Response of Rice Yields in Cameroon: Some Implications for Agricultural Price Policy

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Abstract Rice production contributes to income and welfare of producers in Cameroon. This study tests for the effect of producer price in relation to world price for both local rice and maize as competing crop, to ascertain their effect on production. It is revealed that rice yield may increase 1.24% for a ten percent increase in relative world price to producer price of rice. A ten percent increase in relative price of substitute maize crop accounts for 1.28% decline in yield. Stepwise examination of the effects of the variables reveals that in the short-run a ten percent increase in governmental expenditure for agriculture and irrigation increases rice yield by 1.08% and 0.53%. The estimates infer that the rice sector responds to increasing prices to some degree with the complementarity of better weather and irrigation. The study concludes that producer supply response could be enhanced by a policy that is directed towards promoting irrigation technology, development of market-supporting infrastructure, input incentive package and reduction of production risks.

Key words: Cameroon % Rice % Producer price % World price % Supply response JEL Classification: O13 % Q11

INTRODUCTION

Information about supply elasticity allows for the formulation of appropriate agricultural policies and helps predict short-run and long-run impacts of input changes on production [1-9]. Cameroon is a typical agrarian economy in which agriculture and forestry sectors not only provide for more than 35% of the Gross Domestic Product (GDP) and 70% of employment for the majority of the population [10] but government’s planning and service distribution for these sectors is based on behaviour and response to prices.

Rice, a major cereal crop in Cameroon, is produced largely by subsistence farmers. At the onset of 1960s, rice output stood at 3,500 tons and increased steadily, gaining momentum in early 1970s following the enactment of agrarian and rural development schemes. This contributed to rice production peaking in the country in 1985 at 107,399 tons. However, as shown in Figure 1, a steady decline ensued in the late 1980s and the decline was sustained into an output nadir of barely 29,000 tons in 1993. The production trough in 1993 is explained by both endogenous and exogenous factors and this period coincides with the enactment of stringent austerity

Fig. 1: Production Trend of Rice (paddy) in Cameroon, 1961 - 2006
(Source: Authors’ construction using FAOSTAT, 2008)
macroeconomic policies enshrined in the Structural Adjustment Programme (SAP) aimed at stabilising and adjusting the economy. The devaluation of the CFA franc in 1994 increased the cost of imported farm inputs and the triple elimination of subsidies, general incentives and farmer support programmes grossly limited farmer ability to access modern inputs. Between 1988 - 1998 rice production was constrained by declines in public expenditure and costly production inputs as a result of currency devaluation. Rice production began witnessing and upward swing in 1998 and production gains were consolidated between 2000 and 2003, with output reaching 40,000 tons, testament to positive efforts from some rice development schemes [11-14]. However, improvements in output between 2004 and 2006 have been mere shadow of the boom experienced in early to mid-1980s. Rice production has been on the decline since the liberalization of the sector, due mainly to a lack of access to inputs [10].

Rice is important for household consumption needs [16]. Estimation over a forty-seven year period shows an average consumption of 10.465 kg/capita/yr producing 73.233 Kcal/capita/day (Table 2). In 1999, the consumption rate was about 6.9 kg milled rice per person per year (IRRI, 2007). Cameroon’s milled rice production increased from 37,000 to 51,000 metric tons between 1997 and 2006. At the same period, the domestic consumption increased from 199,000 to 433,000 metric tons. Nowhere is the struggle for increased output more desperate than in the Ndop plains in the Northwestern region and the rice fields in the Northwestern and Northern regions, home to about 60% of Cameroon’s rice growers [18]. In 1994 about 16,847 ha was under cultivation across the country. In 2004, about 15,193 ha of rice was cultivated, indicating a decrease of 9.8% [15]. Less than 25% of the agricultural surface area is used for the production of rice. In the Ndop plains and in the Northwest region in general, almost 25,000 ha of land is available for production. In 2007, only 3000 ha of the available area were cultivated, which is about 9% of available land. Against this backdrop, the average supply in the country is 273,000 tons, i.e. 61,279 tons of local production and 211,720 tons of imported rice [19].

About 70% of domestic rice production is in the Northern region of the country and 30% in the Northwest and West region with 90% of the crop under irrigated lowlands, 8% in rainfed lowland and 2% in uplands. Upland rice is grown as a mono-crop or intercropped with other food crops following the slash-and-burn shifting cultivation. Rainfed rice production is practiced mainly by women on small plots [20]. The irrigated rice production is most structured and was supported with mechanisation and input supply. The support to irrigated rice production has been declining in recent years [10]. Varieties of rice grown and consumed include Oryzae glaberrima, Oryzae sativa and various hybrids of NERICA (New Rice for Africa) [21]. NERICA developed by the West African Rice Development Association (WARDA), based on crosses between African rice (Oyzae glaberrima) and Asian rice (Oyzae sativa) provides opportunity for farmers to stabilise and intensify low-input systems. NERICA varieties tend to resist better against weeds and drought [22]. With generally a much shorter growing cycle (about 90 to 110 days), they have high yield potential and generally out-yield local varieties, under both low and high input conditions [23]. Mindful therefore of the issues at stake in the rice sub-sector, some important questions demand answers: Does world price for rice create a disincentive for increased domestic production? And under the current policy environment, what appropriate strategy is required to better stimulate rice production in Cameroon? This study therefore estimates price supply response coefficients, establish impact levels for other determinants of supply response and recommends ways to enhance rice production in Cameroon.

Rice Policy Regimes in the Context of Food Policy in Cameroon: The implementation of rice policy is adjusted in line with government food policy. Agricultural policy in pre- and post-independence years has recognised rice to be an important crop for producers given that about 75% of the production is commercialised, generating significant contribution to farm-household income [20,24]. Rice has been considered not only as a trade commodity but also political commodity in the context of Food Security. More importantly, the sector has implications for overall agricultural policy as these niche farmers allocate a substantial share of land, labour and working capital to a variety of rice production systems. Thus, various policy regimes also acknowledge it to be an economically important consumer good for households, accounting for a significant share of food expenditure [25]. Given its level of importance for producing and consuming households and the nation, as expounded in Table 2 and the existence of competitive markets for local and imported rice, policies have swung over the years from command-and-control in 1960s to market deregulation of the rice sub-sector in
Table 1: Yield of Rice in Cameroon and selected Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Rice Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameroon</td>
<td>2,360.955</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1,639.272</td>
</tr>
<tr>
<td>Ghana</td>
<td>1,379.134</td>
</tr>
<tr>
<td>South Africa</td>
<td>2,117.187</td>
</tr>
<tr>
<td>Egypt</td>
<td>6,720.419</td>
</tr>
</tbody>
</table>

(Source: Authors’ computation from FAOSTAT, [15])

Table 2: Average Rice Production (paddy equivalent) during different Policy Regimes in Cameroon

<table>
<thead>
<tr>
<th>Period</th>
<th>Production (tons/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-1970 (Post Independence)</td>
<td>0.984</td>
</tr>
<tr>
<td>1971-1980 (Green Revolution)</td>
<td>1.492</td>
</tr>
<tr>
<td>1981-1990 (Oil Boom)</td>
<td>4.226</td>
</tr>
<tr>
<td>1991-1995 (SAP)</td>
<td>3.438</td>
</tr>
<tr>
<td>1996-2008 (Post-SAP)</td>
<td>2.240</td>
</tr>
<tr>
<td>F-value</td>
<td>11.029*</td>
</tr>
</tbody>
</table>

Note: *Significant at 5%

(Source: Author's computations using FAOSTAT, [15])

the year 2000 and from the creation of commodity boards e.g. the Société d’Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) in 1954 to a partial ban on rice imports and establishment of reference prices in the 1990s.

In the early sixties, programs to increase rice production were launched as an integral part of comprehensive food policy with ultimate objective to strengthen food security and alleviate poverty. Rice policy at this period covered various aspect from inputs of production by providing seed, fertilizer, pesticide, financial support and through the promotion of research with the establishment of the Office National de la Recherche Scientifique et Technique (ONAREST) in 1965 to promote agricultural research, training and extension and the Bureau de Developpement de la Production Agricole (BDPA) in 1967. In the 1970s, SODERIM and UNVDA were tasked to not only produce rice but also implement buffer stock strategy, which buys rice at floor price level during harvest season to absorb supply to prevent declining price. They were to ensure that contact farmers received significant subsidy through cheap fertilizer, pesticide and financial support during planting season and guaranteed market for their product. By implementing rice policy and supported with large investment for improving irrigation and massive subsidy provided by government, rice production more than doubled in 1970-1980.

Empirical data showed that favourable conditions had stimulated remarkable increase in the contribution of agricultural sector to GDP, with spillovers to other sub-sectors of food crops, cash crops, livestock and fisheries, which all enjoyed such conducive environment and progressing rapidly. These policy regimes over the years have without doubt thus influenced production levels and market shares and overall productivity and profitability of the sub-sector. As shown in Table 1, the yield of rice in Cameroon compares favourably with other African states that have undertaken similar policy initiatives. Over a forty year period, Cameroon witnessed average yield of 2,360 kg per ha, compared to Nigeria at 1,630 kg per ha and South Africa at 2,100 kg per ha. However, yield levels in Egypt averaging 6,700 kg per ha over the same period highlights the importance of modern irrigation farming systems in enhancing supply response.

The economic crisis in the early 1990s hampered every facet of Cameroon’s economy. Government was forced to change its strategy in 1994 particularly on food policy and it translated, among others by rationalizing the export promotion and price stabilisation strategy.

The post-SAP period of 1996 - 2008 accounts for 2.2 tons per hectare. This compares favourably with the green revolution era of 1971 - 1980 in which average national rice production of 1.3 tons per hectare was recorded (Table 2). Interestingly, these two periods account for opposite policy regimes in the Cameroonian economy: regulation in the 1970s and increased deregulation and openness after 1995 [26]. However, more than expected production levels of 4.2 tons per hectare were observed in the period of 1980s with stable policy environment and declined to 3.4 tons per hectare in mid 1990s due to unstable commodity prices and policy shocks. This would imply that stable policy regimes and certainty in the economic climate enhance production activities, generate surpluses and reduce the risk levels for investors and stakeholders in the agricultural sector [25,27].

Recent developments in Cameroon’s rice policy has witnessed institutional change, state-owned corporations privatized and given the leeway to compete with any other company either as rice producer, importer or engage in other food crops and business activities. The dispensation of liberalization has seen increased competition with imported rice, which may have heralded consumer welfare at the expense of producers. Steeping rice prices recently led to political disturbances, with the government compelled to intervene actively in rice markets through manipulation of taxes on inputs and output, control of international trade and direct participation in marketing through procurement and
distribution of grains. Between 2000 and 2003 import tariffs for rice averaged 37.5% and increased to 39% between 2005 and 2006 [28]. Recent parliamentary and civil society debates have proposed further increase in import tariff to protect rice farmers from competing with cheap imported rice, which cause disincentive to farmers to increase rice production. The proposals so far have not been decided by Ministers of Finance, Agriculture and the Economy.

**Literature Review:** Whereas the opportunities for developing rice production depend to a large extent on the biophysical and socio-economic environments, Defoer *et al.* [22] distinguish three major options for increasing rice production: area expansion, increase in cropping intensity and yield increase - produce per unit area. Mahmood *et al.* [29] show that the factors responsible for fluctuation in rice production include previous area cultivated, previous yield and past real prices. Supply response, which is the variation of agricultural output as a result of variation in price and key inputs, is explained by biophysical, socioeconomic and policy factors [30]. The extent to which agricultural commodities respond to price or input reforms depends not only on the level of variation in prices and or inputs, but also how extensive the price reforms are and at what time period [31]. Abou-Talb and El Begawy [1] estimate the responsiveness of producers for wheat, clover, summer rice and summer maize using a vector error correction model and found out that planned supply is positively affected by own producer price, negatively by prices of competitive crops and structural breaks related to changes in the economic systems.

Chen and Ito [6] Salassi [32] Beckman and Wailes [4] Song and Carter [33] and Farooq *et al.* [3] modelled the responsiveness of rice and the implications for price and trade policy. Their safindings generally indicate the role rice plays in the economics, politics and social aspects of production and trade. Studies show that the success story of rice production across the globe seems to become a history of government capability to formulate a comprehensive food policy with particular reference to rice, coupled with social engineering program that is able to gear-up agricultural practitioners to boast rice production [34,35]. This comes in a package of effort and supporting elements ranging from provision of agricultural inputs for rice production such as increasing fertilizer supply, provision of good quality seed, credit with low interest rate etc. which play key roles in providing basic support to increase productivity, improving rice quality and minimising losses, contributing not only to self-sufficiency but also to marketable surplus [36]. Poor infrastructure and weak technological development, unavailability of irrigation and productive inputs, missing credit markets, seasonal labour shortages and lack of "incentive goods" in the form of industrial consumer products to motivate efforts to earn cash income are typical agricultural supply-response-stifling structural constraints [37,38]. Structural factors such as transportation infrastructure, irrigation and literacy are generally assumed to shift the supply schedule outward [39,40].

Prices are generally the conduit through which economic policies are expected to affect agricultural variables such as output, supply, exports and income [41,5]. The emphasis on market forces, the elimination of marketing boards and the withdrawal of government from direct production all aim for an environment in which agricultural output is responsive to price levels. An analysis of agricultural supply responses to changing prices is, therefore, a crucial element in assessing the effects of increasing openness of the economy. It is in this spirit that Kwanashie *et al.* [42] on estimating price and non-price supply response coefficients for nine individual crops, sub-sectoral aggregates and commodity exports on agriculture, confirmed two results in the supply response literature; that (1) short-run price elasticities of individual crops are smaller than the long-run elasticities and (2) commodity sub-sectoral aggregates do not respond significantly to prices as individual crops. The results also show that the responses of food crops are sensitive to agro-climate and the traditional cropping patterns of smallholder farmers. Other evidence suggests that supply response to price increases do exist even though they are usually relatively small [43,44]. According to Badawi [45] sustainable response of rice production systems depend on four major areas: Government policy and commitment to the implementation of programs; improved technology and better crop management to maximize yield of the improved varieties; external support for marketing inputs and outputs; and farmer participation and acceptance of new technology.

**Research Methodology**

**Analytical Framework:** Agricultural supply response studies have been influenced by the Nerlove [46] framework. In actual estimations the original model has been modified in many diverse ways [46,47]. Most studies of agricultural response include some form of price expectation and partial output adjustments. In these
studies a distinction is often made between actual and desired levels of production and also between actual and expected prices [48, 49, 41, 50]. In this research, $Y_t$ is assumed to be the yield of rice and $P_t$ indicates the price levels. An implicit supply response function is expressed as:

$$Y_t = f(P_t^d, P_t^r, W_t, R_t, G_t, I_t, u_t)$$  \hspace{1cm} (1)$$

Where $P_t^d$ is the producer price for local rice, $P_t^r$ is the global price of rice with important indirect effects to local producers, $R_t$ is the exchange rate of Cameroon currency to foreign currency, $W_t$ weather condition (e.g. rainfall), $G_t$ is government expenditure on agriculture, $u_t$ is the stochastic error term assumed to be independently and normally distributed with zero mean and constant variance. A priori it is expected that:

$$\frac{\partial f}{\partial P_t^d} > 0, \frac{\partial f}{\partial P_t^r} > 0, \frac{\partial f}{\partial W_t} < 0, \frac{\partial f}{\partial R_t} < 0, \frac{\partial f}{\partial G_t} > 0$$  \hspace{1cm} (2)$$

This means that yield is expected to vary positively with producer price of local rice, but it could fall with the strengthening of the local currency against major currencies. Yield is expected to vary positively with land under cultivation but it could either rise or fall with changes in rainfall depending upon whether or not there is a normal rainfall or flood or drought. Equation (1) could be modified to account for relative rather than absolute prices and irrigation. Hence we obtain:

$$Y_t = f\left(\frac{P_t^r}{P_t^d}, \frac{P_t^r}{P_t^d}, W_t, R_t, G_t, I_t, u_t\right)$$  \hspace{1cm} (3)$$

Where $P_t^r$ is the price of competing farm crop and $I_t$ is proportion of rice irrigated area to cultivated area. A central problem in the estimation of supply response equation is that producers respond to expected as opposed to actual prices. In addition, observed quantities may differ from the desired ones because of adjustment lags in the reallocation of variable factors. It is imperative, previous studies, allows for the specification of a shifters (e.g. weather, $W_t$; exchange rate, $R_t$; $u_t$ accounts for unobserved random effects affecting the output from cultivation and has an expected value of zero; and $\delta$’s are parameters with $\delta$, the long-run coefficient (elasticity) of supply response for rice.

Response by rice farmers may be constrained by very small holdings combined with the need to diversify production to spread risks, credit constraints, lack of availability of inputs etc. To allow for this possibility it is assumed, in the Nerlovian tradition that the change in yield between periods occurs in proportion to the difference between the expected output for the current period and the actual output in the previous period. In other words, since full adjustment to the desired output level is possible only in the long-run, the actual adjustment in yield is a fraction (*) of the expected adjustment. This translates to output changes, i.e.:

$$q_t - q_{t-1} = \delta(q_t^d - q_{t-1}) + \nu_t$$  \hspace{1cm} (5a)$$

Rearranging:

$$q_t = q_{t-1} + \delta(q_t^d - q_{t-1}) + \nu_t$$  \hspace{1cm} (5b)$$

Where $q_t$ is the actual output of rice, $q_t^d$ is the actual output in period $t-1$, $q_t^d$ is expected output in period $t$ and $\delta$ is the partial-adjustment coefficient. The relationship is not deterministic and is affected by random shocks as captured by the error term $\nu_t$. The adjustment parameter $\delta$, must lie between 0 and 2 for the adjustment to converge over time, but $\delta > 1$ implies persistent over-adjustment and does not appear plausible in subsistence peasant agriculture. So we limit $\delta$ to lie between 0 and 1. Similarly, the price farmers expect to prevail at harvest time is not observed and account for their expectations based on actual and expected prices [47].

**Cointegration and Error Correction Modelling:**

**Estimation Techniques:** The established technical relationships from Eq. (1) to Eq. (5) and experiences from previous studies, allows for the specification of an empirical parsimonious supply function (possibly in the double log form) as follows:

$$\ln q_t = \theta_1 + \theta_2 \ln P_t^d + \theta_3 \ln P_t^r + \theta_4 \ln q_{t-1} + \theta_5 \ln P_t^r$$
$$+ \theta_6 \ln W_t + \theta_7 \ln G_t + \theta_8 I_t + \epsilon_t$$  \hspace{1cm} (6)$$

The variables are as previously defined. Given that the research employs time series data, techniques in time-
series statistical and econometric analysis are employed to establish the validity of the model [52]. The Engle-Granger approach is employed [1,53] and a test for possible Cointegration is carried out. To ascertain whether the data series for each variable involved in the empirical model exhibit similar statistical properties, test for stationarity in each of the series is undertaken. The Augmented Dickey-Fuller (ADF) statistics are used to test for stationarity and the lag length chosen that ensures that the residual is empirical white-noise. That is, for each variable, per se:

\[ \Delta q_t = \psi_0 + \Omega q_{t-1} + \sum_{i=2}^{k} \delta_i \Delta q_{t-i} + \varphi, \]  

(6)

Where the lag length k chosen for ADF ensures that \( \eta_i \) is empirical white noise. \( H_0 \) (null hypothesis) holds that \( a_i \) is I(1) as against \( H_2 \) being I(0). \( H_2 \) is rejected if the t-statistic on \( S \) is negative and statistically significant when compared to appropriate critical values established for stationarity tests. If found to be non-stationary, the series \( a_i \) requires differencing to become stationary. Once stationary properties of all the individual series \( (Y_t, A_t, P_t, P_t', R_t, W_t, G_t, I_t) \) are established, linear combinations of the integrated series are tested for co-integration, for unless they co-integrate they cannot describe equilibrium relationships. In sum, an equilibrium relationship exists when variables in the model are co-integrated [52]. The idea of co-integration suggests that if \( q(t) \) and \( p(t) \) are both integrated of order 1 (i.e. I(1)), without trends in means, so that their changes are both I(0) and with zero means, then it is possible that there exists a constant such that a linear combination of \( q(t) \) and \( p(t) \), say \( x(t) - kp(t) = z(t) \), is I(0). Test for the nature of the equilibrium relationship that exists between variables in the model is then carried out. If established that the data series have a long-run equilibrium relationship but have significant short-run divergences, the model is given an error-correction representation, theoretically defined as:

\[ \Delta q_t = \pi_0 + \pi_1 \Delta q_t' + \pi_2 [q_{t-1} - q_{t-1}] \]  

(7)

Where \( \Delta q_t \) is the change in the ‘desired’ equilibrium level. The error-correction mechanism captures the short-run dynamics, while making the model consistent with long-run dynamics.

**Nature and Source of Data:** The data used in this study covers the period 1961-2006. Data on rice output (paddy equivalent) and irrigation are obtained from the FAO online statistical database, FAOSTAT. Import quantities for rice into Cameroon and international prices are obtained from UNCTAD’s Trade Analysis and Information System (TRAiNS). Information on producer prices for local rice and maize are obtained from Ministry of Trade and Industrial Development (MINDIC, 2006). Information on government expenditure on agriculture used to capture incentives to farmers is obtained from the Annual Statistical year book from the Ministry of Economy and Planning. Time series information on rainfall is obtained from the FAO’s Africa Rainfall and Temperature Evaluation System (ARTES). This data is generated for countries by the National Oceanic and Atmospheric Association’s Climate Prediction Centre based on ground station measurements of precipitation and temperature. In this study the coefficient of variation of wet season (May - October) rainfall measured in millimetres is used. The importance of irrigation is tested, with information on irrigated area obtained from FAO [15].

**RESULTS AND DISCUSSION**

**Diagnostic Evaluation:** To obtain reliable estimates for the experiment, a test is first test carried out if there is an equilibrium relationship of the variables in Eq. (6), i.e. whether they exhibit similar statistical properties. the Engle and Granger [55] co-integration tests by testing the Augmented Dickey-Fuller (ADF) statistics is employed. In line with the expositions on co-integrating methodology [56,53] ADF test statistics for unit root of the individual series are presented in Table 3. According to the results, the null hypothesis for the existence of unit root cannot be rejected for the series in their level form as the ADF statistics are above the critical value of -3.27. They are observed to be stationary when differenced. The ADF test statistics together with the details on number of lags indicate non-stationarity property in some of the series and the possibility of a long-run equilibrium relationship in their difference form. These observations are robust as they compare favourably with the Phillips-Perron (PP) nonparametric test.

The implications of non-stationarity or random-walk behaviour in the variables highlight the possibility of a stochastic trend feature. This stochastic trend behaviour could imply that: i) the permanent component in the fluctuation of each of the variable is highly volatile and ii) regular shocks in the economy, whether endogenous or exogenous will result in permanent
Table 3: Unit Root Tests for Selected Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF (k)</th>
<th>PP</th>
<th>Variable</th>
<th>ADF (k)</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Y</td>
<td>-2.338 (2)</td>
<td>-2.293</td>
<td>) In Y</td>
<td>-3.429 (1)</td>
<td>-3.590</td>
</tr>
<tr>
<td>In P_m/P</td>
<td>-2.347 (1)</td>
<td>-2.365</td>
<td>P_m/P</td>
<td>-3.438 (1)</td>
<td>-3.599</td>
</tr>
<tr>
<td>In r'/P</td>
<td>-3.275 (3)</td>
<td>-3.148</td>
<td>r'/P</td>
<td>-3.313 (2)</td>
<td>-3.482</td>
</tr>
<tr>
<td>In W_i</td>
<td>-2.362 (2)</td>
<td>-2.428</td>
<td>In W_i</td>
<td>-4.260 (2)</td>
<td>-4.268</td>
</tr>
<tr>
<td>In G_i</td>
<td>-2.299 (4)</td>
<td>-3.778</td>
<td>G_i</td>
<td>-4.588 (3)</td>
<td>-4.765</td>
</tr>
<tr>
<td>In I_i</td>
<td>-2.582 (2)</td>
<td>-2.581</td>
<td>In I_i</td>
<td>-3.425 (2)</td>
<td>-3.432</td>
</tr>
</tbody>
</table>

Critical values at 5% level of significance are -3.27 and -3.41, respectively.

Table 4: Engle-Granger Test for Long-run Equilibrium Cointegration

<table>
<thead>
<tr>
<th>Regressors</th>
<th>ln Y</th>
<th>ln P_m/P</th>
<th>ln P_r/P</th>
<th>ln W_i</th>
<th>ln G_i</th>
<th>ln I_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln Y</td>
<td>n.a</td>
<td>0.126(1.695)</td>
<td>0.026(1.726)</td>
<td>0.082(1.417)</td>
<td>0.325(1.651)</td>
<td>0.219(2.168)</td>
</tr>
<tr>
<td>ln P_m/P</td>
<td>0.124(2.813)</td>
<td>n.a</td>
<td>0.019(1.359)</td>
<td>0.003(1.304)</td>
<td>0.072(1.204)</td>
<td>0.027(2.853)</td>
</tr>
<tr>
<td>In r'/P</td>
<td>-0.128(-1.973)</td>
<td>0.018(1.613)</td>
<td>n.a</td>
<td>0.006(1.175)</td>
<td>0.120(1.167)</td>
<td>0.010(1.921)</td>
</tr>
<tr>
<td>ln W_i</td>
<td>0.295(2.408)</td>
<td>0.022(1.058)</td>
<td>0.081(1.890)</td>
<td>n.a</td>
<td>0.008(1.265)</td>
<td>0.088(2.757)</td>
</tr>
<tr>
<td>ln G_i</td>
<td>0.305(3.368)</td>
<td>0.024(1.926)</td>
<td>0.136(2.699)</td>
<td>0.092(1.018)</td>
<td>n.a</td>
<td>0.063(1.369)</td>
</tr>
<tr>
<td>ln I_i</td>
<td>0.052(2.104)</td>
<td>0.017(1.861)</td>
<td>0.073(1.468)</td>
<td>0.002(1.450)</td>
<td>0.016(1.479)</td>
<td>n.a</td>
</tr>
<tr>
<td>Intercept</td>
<td>10.734(3.462)</td>
<td>11.890(2.604)</td>
<td>10.676(1.985)</td>
<td>6.408(1.856)</td>
<td>8.909(4.285)</td>
<td>7.649(3.899)</td>
</tr>
<tr>
<td>R² adj.</td>
<td>0.635</td>
<td>0.433</td>
<td>0.527</td>
<td>0.217</td>
<td>0.528</td>
<td>0.511</td>
</tr>
<tr>
<td>DW</td>
<td>1.853</td>
<td>1.716</td>
<td>1.893</td>
<td>1.784</td>
<td>1.920</td>
<td>1.937</td>
</tr>
<tr>
<td>ADP</td>
<td>-4.390 (1)*</td>
<td>-3.832 (1)*</td>
<td>-3.368 (2)*</td>
<td>-3.152 (2)</td>
<td>-2.831 (3)</td>
<td>-2.999</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>3.778</td>
<td>3.296</td>
<td>3.232</td>
<td>4.313</td>
<td>2.081</td>
<td></td>
</tr>
<tr>
<td>Schwarz criterion</td>
<td>5.341</td>
<td>4.890</td>
<td>5.352</td>
<td>4.190</td>
<td>6.267</td>
<td>4.746</td>
</tr>
<tr>
<td>Box-Pierce</td>
<td>15.724</td>
<td>13.853</td>
<td>16.074</td>
<td>8.025</td>
<td>13.939</td>
<td>10.648</td>
</tr>
<tr>
<td>J-B</td>
<td>5.865</td>
<td>5.892</td>
<td>4.973</td>
<td>6.866</td>
<td>6.989</td>
<td>5.900</td>
</tr>
<tr>
<td>Chow - F(7,40)</td>
<td>2.891</td>
<td>3.486</td>
<td>3.563</td>
<td>2.978</td>
<td>3.450</td>
<td>4.687</td>
</tr>
</tbody>
</table>

DW is the Durbin-Watson statistic. J-B is the Jarque and Bera statistic with a critical value of 5.89. The critical value for the Box-Pierce statistic is 13.52, while the critical value for the Chow statistic is 2.65. ADP is Augmented Dickey-Fuller statistic with critical value -3.27. a = appropriate lag length required for white noise in parentheses.* indicates Cointegration. n.a = not available

increase in the level of the studied series. These open a vista of policy possibilities, e.g. the long run growth may result from the real supply or technology shocks rather than demand or monetary. An exploration of the determinants of supply response allows us to better ascertain the impact levels and long-run effects of such shocks.

Policy Effects and Long-run Analytics: The policy regimes espoused in section 2 have played on long-run rice production in the country, with producer price for locally produced rice, relative world and substitute crop price, together significantly contribute to 63.5% of the variation in planned rice yield, as shown by the adjusted R² in Table 4. Rice yield may increase 1.24% for a ten percent increase in relative world price to producer price, respectively. A ten percent increase in relative price of substitute maize crop accounts for 1.28% decline in yield. Government expenditure, weather and irrigation are similarly observed to significant contributory effects. The results thus highlight that variations in output levels are caused by random fluctuations in agricultural prices and other supply-side factors e.g. rainfall [56]. This implies supply response and good supply management may in the long-run depend on agricultural price inflation or deflation.

Cointegration is revealed by the ADF statistic for ln_q, ln P_m/P and ln P_r/P. The significant Chow - F test for structural stability [57] in the mean of the variables and the slope coefficient is in line with observations in the policy environment, indicating that rice productivity growth may have been constrained partly by the implementation of structural adjustment programmes in the 1990s that ushered increased openness.
to trade and the elimination of the commodity boards. The SAP package brought a whole new vista of opportunities and challenges on supply response, as government policies for the crop sector changed significantly from "high support and high protection" since the 1970s to "low support and low protection" since the mid-1990s. As shown in Figure 2, a significant jump is observed in productivity in the early 2000s, after years of decline. Overall rice yield trend has a growth rate of 4.723%.

It remains to be evaluated whether this positive growth is due to the government sponsored agricultural development schemes such as the Upper Noun Development Authority (UNVDA), Southwest Development Authority (SOWEDA), Northwest Development Agency (MIDENO) and a plethora of other schemes that strive to support rural producers, which have borne fruits for the 0.2 million hectares of rain-fed upland rice in humid and dryland zones in Cameroon.

**Error Correction, Short-run Dynamics and Yield Response:** The results obtained from maximum likelihood estimation of eq. (6) and presented in Table 5, show that lagged values of yield have significant effects on current rice output, across all the models. Similarly, lagged values of relative world price to producer price for rice do have significant short-run effects on changes in production. A ten percent increase in the relative international price leads to either 1.37%, 1.14%, 1.11%, 1.05% or 0.96% increase in rice production in the short-run, across the

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Table 5: Yield Response of Rice in Cameroon

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
<th>Model V</th>
<th>Model VI</th>
<th>Model VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln Y_{t-1}$</td>
<td>0.235(3.483)***</td>
<td>0.172(2.681)**</td>
<td>0.141(2.515)**</td>
<td>0.126(2.463)**</td>
<td>0.109(2.327)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \ln P_{t-1}^e / P_{t-1}^s$</td>
<td>0.137(2.536)**</td>
<td>0.114(2.445)**</td>
<td>0.111(2.367)**</td>
<td>0.105(2.258)**</td>
<td>0.096(2.207)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \ln P_{t-1}^e / P_{t-1}^s$</td>
<td>-0.0347(-1.742)*</td>
<td>-0.039(-1.705)*</td>
<td>-0.045(-1.628)*</td>
<td>-0.047(-1.503)*</td>
<td>-0.053(-1.489)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \ln W_{t-1}$</td>
<td>0.186(2.413)**</td>
<td></td>
<td>0.151(2.393)**</td>
<td>0.137(2.195)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \ln I_{t-1}$</td>
<td></td>
<td>0.1181.964*</td>
<td>0.1081.801*</td>
<td>0.137(2.195)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0503(3.813)***</td>
<td>0.0328(3.141)***</td>
<td>0.0283(2.925)***</td>
<td>0.0506(3.287)***</td>
<td>0.0681(3.473)***</td>
<td>0.0703(4.261)***</td>
<td>0.0693(4.813)***</td>
</tr>
<tr>
<td>$\mu_{t-1}$</td>
<td>-0.091(-2.235)**</td>
<td>-0.123(-2.260)**</td>
<td>-0.115(-2.188)**</td>
<td>-0.164(-2.351)**</td>
<td>-0.193(-2.378)**</td>
<td>-0.217(-2.399)**</td>
<td>-0.258(-2.483)**</td>
</tr>
<tr>
<td>R2 adj.</td>
<td>0.361</td>
<td>0.473</td>
<td>0.435</td>
<td>0.527</td>
<td>0.563</td>
<td>0.587</td>
<td>0.652</td>
</tr>
<tr>
<td>DW</td>
<td>1.929</td>
<td>1.892</td>
<td>1.827</td>
<td>1.854</td>
<td>1.840</td>
<td>1.836</td>
<td>1.857</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>1.034</td>
<td>1.387</td>
<td>1.499</td>
<td>2.013</td>
<td>2.641</td>
<td>3.301</td>
<td>2.915</td>
</tr>
<tr>
<td>Box-Pierce</td>
<td>2.962</td>
<td>2.901</td>
<td>2.956</td>
<td>3.105</td>
<td>3.264</td>
<td>3.372</td>
<td>3.513</td>
</tr>
</tbody>
</table>

Note: Dependent Variable: Yield. ***=significant at 1%; **=significant at 5%; *=significant at 10%. DW is the Durbin-Watson statistic. J-B is the Jarque and Bera statistic with a critical value of 5.89. The critical value for the Box-Pierce statistic is 13.52.
tested models, suggesting a relative importance of world price for rice production in Cameroon. In model II the ratio of import to domestic price is entered alone, providing a test for market integration; being significant and positive implies producers in Cameroon can ‘price to’ imports, with domestic price following import price. Lagged values of maize price as competing crop in farm production seem to have significant negative short-run dynamic effect on changes in rice production. Changes in production are determined jointly by agricultural expenditure and weather. The elasticities for rainfall are 0.186, 0.151 and 0.137, respectively. Though small they indicate a significant positive correlation with yield, attesting to the importance of rainfall agriculture. A ten percent increase in governmental expenditure for agriculture and irrigation increases rice output by 1.08% and 0.53%, respectively. The error correction terms give the expected negative signs and are statistically significant. The error correction coefficient for the completely specified model VII indicates that more than 25.8% of the adjustment towards long-run equilibrium for rice production is completed in one period. However, it also shows that about 25.8% proportion of disequilibrium in supply in less than one period is corrected in the next period. That the correction is significant, this confirms the long-run equilibrium between the series.

The findings reveal important implications for agricultural price policy. In spite of the increase in rice prices on the international market and a correlation of about 0.466 with local producer prices, as shown in Figure 3, imports of rice to Cameroon have trended upwards and have been increasing steadily, primarily due to the strong appreciation of the CFA franc vis-à-vis the dollar which means that import prices in CFA franc terms remain relatively stable and low. And production constraints imply large unmet domestic demand with an attendant consequence of pushing up imports despite rise in global prices. The attendant implication is the increased competition faced by local producers, which is expected to stimulate positive reaction to production levels. Whilst masked in the analysis is the role of seasonal price which may be very significant in influencing producer response, seasonal price variability is high in many African countries and has remained so even after market reforms [58]. Temporal marketing margins are similarly high [58,59]. The associated exposure to price risk weakens supply response. While downward variation and declining prices may enshrine gains in consumer welfare, it may correspondingly lead to loss in producer welfare. However, the output-price relationship may be reinforced by rising cost of production, causing the country to lose its comparative advantage. Nonetheless, additional shocks may come from changes in government expenditure (G), technology and resource allocation generating random fluctuations [60]. A combination of these factors explain the movement of average yield and domestic price between 1990 and 2005 to 30,177 kg per ha and 93,629 FCFA per ton, respectively. If we relate this to the price and production booms in the early 1970s, then we begin to appreciate the difficult conditions in rice production in recent times. It is without doubt therefore that producers have sought to manipulate labour and land use to guarantee favourable returns from farms.

Market Integration and Model Predictability: The significant coefficient of +0.137 for the relative world price of rice, in model II in the yield response function, indicate a significant integration of Cameroon into the world
trading system. Producers therefore take into account world price in setting the price for their commodity. This drive for market integration and price convergence has important implications for agricultural trade with producers expecting to reap efficiency gains in an integrated market. Avoiding any unintended consequences of this integration will depend on the efficiency of the existing trade and agricultural policy. In this respect, a policy package that is directed towards promoting irrigation technology, access to weather for, reduction of production risks and development of market-supporting infrastructure are crucial for an incentive structure that boosts supply and crowd-out imports. However, Cameroon being a member of the World Trade Organisation and signatory to plethora of bilateral and multilateral trade agreements has surrendered the possibility of using taxes or subsidies on foreign trade as important mechanism for manipulating domestic prices.

The reliability of our estimation is gauged in Table 6 which present sample prediction errors for the yield response model. Sample performance of the production level in each model is measured in terms of root mean squared error (RMSE) and mean absolute error (MAE). The evidence of out-of-sample performance is relatively weaker than in-sample, as the prediction errors in terms of RMSE and MAE from out-of-sample regression are greater than in-sample regression. Models IV to VII exhibit lower prediction errors than models I to III. The differences of prediction errors amongst the models can be interpreted as gains of accounting for the factors that influence production [61,62].

Policy Recommendations and Conclusion: The rice sector is shown to be influenced by yield expectations, irrigation and relative global market price as well governmental expenditure on agriculture. As shown in the response to relative global price for rice, the presence of market power exerted by imported rice, impacts on producer supply response. The magnitude of the effect on producers may be due to the structure of production units and the characteristics of domestic markets. While imported rice provide a competitive environment needed to continuously mobilise innovation and entrepreneurship for the development of the domestic rice sub-sector, price and non-price factors are strategically important for promoting the sector’s response. Future policy would therefore primarily require enhanced monitoring of the rice sector developments and better reinforcement of rice sector interventions to encourage the use of improved varieties to increase yields, encourage use of irrigation, promote improved cultural practices, ensure better storage and facilitate access to working capital to enable increase in size of operations and improve regularity of supply and possibly facilitate entry of new operators in the market to increase competition. In addition, building capacity of rice producers and possibly that of processors and traders would be important to allow stakeholders play proactive role in lobbying for non-rice specific interventions (e.g. infrastructure, input markets, credit) to be taken into account in agricultural policy.

REFERENCES


(1) This study collates national rice production and marketing information from 1961 to 2006. However, the study does not examine the microeconomic analysis of rice farms and households. The objective is viewed from a macro-development perspective. Data on output, prices and conventional agricultural inputs are elicited from secondary sources. On rice output information we use the FAO online data for its reliability, expediency and absence of longer production series information from national agencies. Fertiliser is an important input, however for lack of adequate time series information; it is not examined in the study.

(2) Reference is also made to qualitative information from the International Rice Research Institute (IRRI) and UNCTAD. Maize is studied given its role as an alternative or major competing crop in land-use for rice by agricultural producers in Cameroon (Molua, 2002)

(3) This study is limited by its working hypothesis which is a partial investigation of supply response of rice production in Cameroon in a scenario of increasing openness and importation of subsidised rice from other countries. However, this study acknowledges the existence of other exogenous factors that may influence rice farming. In this regard, this research posits two limitations. First, the model is set in terms of yield response (leading to the derivation of the short-run and long-run output elasticities), although farmers respond to various stimuli not just by adjusting area, but also by adjusting the other inputs into production (such as water, fertiliser, irrigation, climatic factors, etc.). In addition, rural public investment, specifically in the areas of irrigation, soil and water conservation, agricultural research and education, and product storage and warehousing, may also be expected to encourage acreage under a crop. Second, this study focuses on supply response rather than marketed-surplus response because the former encompasses all farmers, whereas the latter is concerned mostly with large farmers. It is conceivable that policies benefiting marketed-surplus response, price incentives, for instance are more likely to benefit large farmers than the small farmers who do not have much to sell; on the other hand, policies benefiting supply response may well benefit both the small and the large farmers.

(4) The Box-Pierce test statistics for residual autocorrelation are significantly different from zero, meaning that we fail to reject the null hypothesis of non-autocorrelation of the residuals except for In $W$ and $I$. The critical value for the Box-Pierce statistic is 13.52. The residuals appear to be normally distributed except for In $W$, $G^*$ and In $I$, in which the Jarque-Bera statistics are larger than the critical values required for rejecting the null hypothesis of normal residuals at the 5 percent level.