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Crop storage efficiency and market competitiveness: Case of groundnut and cowpea in Ghana

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Using groundnut (*Arachis hypogea*) and cowpea (*Vigna unguiculata*), this study empirically demonstrated the correlation between crop storage and economic competitiveness of producers, captured from the degree of market integration and producer shares of the prices paid by consumers, among others. Secondary data covering 1963–1997 were used and complemented with primary data. Results from analysis of market integration showed delayed information flow among groundnut and cowpea markets, especially the latter. This suggests the absence of perfect competition and negatively affects participation of smallholder farmers in profitable marketing of groundnut and cowpea, especially during the lean season. The Harris' inverse margins from estimated equations indicated that cowpea traders, more than groundnut traders, colluded in pricing, implicating price determination outside the market forces. The attack by weevils [*Callosobruchus maculatus* (Fabricius)] and bruchids limits farmers' success in storing cowpea, creating monopoly for traders with better storage facilities coupled with chemical treatments to reduce such attacks. Price spread estimations showed that groundnut unlike cowpea farmers enjoyed a larger share of consumers' payments. The study concludes with recommendations on the need to intensify efforts in effective storage of agricultural commodities at the farm-level, as a way of improving the welfare of farm families without necessarily expanding the land area under cultivation.

Key words: Grains legumes storage, market competitiveness, pricing practices, farmer benefits, Ghana.

INTRODUCTION

In a market economy, prices guide producers in their choice of enterprises (e.g., crops to produce, livestock to keep, how much to produce, production methods to use, and when and how to produce for maximum returns). The ultimate in market integration is achieved when two (or more) markets are yoked together by the Law of One Price (LOP) (Ghemawat, 2001). That is, prices equalize across them. Production and marketing constitute a continuum (Olayemi, 1972). This author noted that lack of development in one retards progress in the other. Marketing contributes to the developmental process of an economy in several ways: First, it provides channel for efficient allocation of economic resources, leading to high value production and better consumer satisfaction.

Second, it stimulates growth by promoting technological innovation and increased supply and demand for different commodities (Scarborough and Kydd, 1992).

Most measures of market integration have scaled to new heights in the last few decades but are still fall far short of economic theory's ideal of perfect integration (Ghemawat, 2001). Agricultural produce storage increases the selling opportunities of farmers and other actors in the value chain. It is also critical for farmers to harness the benefits of agricultural commodity marketing. This is because farm produce storage reduces post harvest losses and enhances farmers' effective access to and participation in marketing. Besides, storage helps to regulate farm produce flows to the market and helps to stabilize prices over time and space. Farm produce storage also helps to ensure food security among most households since it can effectively contribute in reducing the high prices often encountered during the lean season, especially of the difficult-to-store farm produce. Farm produce storage brings

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about time utility and flexibility in the timing of sales with the attendant price advantages. In Ghana, cowpea seed or grain is mostly removed from the pod for storage. A wide variety of containers are used for seed or grain storage including pots, tins and baskets, but the most common is the jute or polypropylene sack (Walker and Tripp, undated). With respect to groundnut, smallholder farmers store it in-shell in earthen pots, mud bins, bamboo baskets or in other types of wicker receptacles. These containers are often plastered with mud or cow dung with little or no use of pesticides. For long-term storage, the containers used in storing groundnut are sealed with mud after the addition of ashes, ground pepper, dried neem leaves or other local herbs to control storage pests (FAO, undated). Generally, post harvest losses are more with cowpea than with groundnut and explain why many producers tend to produce and also store less of cowpea than groundnut at the present level of storage technologies that are available to them.

This study analyses market conduct, market integration, and producers' share of prices paid by consumers for groundnut (*Arachis hypogea*) and cowpea (*Vigna unguiculata*). The objective was to show and compare the effects of crop storage on the economic competitiveness of groundnut and cowpea producers. A better understanding of barriers to market integration can help improve decision-making.

Pests and diseases damage of cowpea and groundnut

Cowpea: Most cowpea farmers in sub-Saharan Africa are confronted with low yields, caused by insect pests and diseases. Cowpeas are susceptible to a wide range of pests and pathogens (e.g., insects, bacteria, viruses, fungi and weed) that attack the crop at all stages of growth. Some 40 species of fungi are cowpea pathogens. In the North Ghana *Maruca vitrata* damage is most significant in areas where maize is a major component of the farming system. In areas where sorghum and millet are cropped extensively, pod-sucking bugs occur much earlier in cowpea pod development. Cowpea weevils [*Callosobruchus maculatus* (Fabricius)] and bruchids are major pests on cowpea in Africa and attack dried cowpeas and other related stored seeds. They are mainly found on cowpea grains in storage and may be the main constraint to increased cowpea production.

Groundnut: The losses during storage are mainly due to diriage loss and through damage by rodents and pests. Damage also occurs due to dampness which develops the moulds, leading to contamination with Aflatoxin.

MATERIALS AND METHODS

Data types and sources

Primary data were obtained from farmers and groundnut and cowpea traders using informal Participatory Rural Appraisal (PRA)

methods. The main primary data collected from farmers were the 1996 and 1997 farm-gate prices for cowpea and groundnut. Secondary data on weekly prices of groundnut and cowpea, covering 34 years (1963–1997), were obtained from the statistical division of the Ministry of Food and Agriculture (MoFA, undated), Accra, Ghana. However, the data for evaluating the producer-wholesaler price spread used in determining the proportion of price paid by consumers that actually reached producers covered only 1996 and 1997.

Data were collected from eight markets. These comprised of three peri-urban markets (Bolgatanga, Wa and Tamale), four urban markets (Koforidua, Kumasi, Tema, and Accra), and one transit market (Techiman). The transit market is located somewhere between the location of the peri-urban market (where some production happens) and urban markets (where mostly consumption takes place). Across the eight markets, a total of 56 market pairs were studied for each of the grain legumes (cowpea and groundnuts).

Data processing

Data entry was implemented using Microsoft Excel. Data analysis was carried out using both Microsoft Excel and the Statistical Package for Social Sciences (SPSS, 2002). Data were explored for descriptive statistics and vital relationships among variables through linear and multiple regression analyses.

Determination of spatial market association

Spatial market association is also known as spatial market integration. The presence and strength of associations between markets were determined using Timmer's Index of Market Connection or Concentration (IMC) (Timmer, 1987). Markets are said to be spatially associated when prices in each market respond not only to its own market forces (supply and demand) but also to the market forces of other markets. Information flows between markets enhance such associations such that scarcities in one market induce the arrival of produce from other markets and vice versa. In order to evaluate the 2-way spatial market integration between say a local market (Market 1) and a reference market (Market r), we used the following multiple regression equations:

$$\begin{aligned} P_l &= f(P_r, X_l, U) & 1 \\ P_r &= f(P_l, X_r, U) & 2 \end{aligned}$$

Where equations (1) and (2) represent the first and second-way associations, respectively for information flow between the Market l with price P_l for Market 1 and price P_r for Market r. x_l and x_r are the dummies representing the seasonal price changes for post harvest and lean periods; u represents the standard error of the equations. Stated explicitly:

$$P_{lt} = \sum \alpha_{1k} P_{1t-k} + \sum \beta_{1e} P_{2t-e} + \sum \epsilon_1 X_{1t} + U_{1t} \dots \dots 1^{st} \text{ way information flow}$$

Where;

$$\begin{aligned} P_{lt} &= \text{Price in market 1 at time t in the first-way equation;} \\ \alpha_{1k} &= \text{Coefficient of prices in market 1 for k number of weeks;} \\ P_{1t-k} &= \text{Prices in market 1 in t-k lags;} \\ K &= \text{1 and 2 weeks for local market status} \\ \beta_{1e} &= \text{Coefficients of prices in market 2 for e number of weeks;} \\ e &= \text{0, 1, 2 and 3 weeks for reference market status} \\ P_{2t} &= \text{Price in market 2 at time t;} \\ P_{2t-e} &= \text{Prices in market 2 in the three previous weeks;} \\ \epsilon_1 &= \text{Coefficient of exogenous variable in first-way} \end{aligned}$$

Equation;

X_{1t} = Exogenous variable in first-way equation;
 U_{1t} = Error term in first-way equation.

P_{2t} = $\sum \alpha_{2k} P_{2t-k} + \sum \beta_{2e} P_{1t-e} + \sum \epsilon_2 X_{2t} + U_{2t}$
2nd way information flow

Where;

P_{2t} = Prices in market 2 in time t;
 α_{2k} = Coefficient of prices in market2 the previous week and two weeks ago;
 P_{2t-k} = Prices in market 2 at time t-k;
 k = 1 and 2;
 β_{2e} = Coefficients in market 1 in time t-e
 e = 0, 1, 2 and 3 weeks time lags;
 P_{1t-e} = Prices in market 1 in at time t-e;
 ϵ_2 = Coefficient of exogenous variable in 2nd way equation representing the influence of external factors on the price in market 1.
 X_{2t} = Exogenous variable at time t in 2nd way equation;
 U_{2t} = Error term in second-way equation 2;

The hypothesis is that in the short-run, $\beta_{1t-e} \neq 0$ and $\beta_{2t-k} \neq 0$. This means that the price in each market is influenced by the price in the other market at a time lag of e and k, respectively.

To determine the strength of the integration however, it was necessary to estimate the IMC or the Timmer's Index. The IMC values helps to determine the strength of the association between two markets. The stronger the association between market pairs, the faster the transmission of price and supply information from one market to the other.

Market conduct and pricing practices

The pricing practices operating at three different channel levels were used to determine and characterize the conduct of the market for groundnut and cowpea. The channel levels at which pricing practices were studied include: the farm gate and the regional market (1); the regional market and the urban market (2); and the farm gate and the urban market (3). Channel level 3 is also referred to as the overall channel.

The empirical model

The empirical models used for the evaluations of market integration were as follows:

$$P_{W1} - P_F = \alpha + \beta P_F \quad (1)$$

$$P_{W2} - P_{W1} = \alpha + \beta P_{W1} \quad (2)$$

$$P_R - P_{W2} = \alpha + \beta P_{W2} \quad (3)$$

Where;

$P_{W1} - P_F$ = Wholesalers' margin in rural market; (P_F = Farm-gate price; P_{W1} = Price of farm intermediary)
 $P_{W2} - P_{W1}$ = Wholesalers' margin in urban market;
 (P_{W2}) = Price of urban wholesaler)
 $P_R - P_{W2}$ = Retailers' margin in urban market;
 (P_R) = Price of retailer as sold to consumers in urban markets)
 α = the intercept and indicates initial benefits resulting from other factors such as gifts.
 β = Regression coefficient indicating the rate and direction of change for the margins

A negative coefficient implies the presence of Harris inverse margin (Harris, 1979). A zero coefficient implies a fixed margin. A zero

intercept implies that the margin consists of only a proportion or a percentage of the purchase price.

Producer-wholesaler price spread

Data used for the estimation of the producer-wholesaler price spread covered only 1996 and 1997. These were considered most appropriate, given that these two years came almost at the end of the 34 year data period (1963-1997) used for the study of market integration and conduct. Data for the study comprised urban wholesale prices and farm-gate prices at corresponding periods of the year. Accra was considered the largest consumer of cowpea and groundnuts on account of its high population. Prices in Accra were used as the highest consumer prices for the estimate. The farm-gate prices in villages around Tamale served as producer prices for the crops. The choice of urban wholesale prices helped to maintain uniformity in the urban prices used since final prices at the retail level were not consistent.

RESULTS AND DISCUSSIONS

Market Integration

For the cowpea market only nine market pairs consisting of six 1st way and three 2nd way associations were found to be highly integrated (this information is based on the Timmer's Index). These were: Accra → Wa, Kumasi → Tema, Tema → Wa, Koforidua → Kumasi, Techiman → Kumasi, Kumasi → Bolgatanga, Wa → Tamale, Tamale → Bolgatanga, and Bolgatanga → Wa. Weak market integrations were identified for 26 market pairs for both ways of information flow. The remaining 21 market pairs were identified as independent or segmented. For the groundnuts market, results revealed 22 highly integrated market pairs, consisting of 11 1st way and 11 2nd way directions. These were: Kumasi → Accra, Techiman → Accra, Accra → Tamale, Tamale → Accra, Tema → Kumasi, Kumasi → Tema, Tema → Techiman, Techiman → Tema, Tema → Tamale, Tema → Bolgatanga, Bolgatanga → Tema, Kumasi → Koforidua, Techiman → Kumasi, Kumasi → Tamale, Kumasi → Wa, Wa → Kumasi, Kumasi → Bolgatanga, Techiman → Koforidua, Techiman → Tamale, Tamale → Techiman, Techiman → Bolga, and Bolgatanga → Wa. While another 15 groundnuts market pairs had weak associations, 14 had segmented pairs. The remaining five market pairs were declared undefined, collaborating an earlier finding by Bediako (2000).

The overall integration results indicate delayed information flow in both directions for both groundnut and cowpea. However, the results from groundnut markets showed a faster information flow than cowpea markets. In particular, cowpea prices in rural producing markets seemed to be little influenced by urban price changes while the urban prices are also minimally affected by changes in rural prices. The implication is that benefits derived by producers and consumers from seasonal urban price hikes and farm-gate price dips, respectively, are only marginal, with the greatest advantage going to intermediaries.

Table 1. Results of cowpea pricing policies in Ghana: 1963–1997.

Level	α	β	R^2	$R^2_{adj.}$	DW [§]	Sig. F
Farm gate and regional market	22.8428 (3.7220)	-0.0884 (0.0499)	0.9242	0.9165	1.8992	0.0791
	Sig. T 0.0000	0.0791				
Regional market and urban market	72.0591 (11.6007)	-0.2076 (0.1276)	0.9205	0.9127	1.6212	0.1065
	Sig. T 0.0000	0.1065				
Farm gate and urban market	101.4661 (11.0153)	-0.4341 (0.1477)	0.9641	0.9567	1.7968	0.0039
	Sig. T 0.0000	0.0039				

[§]Durbin-Watson statistics.

Source: Computed based on data from PPMED MoFA; Standard errors are presented in parentheses.

Pricing practices or market conduct in cowpea markets

The results of pricing policies operating along the marketing channels for cowpea are presented in Table 1. By the indication of the adjusted R^2 , the estimates of the equations fall within acceptable limits. Most of the F and t- statistics indicate that the coefficients are significant at < 5% probability level. The Durbin-Watson (DW) statistics tests indicate no serial correlation among the independent variables. In other words, the Ordinary Least Squares (OLS) assumption that the error terms are uncorrelated was upheld. While the model is not intended for predictive purposes, results obtained do provide the required information for determining the pricing practices of middlemen for both cowpea and groundnuts and hence the conduct of the legumes market in Ghana. The equations derived for pricing practices in cowpea markets (Table 1) suggest:

- (i) For the farm-gate middlemen, (equation 1) there was an average margin of ~9% mark-up plus a fixed sum of Gh ¢ 2.28.
- (ii) At the regional markets (equation 2), the mark-ups of middlemen were ~21% of the purchase price plus a fixed sum of Gh ¢7.2.
- (iii) Between the farm-gate and urban centers (Equation 3), wholesalers gained ~43% of purchase price plus a fixed sum of Gh ¢10.15.

The increasing value of the intercept along the marketing channels indicates increasing fixed returns for cowpea along the marketing channel towards the cities. The estimated equations for cowpea market conduct (though not for predictive purposes) are:

$$\text{Farm-gate margin} = \alpha - \beta P_F = 22.8428 - 0.0884 P_F$$

$$\text{Transit/Peri-urban margin} = \alpha - \beta P_{W1} = 72.0591 - 0.2076 P_{W1}$$

$$\text{Urban margin} = \alpha - \beta P_{W2} = 101.4661 - 0.4341 P_{W2}$$

The signs of the regression coefficients (β) indicate Harris inverse margins (Harris, 1979) for all the equations implying the presence of price determination outside of real market forces. In other words, a fall or rise in the price of cowpea at the supply location does not necessarily lead to a fall or rise in the price at the selling point, suggesting the absence of perfect competition. This depicts a monopoly of cowpea stockpiles by wholesalers with no significant participation in storage functions by producers resulting in a collusive pricing practice to the disadvantage of producers and consumers. In economics, collusion means co-operation between independent firms so as to modify competition. It may be tacit or explicit and may involve fixing prices (Bannock et al., 2003).

Pricing practices or market conduct in groundnuts markets

In the groundnuts market, the results show a tendency towards a more competitive marketing system especially at the primary level of the marketing channel indicated by low intercepts and regression coefficients (Table 2).

The estimated equations for groundnut marketing policies are:

$$\text{Farm-gate margin} = \alpha - \beta P_F = -2.969 + 0.1109 P_F$$

$$\text{Transit/Peri-urban margin} = \alpha - \beta P_{W1} = 25.91 + 0.1419 P_{W1}$$

$$\text{Urban margin} = \alpha - \beta P_{W2} = 18.3246 + 0.3206 P_{W2}$$

The low intercept value of -2.96, 25.91 and 18.32 for equations 1, 2 and 3, respectively; indicate a competitive pricing system in which margins are reasonable percentages of the purchase price. As one moves further down the channel towards Urban centers, transit and other

Table 2. Results of groundnuts pricing policies in Ghana: 1963–1997.

Level	α	β	R^2	$R^2_{-adj.}$	DW ^s	Sig. F
Farm gate and regional market	-2.969 (2.1597)	0.1109 (0.0258)	0.9308	0.9123	1.9190	0.0000
	Sig. T 0000	.1716				
Regional market and urban market	25.91 (3.2353)	0.1419 (0.0329)	0.9138	0.9068	1.8910	0.0001
	Sig. T 0.0000	0.0001				
Farm gate and urban market	18.3246 (3.1897)	0.3206 (0.0376)	0.9658	0.9607	1.7092	0.0000
	Sig. T 0.0000	0.0000				

^sDurbin-Watson statistics.

Source: Computed based on data from PPMED MoFA; Standard errors are presented in parentheses.

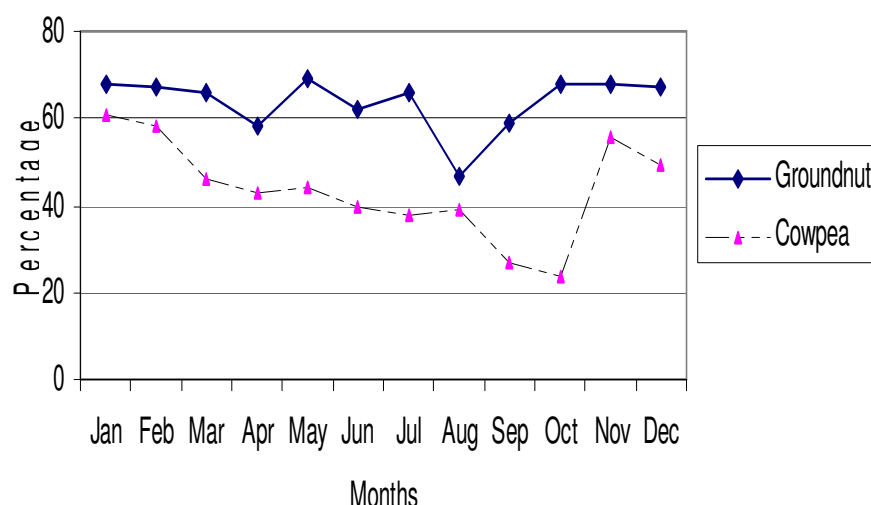


Figure 1. Producers' share of urban wholesale prices for cowpea and groundnut (1996).

Source: Compiled from market survey data.

marketing costs play a key role in determining margins than brokerage activities. In other words producer participation in storage functions creates competition, reduces windfall margins for intermediaries and enhances fair sharing of consumer payments among all stakeholders along the marketing channel. The positive coefficients for higher level equations indicate the absence of inverse margins in groundnuts market. The condition shows the existence of interactions and information flow between groundnut markets implying that unlike the cowpea market, all channel members including producers have an influence on groundnut price determination throughout the year.

Producer – wholesaler price share

The results obtained for the producer's share of payments by consumers to urban wholesalers revealed higher dividends to producers for groundnuts sales than

for cowpea sales in both 1996 and 1997 (Figure 1 for 1996 and Figure 2 for 1997).

In 1996 groundnut farmers obtained shares ranging from 47–69% with an average share of ~64% of the payments made to wholesalers in urban markets. In 1997, the average share received by farmers for groundnuts increased to ~67% (ranging from 60–71% over the twelve-month period). In contrast, the situation identified for the cowpea market indicated lower compensation to farmers with an average share of ~44% in 1996 (ranging from 24–61%). Though the value also rose in 1997 to an average of ~55% (ranging from 47–63%), it still fell below benefits derived from groundnuts.

IMPLICATIONS OF RESULTS

The outcome of the analysis is due to producers' inability production. Hence farmers are able to produce higher quantities of groundnuts than cowpea. In other words to

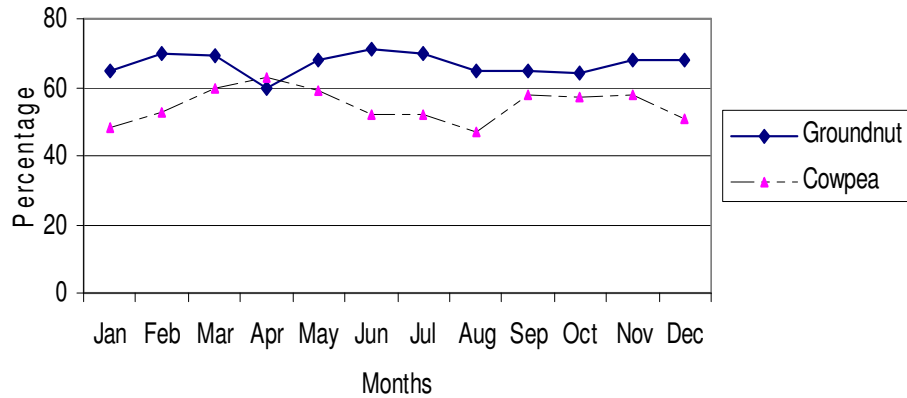


Figure 2. Producers' share of urban wholesale prices for cowpea and groundnut (1997). Source: Compiled from market survey data.

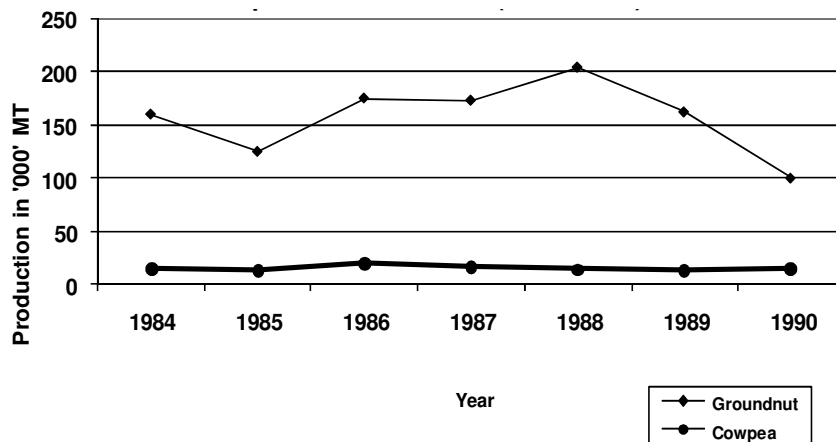


Figure 3. Annual production levels of groundnuts and cowpea in metric tones (1984-1990). Source: Drawn using data from PPMED, MOFA, Ghana.

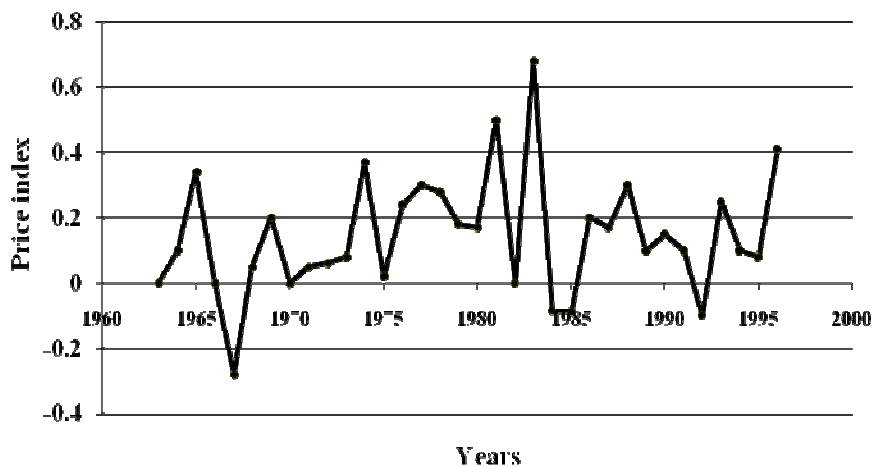


Figure 4. Annual cowpea price indexes (1963-1996). Source: Drawn using data from PPMED, MOFA, Ghana.

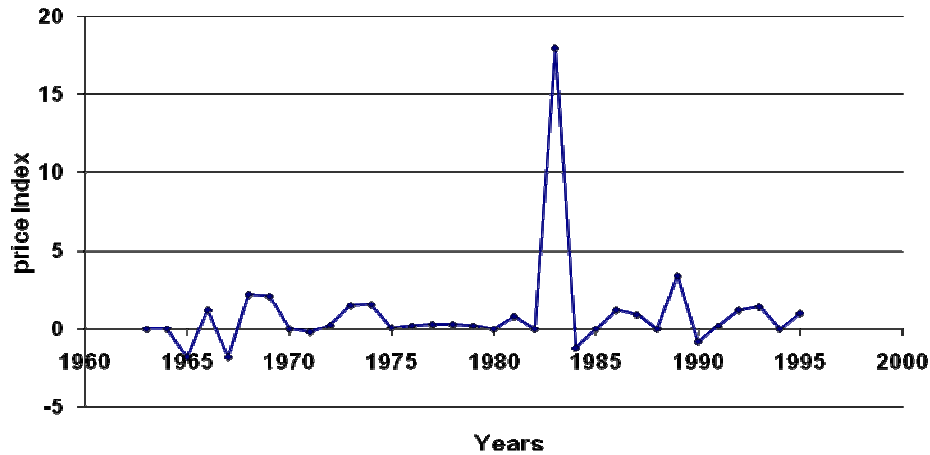


Figure 5. Annual groundnuts price indexes (1963-1996).
Source: Drawn using data from PPMED, MOFA, Ghana.

store as much cowpea as groundnuts, thereby losing much of the high price regimes of the lean seasons. Indications are that intermediaries in the cowpea market enjoy a storage monopoly, which deprive farmers of adequate remuneration for their production. This puts farmers in a state of persistent uncertainty concerning their fate in cowpea production, resulting in annual trends of low cowpea output and unstable price indexes (Figures 3 and 4) for the crop whose production is centered in the three northern regions where poverty is highest, in spite of the annual high demand in the better endowed southern sector of the country.

More favorable storage features of groundnuts as compared to cowpeas contributed to the slightly more stable prices of groundnut. Better storage strategies are required to help stabilize the prices of cowpeas and increase the benefits that farmers derive from growing cowpea. Better storability and prices must have been contributing to the increased attention that farmers give to groundnut compared to cowpea in the farming systems of Ghana. The market for cowpea is expected to improve and expand with improvements in storage that reduces post harvest losses.

In contrast, groundnuts enjoy higher production and stable annual price indexes (Figured 3 and 5). The annual prices for groundnuts show a more stable and regular trend than cowpea prices. For both crops, the price index for 1983 was the highest portraying the severity of food scarcity in Ghana in 1983 when fires raged through the country. This situation of high food prices was similar across many African countries in the same year (1983).

Conclusion

The capacity of farmers to store groundnuts enables them to participate in pricing decisions resulting in better market integration and the derivation of better benefits from groundnuts production than from cowpea monopoly

of stockpiles by intermediaries in the marketing of agricultural produce, with no significant participation by producers results in collusive pricing by intermediaries to the disadvantage of producers and consumers. This restraining effect of storage capacity on the economic competitiveness of producers highlights the need for more effective technologies for food storage at the farm level in Ghana as well as other developing countries. The study recommends renewed scientific effort in the development of simple and affordable technologies for storing cowpea. Otherwise, the associated disincentives in the inability to store cowpea will engender a lack of interest to increase production by farmers.

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