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SUPPLY RESPONSE FOR COCOA IN CAMEROON

by

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Résumé:

La présente étude présente une serie de modèles de décision du producteur de cacao au Cameroun. Les modèles utilisés s'inspirent de Nerlove et Wickens & Greenfiled.

Le modèle de Nerlove suppose que le planteur se fixe un niveau de production à atteindre, celui-ci fait des anticipations relatives au niveau du prix de cacao au producteur que le gouvernement choisira au début de la campagne de commericialisation, et est contraint par les structures techniques et économiques, matérialisées par la fonction d'offre. Il peut arriver que la production désirée ne soit pas atteinte, de même que le gouvernement peut choisir un prix différent de celui que le planteur aura anticipé. Les années suivantes, son processus de décision est modifié en tenant compte des erreurs précédemment commises. Le niveau de production est ajusté selon un processus du stock d'ajustement alors que le niveau du prix est ajusté selon un processus adaptatif. Ces ingrédients permettent alors de déduire un modèle qui permet d'analyser la réaction de la production suite à une variation des incitations, dont le prix à la production.

Le modèle de Wickens et Greenfield améliore le précédent en incorporant les éléments relatifs aux couts de production, les activités de récolte, et la regénération des plants. Cette formulation a également l'avantage de tenir compte du cycle de production de la plante.

Dans chacun des cas, des équations de forme "réduite" sont déterminées et les estimations économétriques permettent de calculer les élasticités de courte, moyenne et longue période. En utilisant les prix relatifs calculés soit à partir de l'indice

général des prix à la consommation, soit du déflateur du produit intérieur brut et le niveau de production sur la période 1949 - 1988, l'on trouve que l'offre de cacao est rigide à court terme, et inélastique à moyen terme. L'élasticité de longue période varie entre 0,28 et 0,55. Par conséquent, une baisse du prix au producteur n'aura presque aucun impact dans les premières années, mais à long terme elle sera responsable au minimum d'une baisse de la production de 28%.

L'implication relative à la formulation de politique économique est évidente. Se limiter aux effets immédiats des mesures d'incitation conduit à des décisions pouvant détérirorer davantage les performances économiques.

INTRODUCTION

Two alternative views have emerged explaning the origin of current economic problems that the Cameroonian economy currently experiences. The first opinion traces the origin of the crisis mostly to external factors: international commodities markets, terms of trade and external indebtedness caused by industrial countries' macroeconomic and commercial policies. The second opinion, shared by most donor agencies, attributes these problems to poor economic managment, distorted markets and irrelevant trade policies. Although both views have of recent accepted some of the claims of the opposite side, the move has been towards reliance on market mecanisms in the design of policies.

Most donor agencies explicitly favors an outward oriented development strategy. The underlying assumption being that, despite the many constraints facing the economy, a steady growth path can more easily be found and maintained when the country moves toward competitive conditions. As Marsden and Belot (1987) write,

> " Economic analysis suggests that private enterprises contribute most to the generation of high economic returns (as opposed to just financial rewards to investor) in a liberal environment characterized by few constraints on access to inputs and markets, autonomy in investment and operating decisions and a common framework of incentives applied consistently and uniformly to all sectors -- these conditions -- are important targets to strive for in the interest of development." p Vii.

As agriculture remains the sector employing above three - fourths of the population, greater attention should be paid to the application of market mechanisms in the design of agricultural policy. Price policy should be given high priority as prices remain

the best indicator of scarcity and value to society of resources used. Appropriate price analysis may lead to adequate incentives that may lead to higher production. These incentives will also certainly lead to increases in farm income and government revenue through taxation, and thus, faster economic development. As Timmer rightly puts it;

> "Agricultural prices have subtle and dynamic effects on the entire economy in addition to their direct and more immediate impact on the agricultural sector itself. Price policy analysis can help identify the trade-offs in given circumstances and may even point the way to more efficient sources of revenues or less distorting interventions that achieve the same social welfare objectives " (1986, p265).

The shift in emphasis, from previous import - substitution strategy, will certainly affect the allocation of resources in agriculture and in other sectors. In order to formulate appropriate policies that will allow the agricultural sector to assume its leading role, the response of farmers to incentives is important. Farmers, like other economic agents make their decisions after a cost benefit analysis of current and future opportunities. In all countries, they make their decision to plant, harvest, or take care of their farms based on a set of incentives offered either by the market or the government. "The nature, magnitude and timing of the effects of these policy changes ... are included in the concept of supply response" Ademola (1990).

The success of the reform process thus calls for bringing prices close to international levels. Supply response is measured by elasticities of aggregate, sub - sectoral and individual crop supply to price and non price variables. Estimation of aggregate

and sub - sectoral supply elasticities encounters at least two problems. In the first place, to obtain an aggregate or sub - sectoral supply curve, one needs to aggregate individual supply functions. Each individual supply having its underlying technological and biological structure, speed of adjustment to target quantities and prices, aggregation scheme is not straight forward. Even if one could obtain a decent agregate output, one needs to determine a composite producer price. Econometric estimation of such function does not usually take into account inter activity substitutional and complementary possibilities, thus derived elasticities are often downwardly biased and as such do not allow evaluation of adjustment policies.

The aim of this study is to analyse Cameroonian farmers' responsiveness to prices. The focus is on a perennial crop of importance to Cameroon: cocoa. The paper is organized as follows. In the first section, farmers' decision making process is analyzed using an adapted version of the model proposed by Nerlove (1956, 1958) for the estimation of agricultural supply functions. We present estimates of short and long run supply elasticities, the speed of adjustment to disequilibria and the process of expectations formation together with an analysis of findings. The paper concludes with policy implications of the results.

Section I: THE MODEL

I 1 Theoretical framework.

The framework for estimating supply response is adapted from the model proposed by Nerlove (1956, 1958). The Nerlovian model is based on the following three equations.

$$Q_t - Q_{t-1} = a(Q^*_t - Q_{t-1}) \qquad (1)$$

$$P^*t - P^*_{t-1} = b(P_{t-1} - P^*_t) \qquad (2)$$

$$Q^*t = S_0 + S_1 P^*_t + E_t \qquad (3)$$

with $0 < a,b < 1$; S_0, $S_1 > 0$ and Q_t is a measure of area planted to cocoa or of output produced at time t, P_t is a measure of price at time t. Starred variables indicate desired or target levels. All variables are measured in logarithmic form.

The structure of the model is mostly based on three elements, namely a supply function (3), a stock adjustment (1), and a price expectation formation scheme(2).

The model assumes that in their decision to plant, care for, and harvest cocoa, farmers integrate three components. First, there is a target output they want to reach (Q^*_t), second, at the begining of the season they make some forecast of the price that will prevail at harvest time (P^*_t), and third, there is a supply function relating expected producer price and expected output level. The underlying assumption here is also that farmers have solved an optimization problem that allows the determination of the above targets.

Equation (1) describes the stock adjustment hypothesis. It is assumed that farmers, in their decision to plant or to take care of their farms have a target output they wish to produce. Deviation from such a target level, for technological,

institutionnal and economic reasons cannot be eliminated instantaneously. Adjustment to this target or equilibrium level will be slow but steady. Hence, in each cropping season, planting and harvesting decisions are made in such a way that part of the deviations from target output is reduced.

The pace at which these deviations are reduced may vary. The reduction may be very important at the begining and then decline gradually, or it may be negligible at the begining to allow for a learning period and then rise, reach a maximum and then gradually decline. The coefficient, a, gives the magnitude of the yearly reduction during the cropping season. It is henceforth called the adjustment coefficient and should be a positive number no greater than 1. The exact value of coefficient a, is data determined.

Equation (1) can also be written such as to define current output level as a weighted average of past observed output levels, with lesser weights given to the more distant past output levels. These weights will decline geometrically only if the adjustment coefficient is between 0 and 1. In fact equation (1) alone can be rewritten as

$$
\begin{aligned}
Q_t &= aQ^{*}_{t-1} + (1-a)Q_{t-1} \\
&= aQ^{*}_{t} + a(1-a)Q^{*}_{t-1} + a(1-a)^2 Q^{*}_{t-2} + \ldots \\
&= \Sigma\, a\,(1-a)^{i}\, Q_{t-i} \qquad (4)
\end{aligned}
$$

Hence, equation (4) says that the stock adjustment assumption is equivalent to computing current output as a Koyck-weighted linear combination of current and previous desired output levels. The weights decline geometrically according to the adjustment

parameter.

Equation (2) describes the formation of expectations. This specification follows the adaptive expectation approach. As in equation (1) above, it is assumed that farmers have a target price level in mind while making their decisions. This target price does not prevail on the market now but it is assumed a process is under way that will guarantee its attainement.

In Cameroon, the cocoa producer price is determined by the government. It is announced in the first half of the harvesting season. The target price is thus the one farmers while working on the farm during the year expect the government to choose. The adaptive expectation approach is also called error-learning since it specifies that price forecasts are updated each time that new information becomes available. The updating process is such as to improve earlier price forecast. The expectation formation parameter can assume any value between zero and one. A zero value to this coefficient would mean that once price expectations are made they are not changed during the season even if additional information became available. A value of one to the expectation coefficient would mean instantaneous adjustment regardless of past history. Neither of these extreme values (0 or 1) seems plausible. A value strictly between zero and one means adjustments are made by a certain amount each season. The exact value is also data determined.

Equation (2) can be solved for P^{*}_{t} to obtain

$$P^{*}_{t} = bP_{t} + b(1-b)P_{t-1} + \ldots\ldots$$

$$= b \sum_{i} (1-b)^{i} P_{t-i} \qquad (5)$$

The weights of lagged price in this equation form a geometric series that converges if coefficient b is a positive number less than one. In this way it appears that the adaptive expectation assumption is equivalent to determining the current expected price as a Koyck-weighted linear combination of current and all previously observed prices.

Equation (3) is the standard supply function with S_0, and S_1 being two non - negative numbers. The three equations together characterize Nerlovian assumptions about cocoa farmers' decision. Farmers have a target output and price which are determined such as to satisfy their needs. An underlying assumption is the existence of an optimization problem, the solution of which yields the expected or target price and output. Although equations 1 and 2 could, as shown above, be expressed in an estimable form, we will not proceed in this way as interactions with other assumptions need to be taken into consideration. We will instead solve the system of equations for a reduced form that contains only observable variables. The estimable reduced form equation should integrate the entire decision making process.

Solving the three system model for the reduced form equation by combining equations (1), (2), and (3) yields the following.

$$Q_t = abS_0 + aS_1b\ P_{t-1} + (2-b-a)Q_{t-1} - (1-a)(1-b)Q_{t-2} + aE_t - a(1-b)E_{t-1} \quad (6)$$

$$= C_0 + C_1\ P_{t-1} + C_2\ Q_{t-1} + C_3\ Q_{t-2} + U_t \quad (7)$$

with C_0, C_1, and C_2 positive and C_3 negative. As can be seen from (6), the error term in the estimating form (7) has a complicated autoregressive moving average structure.

Note that the inclusion of lagged variables in the expectation formation scheme, and the adjustment to equilibrium, introduce dynamic elements in the model. An equilibrium solution of the model is secured once the adjustment and expectation formation parameters are both positive numbers no greater than one.

I.2 Data and variables used.

The data used to estimate alternative specifications of the model are from Lindon et. al. (1983) for the period 1949 to 1978 and from the NPMB from 1979 onwards. Quantity data (Q) are expressed in thousands of tons. Three price measures (P) are used: producer price(or price received), and two relative price measures; computed with respect to the consumer price index and the GDP deflator respectively. Producer price is measured in CFAF per kilogram. The base year for the price indices are 1982 and 1980 for the CPI and GDP respectively. Behavior of the variables over the estimating period is given in figure 1.

There are several reasons for using more than one price measure in a study like this one. Applications of market mechanisms suppose price measures opportunity cost. The relevant price to use should be the one that most accurately characterizes farmers' valuation and hence most significantly impacts their production decisions. As Askari and Cummings (1977) put it, the relevant price variable depends upon farmers motivations. The decision making process at the farm level in Cameroon as well as elasticity estimates are scarce. Hence, there are very few results to which ours may be compared. We will consider those pricing alternatives that have some theoretical explanation to allow some comparison.

The price variable may be defined relative to the commodity considered alone, or relative to competing commodities locally produced or otherwise. In case farmers' decision is mostly based on the comparison of the return from cocoa to that of alternative crops or activities, be it on the farm or not, the relevant price appears to be a ratio of cocoa price to an average of the prices of alternative crops or the return from other activities.

Relative prices are used under the assumption that cocoa farmers make their decision by integrating economic conditions in cocoa production and other activities. They are computed relative to the consumer price index and to the GDP deflator. A better choice for the deflator would have evidently been the price of other commodities or of inputs. A good proxy for these is lacking.

If instead the decision is geared towards the satisfaction of specific social needs, it is possible that no valid price variable may be found. It is also possible that no appropriate price variable is available because of the absence of a formal market in which prices may signal scarcity. It is equally likely that farmers' motivations change such that a formerly valid price measure stops being so. Should this be the case, a long series may not be appropriate. Hence, the necessity for testing for structural change before making any inference.

Significant deviations from market levels do exist in the case of most export crops in Cameroon due to the important role entrusted to the national marketing produce board (NMPB " ONCPB"). The NMPB had the exclusive right of marketing cocoa on international markets over the estimation period. On domestic markets cocoa is bought only by accredited buyers and at the officially determined price, uniform all over the national territory. In this way relative scarcity cannot be reflected through price, in addition to the fact that adequate specialization scheme can not be considered because of deviations from border or quasi equilibrium price. In fact it is not uncommon to have the fob price more than twice the producer price. The increment going to buyers' margins and taxes to government. The efficiency of current market organization is also faulted by the quota system that buyers are subjected to.

Some of these e.g. the exclusive right to market cocoa on domestic and foreign markets, and the quota system has been

simplified for the 1990 campaign in the liberalization program implemented within the Structural adjustment framework. Reasons for using producer price are self explanatory. We suppose that this price reflects scarcity at the farm level. It sufficiently rewards farmers' activity on the cocoa farm.

Section II. Empirical Application.

Above reduced form equation has been estimated for alternative price measures. These are presented in this section as models I - IV.

II.1 Nerlovian Model.

A) Model I

This model includes the stock adjustment assumption, the adaptive approach to expectations formation and the supply function. The estimating equation is the reduced form (5). The estimated equation for alternative price specifications are, for the period 1955 - 1989.

A.1 Model I with nominal producer price.

$$Q_t = 0.88 + 0.030\ P_{t-1} + 0.565\ Q_{t-1} + 0.215\ Q_{t-2} \qquad (8)$$

$$(2.30)\quad (1.04) \qquad (3.24) \qquad (1.31)$$

R^2 $(\bar{R}^2)$ = 0.79(0.77) D.W. = 2.12 h = 0.66 F = 55.89

The model suggests, based on the coefficient of determination adjusted for degrees of freedom $(\bar{R}^2)$, that 79% of current output

level can be explained by previous period's price level and previous two periods' output levels.

The h-value indicates that there is no first order autocorrelation even though, as will be the case below, the Durbin-Watson statistics may suggest the contrary. The Durbin-Watson test for serial correlation applies when all independent variables are nonstochastic. This is not the case when lagged dependent variables are used as regressors. In that case, the D.W. statistic is biased toward 2. The valid test is to use the h statistic introduced by Durbin (1970) which is given by

$$h = r \sqrt{\frac{n}{1 - nV(\beta)}} \qquad (9)$$

where $V(\beta)$ is the estimated variance of the coefficient of the lagged dependent variable and r is the estimated coefficient of first order autocorrelation when ordinary least squares are used (it is approximated by 1-d/2); provided $1-nV(\beta) > 0$; this condition was satisfied in the above equation as well as subsequent ones reported below. Under the null hypothesis of no serial correlation, h is asymptotically standard normal.

The coefficient of the previous period's price and that of two period lagged output level are not significantly different from zero. In addition, the coefficient of Q_{t-2} is of the wrong sign (from (6), this coefficient is - (1-a)(1-b) i.e. is negative).

The estimated coefficients of Q_{t-2} and P_{t-1} suggest that the a priori restrictions assumed on the price expectation or on the stock adjustment parameters may be inappropriate; at least one of these coefficients assumes its extreme value(0 or 1), or is greater than one and the model would not yield an equilibrium. Under these conditions no meaningful structural parameters -- adjustment, expectations, or supply function -- can be derived within this framework. We then need to reconsider the specification of the model if the producer price is the relevant one. The following are estimates of the same equation using relative price measures.

A.2) Model I estimated with relative producer price(CPI)

$$Q_t = 0.907 \quad -0.017\ P_{t-1} \quad + 0.610\ Q_{t-1} \quad + 0.218\ Q_{t-2} \qquad (10)$$

(1.19) (-0.243) (3.53) (1.24)

$R^2(\bar{R}^2)$ = 0.78(0.76) D.W. = 2.10 h= F=36.95

A.3) Model I estimated with relative producer price(GDP)

$$Q_t = 0.776 + 0.050\ P_{t-1} + 0.534\ Q_{t-1} + 0.237\ Q_{t-2} \qquad (11)$$

(0.872) (0.63) (2.72) (1.20)

$R^2(\bar{R}^2)$ = 0.649(0.61) D.W. =2.11 h= F=15.39

These two estimated equations share the same problems as (8), suggesting a reconsideration of the model.

B) Model II

This model drops the stock adjustment represented by equation (1) but keeps the supply function and the expectation formation assumption. The implied decision framework being that farmers do not have a target output in mind but form some expectation on the price that will prevail on the market; that price will determine production according to the supply function. The model is given as follows.

$$P^*_t - P^*_{t-1} = b(P_{t-1} - P^*_{t-1}) \qquad (12)$$

$$Q_t = S_0 + S_1 P^*_t + E_t \qquad (13)$$

Equation (12) can be rewritten as

$$P^*_t = P^*_{t-1} + bP_{t-1} - bP^*_{t-1} = bP_{t-1} + (1-b)P^*_{t-1}$$

$$= \sum_{i=1} b(1-b)^{i-1} P_{t-i} \qquad (14)$$

or by substitution of (14) into (13) we obtain

$$Q_t = S_0 + bS_1 P_{t-1} + b S_1(1-b)^1 P_{t-2} + S_1 b(1-b)^2 P_{t-3} + \ldots + E_t$$

$$= S_0 + D_1 P_{t-1} + \ldots\ldots\ldots\ldots + E_t \qquad (15)$$

Equation (15) has an infinite number of terms. It can be estimated via the usual Koyck's transformation that yields

$$Q_t = bS_0 + bS_1 P_{t-1} + (1 - b) Q_{t-1} + E_t - (1-b)E_{t-1} \qquad (16)$$

The error term has an autoregressive structure. The AR(1) coefficient being -(1-b). We use generalized least squares to estimate it. Estimations are presented as B1 - B3.

B.1) Model II estimated using producer price

$$Q_t = 0.602 + 0.019\ P_{t-1} + 0.853\ Q_{t-1} \qquad (17)$$
$$(2.50) \quad (1.18) \quad (7.66)$$

$R^2(\bar{R}^2) = 0.81(0.78)$ DW = 1.98 Rho=-0.415 h = .43 F = 42.56

Comparing this result with that of the first model we note that the predictive power of the model has not declined by dropping the partial (stock) adjustment hypothesis. All coefficients are of the expected sign although the price variable is still not statistically significantly different from zero. The advantage of this specification over the initial one is the possibility of deriving the supply curve, the expectation parameter and the multipliers. The other specifications of the price variable yield the following results which are not qualitatively different from the above ones.

B.2) Model II with relative price (CPI)

The estimated equation is as follows:

$$Q_t = 0.229 + 0.024\ P_{t-1} + 0.924\ Q_{t-1} \qquad (18)$$
$$(0.268) \quad (0.33) \quad (8.23)$$

$R^2(\bar{R}^2) = 0.80\ (0.78)$ D.W.= 1.98 Rho = -0.458 h = 1.35 F = 40.77

B.3) Model II estimated using relative producer price (GDP)

$$Q_t = 0.215 + 0.068\ P_{t-1} + 0.876\ Q_{t-1} \qquad (19)$$
$$(0.22) \quad (0.68) \quad (6.48)$$

$R^2(\bar{R}^2) = 0.66\ (0.63)$ D.W. = 2.00 Rho=-0.446 h = 0.68 F = 16.86

An equivalent model is obtained by going back to model I, keeping the partial or stock adjustment hypothesis and changing the expectation formation assumption from the adaptive to the naive one. The implied decision framework now is that farmers have a target output level, a target price; but the target price that they expect will prevail on the market at harvest time is the previous cropping season's price. This is the usual Cobweb model used for analyzing agricultural prices. The model can be written as follows:

$$Q_t - Q_{t-1} = a(Q^*_t - Q_{t-1}) \qquad (20)$$

$$P^*_t = P_{t-1} \qquad (21)$$

$$Q^*_t = S_0 + S_1 P^*_t + E_t \qquad (22)$$

A model with the naive expectation formation hypothesis is equivalent to assuming that price follows a random walk as can be seen from (21).

Substitution of (20) and (22) into (21) yields the following reduced form equation

$$Q_t = aS_0 + aS_1 P_{t-1} + (1-a)Q_{t-1} + aE_t \qquad (23)$$

The error term in this model has the same properties as the error term in the initial model. The difference with (16) being that the error term may not be white noise as assumed in (23). However, in estimating (16) no autoregressive or moving average structure was found in the residuals.

C) Model III

In the two preceding cases, at the usual 5% significance level, we note that the price variable is not statistically different from zero. Should this be the case it would mean that output follows a random walk, or at best, price as measured here is not the relevant variable to which farmers respond. The model obtained is as follows.

$$Q_t = S_0 + S_1 Q_{t-1} + E_t \qquad (24)$$

The estimated model is given as:

$$Q_t = \underset{(1.30)}{0.491} + \underset{(10.9)}{0.897} Q_{t-1} \qquad (25)$$

$R^2(\bar{R}^2) = 0.80\ (0.78)$ D.W. = 1.98 Rho = -0.398 h = -0.13 F = 11.25

Equation (25) was estimated with ordinary least square technique. We then tested and detected the presence of serial correlation which was corrected using the Cochran - Orcutt procedure. The above equation was obtained assuming that the error term has a moving average of the first order.

D) Model IV.

Model four drops the assumption of price expectation. Hence current price affects output instantly. Since price is announced during the harvesting season, we assume here that harvesting decision can nullify all efforts made during the entire year. We still assume that the stock adjustment hypothesis holds. The model is thus obtained as follows.

$$Q_t - Q_{t-1} = a(Q^*_t - Q_{t-1}) \qquad (26)$$

$$Q^*t = S_0 + S_1 P_t + E_t \qquad (27)$$

Substitution of (26) in (27) yields the following reduced form equation:

$$Q_t = aS_0 + aS_1 P_t + (1-a)Q_{t-1} + E_t \qquad (28)$$

The error term also suggests first estimating the equation using ordinary least squares technique.

D.1) Model IV estimated using nominal producer price.

$$Q_t = \underset{(2.77)}{0.662} + \underset{(1.74)}{0.028} P_t + \underset{(7.31)}{0.83} Q_{t-1} \qquad (29)$$

$R^2(\bar{R}^2)$ = 0.78(0.77) DW = 2.10 Rho = 0.396 h = 0.34 F = 43.86

D.2) Model IV estimated using relative producer price (CPI)

$$Q_t = \underset{(-0.24)}{-0.19} + \underset{(1.01)}{0.068} P_t + \underset{(9.70)}{0.961} Q_{t-1} \qquad (30)$$

$R^2(\bar{R}^2)$ = 0.80(0.79) DW= 1.95 Rho= -0.521 h = -0.03 F= 43.55

D.3) Model IV estimated using relative producer price (GDP)

$$Q_t = \underset{(-0.24)}{-0.21} + \underset{(1.36)}{0.125} P_t + \underset{(7.23)}{0.898} Q_{t-1} \qquad (31)$$

$R^2(\bar{R}^2)$ = 0.69 (0.66) DW= 1.99 Rho= -0.45 h = -0.03 F=18.89

As in the case of model III, in each specification all the coefficients have the expected signs allowing the derivation of structural parameters of the relevant structural equations.

In these equations the price variable is very unstable across model formulations. The best we can say from all these is that production follows a random walk. This is consistent with the behavior of first difference of output level represented in figure 2; first difference of output level has virtually been constant over the entire period of analysis. The implied structural parameters suggest reconsidering the model by, e.g., incorporating planting and investment decisions. We will adapt the model suggested by Wickens and Greenfield (1973), Dowling and Jessadachatr (1979), or Hartley et al. (1984)

II.2 ALTERNATIVE MODEL.

The Nerlovian model as presented above has been criticized by several authors among them Wickens and Greenfield (1973) and Dowling and Jessadachatr (1979). The basic critique concerns the failure of standard Nerlovian models to spell out a decision framework based on a specific optimization scheme. Specifically the relevant model for estimating farmers' responsiveness to incentives should include, in addition to those elements previously introduced (adjustment, expectations and supply function), an explicit production or cost function, elements pertaining to caring for the farm, and harvesting decisions. Harvesting here includes both harvesting cocoa from the trees and other required work for obtaining a quality final product. The standard Nerlovian model will be modified to include these elements.

First, a vintage production function integrating the age profile of cocoa trees is defined. It gives the maximum potential

output at time t as a linear combination of area planted to cocoa. The defining equation is as follows:

$$Q^{*}_{t} = \sum_{i} d(i,t)\ I_{ti} \qquad (32)$$

where I_{ti} is the stock of trees of cocoa planted at time i and surviving at time t, and d(i,t) is yield per hectare of cocoa trees planted in year i and still producing; it gives the age-yield profile of cocoa trees. The inclusion of t in the yield profile is intended to take technical progress into consideration. This, in addition to unduly complicating the model, requires detailed data on the age profile of trees producing at year t; data we do not have. We will assume away technical progress considerations and just take d(i,t) = d(i).

Secondly, we may introduce an investment function into the model by assuming that the flow of investment at year t is represented by reductions or increases of area under cocoa cultivation. Also, letting the price variable be net of production cost, and assuming that we have a well behaved cost function, we may write the net revenue as

$$NR_{t} = P^{*}_{t}Q^{*}_{t} - C(Q_{t}) \qquad (33)$$

where the area variable has been substituted for by output, with the assumption that output is in fixed proportion to area.

Thirdly, since cocoa is a perrenial crop, its income accrues to the farmer through time. We thus assume a discount factor (r) which, for simplicity we take to be time independent.

The investment decision in this way simplifies the maximization of expected discounted net revenue subject to the vintage production function constraint.

The problem we need to solve is the maximization of the discounted net expected revenue subject to the vintage production constraint. It is given as:

$$\text{Max } \Sigma\ (1+r)^{-i}\ NR_i \quad \text{s.t. } Q^*_i = \Sigma\ d(i)\ I_{ii} \qquad (34)$$

This is a standard non - linear programming problem that we may solve via the Lagrange multipliers technique. Assuming a concave cost function and the constraints being linear, hence concave, the second order conditions are satisfied; the maximum will exist. In addition, the above assumptions guarantee the existence of an interior solution. We may write the first order necessary conditions of the above optimization problem that yields the following decision rule.

$$C'(I_i) = \sum_{i=0}^{i=n} (1+r)^{-i}\ P^*_i d(i) = R^*_i \qquad (35)$$

A farmer will keep on working on cocoa related activities only up to the point where the marginal cost is equal to future expected profits from cocoa. This decision rule may be rewritten, via the implicit funciton theorem as

$$I_t = g(R^*_t) \tag{36}$$

Assuming a quadratic cost function and using the fact that the flow of investment is equal to change of area under cultivation and, assuming as do WG and Hartley. et. al. that R^*_t is a function of expected future prices, harvesting cost, the age-yield profile and the discount rate. These arguments of expected revenue are modeled by a distributed lag of current and past prices only. This leads to a harvesting equation of the form

$$Q_t = a \sum_{i=1} B_i Q_{t-i} + \sum_{i=0} C_i P_{t-i} + U_t \tag{38}$$

Equation (38) is similar to the reduced form model obtained with the Nerlovian model. The difference here is that several lagged values of prices and quantities can be used. We may further assume constant density of planting such that changes in area under cocoa cultivation is given as

$$A_t = d\ g(R^*) + U_t \tag{39}$$

where d is the density of planting and U_t stands for uprooted or abandoned area. In case U_t is not large relative to changes in area under cultivation, U_t may be treated as a random term. In this case, (38) gives a supply function incorporating the entire decision making process.

The estimation of equations such as (38) is tedious as we need to choose the correct number of terms to include. The introduction of lagged variables reduces the number of data points used in the

estimation. This is a problem especially in cases like ours where the length of the series is not long enough. In addition, multicollinearity is potential as the same variable considered at subsequent time periods may be linearly related. Under these conditions least squares estimates are not precise. It is better to assume that equation (38) can be estimated using polynomial distributed lag (PDL) technique. The essence of the PDL technique is to force the coefficients of each lagged variable of the equation to lie on a polynomial of an appropriately chosen degree once the lag length has been determined. Coefficients B_i's and C_i's can then be written as follows:

$$B_i = b_0 + b_1 i + b_2 i^2 + \ldots + b_q i^q \quad \text{with } i = 0,1,\ldots q. \quad (40)$$

$$C_i = c_0 + c_1 j + c_2 j^2 + \ldots + c_p j^p \quad \text{with } j = 0,1,\ldots p. \quad (41)$$

We thus need to choose the correct lag length and polynomial degree, otherwise, estimates obtained are either biased or inefficient. Trivedi and Pagan (1979) stated conditions under which biased or inefficient estimates are obtained.

Procedures have been proposed as guidelines for correct choice of lag length and polynomial degree. We need to choose the maximum lag length and sequentially lower the degree by one, thus adding one restriction on the estimates; and then choose as the best lag length the one that produces the last acceptable hypothesis under the adopted norm and procedure. The choice of polynomial degree follows the same lines. These norms are either based on mean square error (Mallow's Cp-statistic, Akaike's Final Prediction Error

(AFPE), Bayesian criteria, or the standard F-test), or the decomposition of the observation matrix (Pagano- Hartley t-test). Batten and Thornton (1984) is an application of these criteria when, as in our case, the estimated equation involves two variables for which the PDL technique is applied. Regardless of the criterion adopted the lag length is chosen first and then the polynomial degree.

We adopt the Akaike's FPE hereafter AFPE. The AFPE's is based on the minimization of the risk of bias due to a short lag and the risk of inefficiency due to too a long lag structure. The quantity to minimize is given as follows:

$$FPE_{L,j} = \frac{T + (L + 1 - j)}{T - (L + 1 - j)} \; \frac{RSS_{L,j}}{T} \quad , \; j = 0,1, \ldots, L. \qquad (42)$$

where $RSS_{L,j}$ is the residual sum of squares with j restrictions imposed. The procedure is to consider as optimal lag structure that for which FPE is minimized.

The lag length is often chosen based on extraneous information such as the number of lags the analyst is prepared to accept. The maximum lag was fixed at 30 years based on the agronomic yield profile. (see Mememto de l'Agronome pp 814-27) A cocoa tree is expected to start producing at 5 to 6 years, reach its maximum production between 7 and 12 years, and may survive up to 30 years

after planting. Results were not basically different when a shorter maximum length was chosen.

F.1 Alternative model using nominal producer price

The optimal model based on AFPE criterion is polynomial lag of length 10 for output and 15 for price, and with degrees 4 and 3 respectively. The etimated model is as follows:

$$Q_t = 1.71 + 0.132\,P_t + 0.061\,P_{t-1} + 0.010\,P_{t-2} - 0.023\,P_{t-3}$$

(2.43) (2.45) (2.69) (1.42) (-1.37)

$$- 0.041\,P_{t-4} - 0.046\,P_{t-5} - 0.041\,P_{t-6} - 0.03\,P_{t-7} - 0.013\,P_{t-8}$$

(-1.76) (-1.90) (-1.95) (-1.95) (-1.51)

$$+ 0.006P_{t-9} + 0.026P_{t-10} + 0.043P_{t-11} + 0.054P_{t-12} + 0.059P_{t-13}$$

(0.75) (1.60) (1.80) (1.88) (1.92)

$$+ 0.53\,P_{t-14} + 0.034\,P_{t-15} + 0.174\,Q_{t-1} + 0.10\,Q_{t-2} + 0.052\,Q_{t-3}$$

(1.95) (1.97) (2.41) (2.31) (2.17)

$$+ 0.024\,Q_{t-3} + 0.008\,Q_{t-4} + 0.001\,Q_{t-5} - 0.001\,Q_{t-6} - 0.001\,Qt-7$$

(1.94) (1.57) (0.80) (-1.31) (-2.57)

$$- 0.0002\,Q_{t-8} - 0.0003\,Q_{t-9} - 0.001\,Q_{t-10} \qquad (43)$$

(-0.74) (-1.41) (-2.82)

R2 (R2) = 0.85 (0.81) DW = 1.81 ΣB_i = 0.356 (2.26)

ΣC_i = 0.283(2.34)

F.2 Alternative model using relative producer price (CPI)

The optimal model in this case is a distributed lag of length 10 on output and 11 on price; the degrees of the polynomial are respectively 4 and 3. The estimated model is as follows:

$$Q_t = 2.26 + 0.076\ P_t + 0.001\ P_{t-1} - 0.026\ P_{t-2} - 0.36\ P_{t-3}$$

(0.15) (0.65) (0.18) (1.00) (-1.22)

$$- 0.031\ P_{t-4} - 0.011\ P_{t-5} + 0.015\ P_{t-6} + 0.043\ P_{t-7} + 0.066\ P_{t-8}$$ (-

0.84) (-0.31) (0.48) (1.41) (1.95)

$$+ 0.079\ P_{t-9} + 0.076\ P_{t-10} + 0.052\ P_{t-11} + 0.015\ Q_{t-1} + 0.064\ Q_{t-2} +$$

(2.07) (2.04) (2.00) (0.76) (0.50)

$$+ 0.025\ Q_{t-3} - 0.036\ Q_{t-4} - 0.073\ Q_{t-5} - 0.060\ Q_{t-6} + 0.009\ Q_{t-7}$$

(0.18) (-0.35) (-1.03) (-0.83) (0.11)

$$+ 0.120\ Q^{t-8} + 0.239\ Q_{t-9} + 0.312\ Q_{t-10} + 0.264\ Q_{t-11}$$ (44)

(1.33) (2.22) (2.38) (2.26)

R2 (R 2) = 0.70 (0.60) DW = 1.95 ΣB_i = 0.878 (3.18)

$\Sigma\ C_i$ = 0.312 (1.79)

F.3 Alternative model using relative producer price (GDP)

The optimal model in this case is a distributed lag of length 10 on output and 11 on price; the degrees of the polynomial are respectively 4 and 3. The estimated model is as follows:

$$Q_t = -0.24 + 0.157\ P_t + 0.048\ P_{t-1} - 0.019\ P_{t-2} - 0.052\ P_{t-3}$$

(-0.90) (1.44) (0.87) (-0.68) (-1.82)

$$- 0.057\ P_{t-4} - 0.043\ P_{t-5} - 0.015\ P_{t-6} + 0.017\ P_{t-7} + 0.047\ P_{t-8}$$ (-

1.78) (-1.39) (-0.58) (0.70) (1.71)

$$+ 0.068\ P_{t-9} + 0.072\ P_{t-10} + 0.052\ P_{t-11} - 0.002\ Q_{t-1} + 0.107\ Q_{t-2} +$$

(2.13) (2.28) (2.33) (0.01) (0.98)

$$+ 0.078\ Q_{t-3} - 0.001\ Q_{t-4} - 0.069\ Q_{t-5} - 0.088\ Q_{t-6} - 0.041\ Q_{t-7}$$

(0.65) (-0.01) (-1.08) (-1.18) (-0.49)

$$+ 0.061\ Q^{t-8} + 0.185\ Q_{t-9} + 0.274\ Q_{t-10} + 0.247\ Q_{t-11} \qquad (45)$$

(0.75) (2.12) (2.48) (2.41)

R2 (R 2) = 0.70 (0.60) DW = 1.95 ΣB_i = 0.752 (2.98)

$\Sigma\ C_i$ = 0.275 (1.65)

II.3 STRUCTURAL PARAMETERS and STABILITY CHECK.

The structural parameters embedded in equations (1), (2), and (3) are, the short and long run supply elasticities, the expectation formation and the stock adjustment parameters. The price variables chosen are intended to be the measure of scarcity at the cocoa farm level (producer price), and the return to cocoa as compared to other economic activities (relative prices). As can be seen from previous results, the underlying assumptions could not hold in all cases; hence the models were reconsidered by reducing the number of parameters that could be derived from the estimated reduced form equations. This corresponds to eliminating one of the economic assumptions -- stock adjustment, price expectation---.

An estimated equation such as that reported in this paper can be useful for policy analysis if, among other things its structure has remained the same over the estimating period. Chow (1960) proposed a test for comparing regression equations containing the same set of regressors. His test requires that a point be determined and used to divide the data set into two. This is

usually forthcoming when an event can be used for such a division, or residual analysis yields such a point.

When the breaking point is not evident, Dufour (1980) proposed an alternative test based on dummy variables. He suggested including dummy variables for each of the data point that may cause the instability of the equation.[See Mehra (1989) for a stright forward presentation as well as an alternative test for stability using Engle and Granger's test of cointegration.] Dufour Statistic follows an F-test that leads to the rejection of the null hypothesis of stuctural stability for large values. The Chow test was applied using 1972 as the breaking point. Dufour test was also applied using a dummy variable for each of the years from 1973 onwards. In both cases we found the equations to be unstable at the usual 5% significance level. They were stable when a 10% significance level was used.

The reduced forms estimated in this study allow derivation of structural parameters such as the expectations and adjustment coefficients, the intercept and slope of the supply curve. To study the short, intermediate and total effect of a price change on production, we need to derive the final form that gives output level as a function of current and lagged price level only (see Theil 1971, pp463-4). For the cases where we have in the reduced form equation only current and no more than one period lags of exogenous and endogenous variables, the equation may be written as follows:

$$Q_t = \alpha_0 + \alpha_1 Q_{t-1} + \alpha_2 P_t + \alpha_3 P_{t-1} + E_t \qquad (46)$$

that can after several substitutions be written as

$$Q_t = \frac{\alpha_0}{1 - \alpha_1} + \alpha_2 P_t + \sum_{i=1} (\alpha_1 \alpha_2 + \alpha_3) \alpha_1^{i-1} P_{t-i} + U_t \qquad (47)$$

From this equation we can derive the impact or short run, the interim and long run elasticities. The short run is obtained as α_2, the interim elasticities are $\alpha_1 \alpha_2 + \alpha_3$, $\alpha_1(\alpha_1 \alpha_2 + \alpha_3)$, ... $\alpha^{p-1}(\alpha_1 \alpha_2 + \alpha_3)$ for one, two, ..., and p periods' lag. The total effect or long run elasticity is obtained by adding the short and all interim elasticities. It is given as

$$LRE = \alpha_2 + (\alpha_1 \alpha_2 + \alpha_3) + \alpha_1(\alpha_1 \alpha_2 + \alpha_3) + \ldots + \alpha_{p-1}(\alpha_1 \alpha_2 + \alpha_3)$$

$$= (\alpha_2 + \alpha_3)(1-\alpha_1)^{-1} \qquad (48)$$

We restrict the final analysis on four sets of equations; the two in model II using relative prices and the two alternative specifications using the relative prices. These equations have their coefficients statistically different from zero; hence, yield structural parameters that are statistically significant.
We may just point out the qualitative results that emerge . The expectation parameters in the two Nerlovian specifications are 0.076 and 0.124 respectively for the relative price, measured with respect to the CPI and the GDP deflator. The implied supply curve in each case is given as

$$Q_t = 3.013 + 0.316\ P_t \qquad (50)$$

and

$$Q_t = 1.73 + 0.548\ P_t \qquad (51)$$

with Q and P measured in logarithmic terms.

The alternative model, adapted from Wickens and Greenfield (1973) incorporates into the models harvesting and planting decisions. This yields a distributed lag model in the price and output variable. An advantage of this specification is the possibility of tracing through the impact, intermediate and long run multiplier of a one time price change. The short run or impact multiplier measures the response of output to a price change during the current cropping season. It is given as the coefficient of current price in the estimated equation. The short run multiplier implied by each of the estimated equation is not statistically different from zero. This suggest that the effect of a given price change will not be felt during the year of the change.

The long run elasticities are respectively 0.312 and 0.275 using The CPI and the GDP deflator to compute relative price. Figure 4 gives the pattern of price coefficients.

Conclusion

The intended objective of the study was to analyze farmers response to cocoa price changes in Cameroon. The model used follows the work of Nerlove, and is based on three basic elements, namely

stock adjustment, expectation formation and the supply curve. The basic model has been reformulated to incorporate elements pertaining to the optimization scheme. Results can be summarized as follows.

Variations of prices will have negligible or no effect at all in the short run. Short run elasticities are not statistically different from zero. This suggests that a price drop such as the one experienced in 1989 will have no immediate effect on production. Long run elasticities computed or estimated in this study suggest that, in the long run such a price drop will cause serious drop in production. For the most plausible version of the models-- price measured with respect to the GDP deflator-- the drop will be greater than 50% .

The reformulated model yielded similar results. In addition, the pattern of the distributed lags of the price variable gives indications pertaining to the yield profile as suggested by WG and Hartley. et. al.. Coefficients are negative and/or statistically not different from zero until year 6 when cocoa trees start producing on economic scales. The residual however shows a pattern that could not be captured with the variables used; this is probably due to lack of data on key arguments of the production function such as labor and pesticide. These results also suggest that pricing policy, although very important will be of limited value in the current economic framework. A price change has no short run impact because price do not reflect scarcity and also information does not flow to decision makers at the farm level.

Price will not reflect scarcity as long as a uniform price is set without taking into consideration production arrangements. Prices will not reflect scarcity and information will not flow to farmers as long as the marketing channels are monopolized. We may conclude with Marsen and Belot (1987) that an environment in which prices reflect opportunity cost is called for if the development process has to succeed.

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