent of the costs of pest control. These subsidies were not considered by Bautista and Gehlhar (Amin I. Abdou). Quality degradation over an increasing proportion of the crop since the mid sixties explains much of the export-farm gate price gap.

Jean-Marc Boussard, commenting on the Gerrard and Spriggs paper observed that, in fact, the stabilization cost will be infinite. If we assume that agricultural production functions are homogenous and of degree 1, then the long-run marginal cost curve is flat. With a government buying any quantity supplied at fixed price, the demand is also parallel to the x axis. Then the production, stock and the cost of stabilization is infinite.

W.K. Asemso-Okyere (Ghana) suggested that in the Ehui and Ehui analysis the long-run dynamics of the cocoa industry should be taken into account. Since cocoa is produced from trees of different ages, modelling should have been with vintages so that the age-composition of the trees are taken into account. There are short-run supply responses but the government should maximize its revenues based on long-run supply response.