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THE ECONOMICS OF FARM COMMODITY STORAGE: A POLICY MODEL FRAMEWORK

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ABSTRACT

This study presents a (simple) policy model underlying farm commodity storage for a developing economy. Utilizing a simple statistical/mathematical formulation, the policy model highlights the following: storage is a profitable enterprise with the net revenue function being at equilibrium position where the quantity stored is multiplied into the price difference less storage cost; market price differences resulting from storage activities will become more significant when storage is done for the economic benefit of the farmer such that the net benefit estimates become one of the planning decision parameters. The implication this has for increased government funding in the provision of storage facilities for Nigerian farms cannot therefore be over-stressed.

Key words: Farm Commodity, Storage, Economic Development.

INTRODUCTION

Deep-rooted in the structure of developing countries' agricultural systems is the unsatisfactory situation of supply-demand shortfalls, occasioning frequent (food) deficts which exacerbate the food problem. Among the frequently cited causes of this problem are: the predominance of small-scale, subsistent peasant nature of arable farming with little or no marketable surplus; the inefficient marketing and physical distribution systems; the very low level of farm incomes; and, among others, in recent years, in Nigeria, the dominance of the oil/petroleum sector as a major foreign exchange earner for the country.

One of the perennial causes of food shortages often omitted in discussions of the food problem is that of agricultural wastes, occasioned by poor and/or primitive storage facilities, that is, inefficient and primitive food processing and preservation system. The importance of nutritionally adequate diet in the growth of manpower resources, efficient labour productivity and general development of any economy cannot be over-emphasized. In this context, the minimization or total elimination of agricultural wastes can provide a quick and meaningful solution in ameliorating Nigeria's food problem. In other words, the development of the food sub-sector calls for a simultaneous improvement in production/marketing and product storage and/or preservation. The interesting and mutually reinforcing relationship between increased productivity and effective food storage/preservation has been firmly established. (Ihekoronye and Ngoddy, 1985; Okoh, 1994).

A broad classification of all agricultural products into perishable and non-perishable categories is adopted in this study. The discussion concentrates on the non-perishable commodities, that is, those that have very low water content at harvest, namely, grains (cereals and legumes) which are about the easiest class of commodities to store.

The objective of this paper is to provide a framework with the help of simple mathematical/statistical model for looking at theory and policy on the economics of farm commodity storage. In what follows, section II

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presents briefly the theoretical framework of the study while section III deals with the Methodology and Model Specification/Derivation for the study. Section IV summarizes by discussing very briefly the policy relevance/implications of the study.

THEORETICAL FRAMEWORK OF STUDY

(i) Conceptual and Definitional Issues:

Conceptually, storage, as it applies to farm commodities, connotes the preservation of stocks (food) for continuous use into the future through such means as salting, smoking, sun-drying, canning or freezing. Drying and controlled freezing are more appropriate for grains and cereals.

Having food commodities in various kinds of storage, generally serves to stabilize prices over time in various countries. The stabilizing effect of storage on farm and consumer prices is sometimes considered a mixed blessing by farmers and consumers (Kohls and Uhl, 1988). Inventory, carry-over and reserve food stocks each shift the supply of farm commodities from lower-valued to higher-valued time periods. This raises the price in the low-valued market and reduces it in the higher-valued market (Kohls and Uhl, 1988).

Food stocks, either seasonal, carry-over or reserve stocks are kinds of food storage, serving various purpose. These stocks keep the marketing pipeline full, contributing to full capacity operations and preventing supply disruptions. Both consumers and food marketing firms maintain these working inventories for convenience and efficiency. Carry-over stocks refer to the amount of commodity left over from one marketing year to the next. Annual production and consumption seldom balance precisely and there may be carry-overs ("Old crops") or shortfalls, going into the next market period. These carry-overs then become an addition to the supply available for consumption in the following year. Food reserves are intended to balance food supplies with demand over the long run and between countries. The objective is food security storing in "fat" years as protection against "lean" years. For instance, the 1977 united States farm bill contained provisions to encourage an international system of farm-held food grain reserves for the world.

Storage operations are carried out at every level of the food industry. All food marketing firms perform some storage and ware-housing functions. Farmers are assuming increased responsibility for commodity storage. Consumers also store considerable quantities of food in refrigerators, freezers and pantries. The storage-marketing function is associated with the creation of time-utility-an important source of value in the food industry, where supply and demand are seldom in immediate balance. Storage operations are necessary to bridge the time gap between periodic harvests and marketing and relatively stable consumption of food on a year-round basis.

Storage is interrelated with other marketing functions, such as transportation, processing, financing and risk bearing. A shortage of transportation facilities during a harvest glut piles up grains at the farm and local elevators, resulting in falling cash prices. And because storage operations delay sales and subject the firm to inventory risk, financing and risk bearing are considered part of the storage function (Kohls and Uhl, 1988).

(ii) The Role of Storage in the Economy:

Five important functions are recognized to be performed by storage in any given economy. These functions are, respectively, preservation, quality improvement, quantity equalization, price stabilization and entrepreneurial speculation. We examine briefly each of these functions.

1. Preservation Function

The influence of climatic forces on the nature of production of most agricultural products makes storage highly desirable principally for the mere continuity of production. From an economic point of view, seeds have to be stored at harvest time in preparation for subsequent replanting. In the circumstance of all economic agents, the most economic form of storage is a least-cost technique which maintains a high level of seed viability and ensures continuous production.

2. Quality Improvement Function

Farm commodities are sometimes stored solely for the improvement of the quality of the produce. The storage of tobacco leaf under ideal conditions, for instance, is said to improve not only the aroma of the leaf but stabilizes the nicotine content of the leaf, which helps in the production of cigarettes of consistent standard and quality. The economic advantage to be derived with a better quality product is incontrovertible. Storage has to be encouraged in all cases where storage improves quality, and the demand pattern compensates for quality by positive price difference.

3. Quality Equalisation Function

This is perhaps the most universally known function of storage. This function is very important because of the time lag in demand and supply of agricultural products, particularly for food stuffs. With some industrial crops, storage (or stock-piling) is usually done by the manufacturers. Similarly, there is an advantage for producers of primary products to engage in extensive storage programme aimed at equalization of demand and supply quantities of their products that get to the market.

The storage function will have to be performed for as long as market price variation allows enough income to cover the storage cost.

4. Entrepreneurial Speculation Function

Storage is a field of business that accommodates a free play of speculation. The storage speculators perform a type of function which is invariably a combination of quantity equalisation and stability. An entrepreneur who engages in storage activities will "stay in business" only as long as he can realize an "incentive income" (Bellerby, 1956).

Speculators also perform an additional role of financing the market system.

5. Price Stabilization Function

The objective here is to achieve stabilization or reduce fluctuations in market prices. This function incorporates costs and prices, demand and production levels and thus serves as a guide for storage at the macro level. The derived advantages here are two-folds. First, the market forces operate more efficiently under improved knowledge of a relatively stable market price. Second, the production planning process is considerably improved by minimizing the risk factor.

The familiar cobweb** theorem is the usual explanation of the behavioural patterns resulting from price fluctuations. In so far as the farmer as an entrepreneur is faced with a high degree of risks and uncertainties due to fluctuating prices, the inefficiency that culminates in the usual cobweb situation is certainly to be expected.

In a market economy price is regarded as the thermostat responsible for the efficient or inefficient allocation of resources under pure competition. On the farmer's part, a stable price is a correct signal and persistently transmitted, helps him to "deduce exactly what kind of product is desired" (Collins, 1959). In figure 1 below

** The explosive and the constant cycle cobwebs are more common for most food stuffs.

we demonstrate graphically the role of storage as an instrument of price stability. We define the total supply in time 1 as H_1. If H_1 is the quantity allowed in the market, with the given demand curve in the graph, the price will be P_1. If the quantity (S_1) is stored at a cost of (P_1^1- P_1), then the final price stays at P_1^1. In period 2, if supply drops to H_2 the price will rise to P_2. However, if the stored quantity S_1 were now to be released (in period 2), the price will drop to P_2^1. Without storage, the price difference between the two periods, designated as 1 and 2, will be $P_2 - P_1$. With the storage of quantity S_1, the price difference will be $P_1^1 - P_2^1$. Thus, the quantity stored, S_1 (in this hypothetical example) is highly significant. It follows logically that an arbitrary storage quantity can have a destabilizing effect with probable adverse implication on the economy.

We define storage as economically efficient under conditions of perfect competition when temporal price spread is equal to the storage cost. Mathematically, we render this relationship as:

$$P_2 - P_1 = C_S \quad \ldots \quad (1)$$

Where P is price, and C_s is the storage cost over time, that is, between periods 1 and 2.
Therefore, for an efficient storage aimed at effectively reducing price fluctuations, the nature of the temporal price spread (difference) must be examined. These (price) differences are then related to storage costs with the particular type of storage method also specified, and at existing rates. Except where the criterion of economic efficiency is overridden by other social objectives, the rational decision to store any commodity should decidedly be based on a storage rule such as expressed in the objective function dealt with above. For any departures from the attainment of economic efficiency through commodity storage, such objectives should be clearly stated, their probable trade-offs and full economic and social implications recognized by both policy makers and planners.

METHODOLOGY AND MODEL DERIVATION

Consider a statistical decision function such that when the values of the relevant variables are known the level of storage stock is determined.

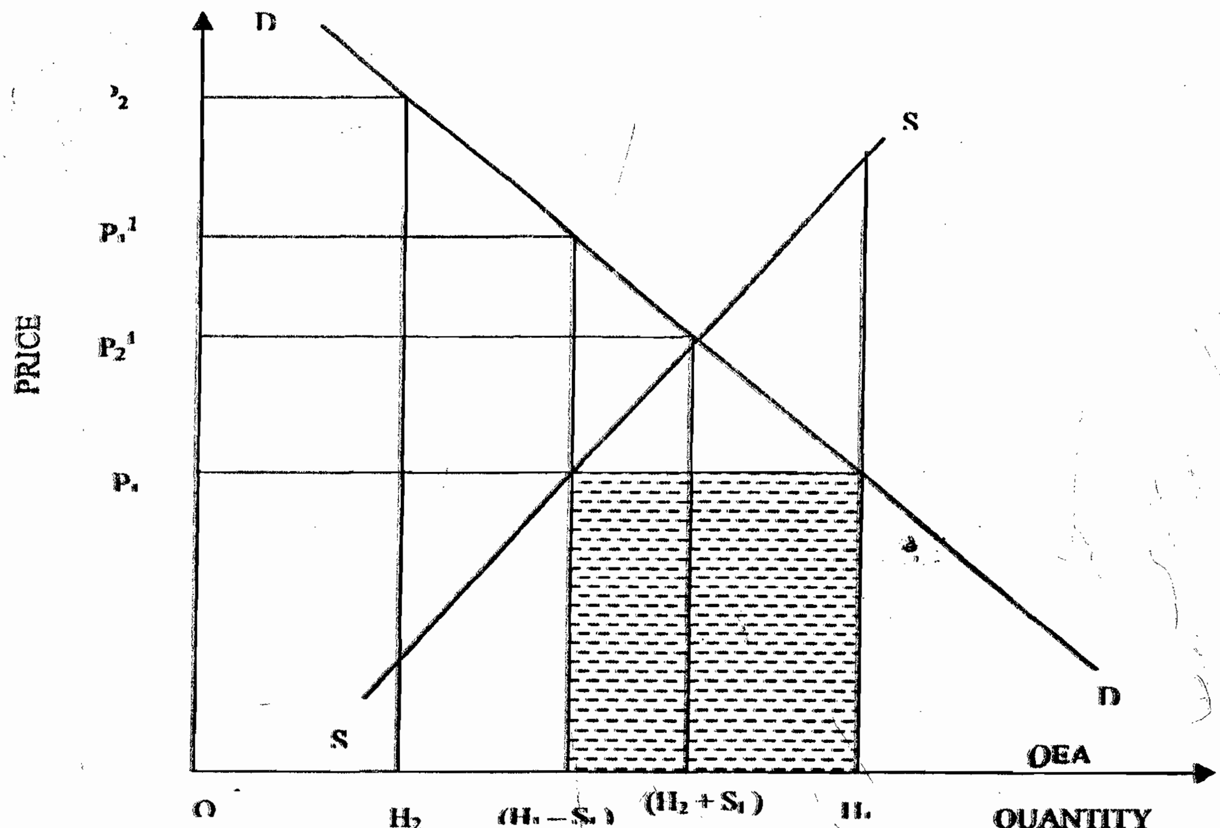
An effective storage policy calculus takes into account the following facts which are assumed to be known:

(i) The demand function for the commodity in question;
(ii) Rational expectation of the size of next period's/year's/season's crop (assume that an average crop yield is a "best estimate" of the next period's yield);
(iii) The probability distribution of crop size;
(iv) The value of the stock held if there had been any previous storage;
(v) Change in the value of crops themselves as affected by storage;
(vi) The time horizon for storage.

Along with these the following properties of the storage function underline the model to be specified:

(i) An unlimited time horizon among the three general types is the focus of our discussion. The other two are the intra-seasonal and inter-seasonal storage time horizons.
(ii) The storage function is composed of a constant portion and a variable portion. The constant portion stipulates the quantity over and above which storage will be desirable. When the quantity of supply is less than total level of demand at equilibrium price, storage is undesirable for obvious reasons:

(a)* The variable portion relates the quantity to be stored to the total quantity available when the constant is exceeded (Gislason, 1960).



Key: H_1 : Total Supply in Period 1

$H_1 - S_1$: Market Supply in Period 1

H_2 : Production in Period 2

$H_2 + S_1$: Total Market Supply in Period 2

P_1: Price in Period 1 without Storage

P_1^1 : Price in Period 1 with Storage of S_1 quantity

P_2: Price in Period 2 without Storage

P_2^1 : price in Period 2 with release of product stored in Period 1.

Figure 1: The Effect of Storage on Demand, Supply and Price

The following underlying assumptions are also made in the discussion/derivation of our (conceptual) mathematical/statistical model:

(i) Demand is known and assumed linear thus:

$P=A-Bq$

Where P is price and q the quantity; A is the constant (intercept) term and B is the slope (coefficient) of the quantity variable.

(ii) Distribution of crop size is to be a known function independent of the storage policy. We thus assume that total production (stored and distributed) will have to be consumed over the time horizon being used in the estimation.

(iii) Storage costs are known and assumed to be of the nature that the marginal costs (MCs) are equal to the average variable costs (AVCs) and independent of the value of product being undertaken. Thus we have our estimation as:

$P_2 - P_1 = C_S$ ... (1a)

Where P_2 is the price of commodity in Period 2, P_1 is the commodity price in time 1 and C_s is the storage cost. Of course, equations (1) and (1a) are the same but for the definitional elaboration here.

(iv) Storage is a profitable enterprise. With profit maximizaion assumption, the net revenue (NR) function will be the equilibrium position, where the quantity stored (S) is multiplied into the price difference less storage costs.

$NR = S(P_2-P_1) = C_S$ ... (3)

We consider now, in general, that a speculator will be carrying over stock for a limited time horizon in order to make profit. Given this domain, we can go further to derive our mathematical model.

If we let Y_1 be the quantity of commodity available in period 1, q_1 the quantity consumed in time 1 under a given demand function, we can therefore state thus:

$P_1 = A-Bq_1$ ... (2a)

If S_1 is the quantity stored in period 1, then $q_1 = Y_1-S_1$ — (4)

Therefore, $P_1= A-B(Y_1-S_1)$ ... (2b)

If M_2 is the expected production available for the market at the beginning of season, that is, period 2, the total quantity available in time 2 will be M_2+S_1; and an expected price $E(P_2) = P_2$ is given by $P = A - B(M_2+S_1)$ ... (5)

If we substitute (2b) and (5) into (1a) we have:

$A - B(M_2+S_1) - A-B(Y_1-S_1) = C_S$ ... (6)

Equation (6) solves to become:

$2BS_1 = C_S - B(Y_1-M_2)$ ... (7)

Solving equation (7) for S_1, we obtain:

$S_1 = B(Y_1-M_2)/2B - C_S/2B$ ... (8)

Therefore the quantity of storage at time 1 is given by the equation:

$S_1 = ½ (Y_1-M_2) - C_S/2B$, if $Y_1 > (M_1 + C_S/B)$ ... (9a)

M_1 is the expected production available for the market in period 1.

$S_1 = 0$, otherwise ... (9b)

(a) " These reasons include the danger of price inflation, distortions in the economy and the misallocation of resources that may result.

We can build (work out) the model for a limited time horizon from the simple case given above. Let S_t be the quantity stored in time t, M_t the quantity available in time t, $S_t - 1$ the quantity stored in time t – 1, and $M_t + 1$ the quantity available in time t +1. Equation (9a) can be converted to:

$$S_t = ½ (M_t + S_{t-1}) - (M_{t+1} - S_{t+1}) - C_S/2B \quad \ldots \quad (10)$$

Market price differences resulting from storage activities will become more significant when storage is done for the economic benefit of the farmer. As a consequence, the net benefit (NB) estimates form part of the model. In deriving the equations for two periods' time horizons, we define P_1 as the price without storage in time 1, P_1^* the new price with storage in time 1, P_2^0 the price without storage in time 2, and P_2^* the price with storage in time 2.

For a two period horizon, we assume a linear demand function of the form;

$$P = A - B(M_2+B_1) \quad \ldots \quad (11)$$

Then from our definition and specification above,

$$P_1^* - P_1 = P_2^* - P_2^0 = BC_{S1} \quad \ldots \quad (12)$$

Therefore, the total benefit (TB) is given by the equation:

$$TB = BS_1(M_1 - M_2) \quad \ldots \quad (13)$$

The net benefit (NB) then becomes:

$$NB = BS_1(M_1 - M_2) - (S_1P_1 \,.\, S_1P_1) - C_SS_1 \quad \ldots \quad (14)$$

OR

$$NB = 2BS_1(M_1-M_2) - 2BS_1^2 - C_SS_1 \quad \ldots \quad (15)$$

For a maximum, we take the first derivatives (partials) of NB in equation (15) with respect to S_1 and set this equal to zero. We thus have:

$$dNB/dS_1 = 2B(M_1 - M_2) - 4BS_1 - C_S = O \quad \ldots \quad (16)$$

Solving for S_1, we obtain:

$$S_1 = ½ (M_1-M_2) - C_S/4B, \text{ if } S_1>0 \quad \ldots \quad (17)$$

$$S_1 = O, \text{ otherwise} \quad \ldots \quad (17a)$$

For an unlimited time horizon, the total storage cost in the second year (T_CS_2) can be rendered as:

$$T_CS_2 = S_2P_2 - S_2P_3 + C_SS_2 \quad \ldots \quad (18)$$

Which from equation (14) reduces to:

$$T_CS_2 = BS_2 (M_2 - M_3) + 2BS_2^2 - BS_1S_2 + C_SS_2 \quad \ldots \quad (19)$$

Where S_2 is the quantity accumulated in year 2 (second period).

The NB equation thus becomes:

$$NB = BS_2(M_2 - M_3) - S_2P_2 - S_2P_3 - C_SS_2 \quad \ldots \quad (20)$$

OR

$$NB = 2BS_2(M_2-M_3) - 2BS_2^2 + BS_1S_2 - C_SS_2 \quad \ldots \quad (21)$$

Setting the partials of NB in equation (21) with respect to S_2 equal to zero, we have:

$$dNB/dS_2 = 2B(M_2-M_3) - 4BS_2 + BS_1 - C_S = 0 \quad \ldots \quad (22)$$

Solving equation (22) for S_2 (or S_t as the general case may be), we have:

$S_t = ½ (Y_t – (M_{t+1} – CS/2B$; if $S_t>0$, ... (23)

OR

$S_t = 0$, otherwise ... ... (23a)

In our consideration M_t+1 is the anticipated crop to be marketed. We in this context define marketed harvest as:

$M_t+1 = f(Q_t + 1, H_t+1, \alpha)$ ... ... (24)

Where Q_t+1 is the aggregate crop harvested, H_t+1 is the subsistence needs of the household (farm – family) both in time period t + 1; and α is the price function.

SUMMARY AND CONCLUSION

Storage of farm commodities is a profitable enterprise. Through the functions it performs in the marketing process, storage is a veritable and important economic planning tool both on the micro (individual farmer) and macro (aggregate/national) economic levels. For the individual farmers, the ability to 'stay in business', reap tolerable levels of profits, and operate at a least cost point of production are assured by the speculation, quantity equalization/quality improvement and preservation rules that a rational entrepreneur is assumed to operate within. For the policy makers/planners who may plan for the national economy, an efficient storage policy serves to guarantee stable market prices as well as minimize production risks all under improved marketing information system and production planning process.

The following elaboration and/or comments may broadly be made about the Nigerian situation.

Both academic and official views of concerned citizens affirm that food and agricultural products lost to spoilage after harvest are a cost to the society (Ihekoronye and Ngoddy, 1985; Nigerai, 1991; Okoh, 1994). Inadequate storage facilities, characteristic of our primitive systems of storing arable crops in Nigeria, some contend, cause much wastes and constitute very serious and direct impediments to rural development (Idusigie et al, 1973). In our very humid climate with its highly enervating and debilitating characteristics, storage losses can be very excessive and these are annually worsened by non-application of techniques of modern storage already available and/or the non-existence of strategically located storage, drying and fumigating facilities (Anthonio, 1963).

In most rural areas of the country, which are devoted to the cultivation of arable crops, the processing of farm produce is essentially a "neglected child". Primitive systems of processing are still adopted and these result in three serious forms of wastes.

First, there are high losses of produce resulting from improper control of the inefficient processing system for instance, less than 60 percent of the extractable oil is obtained from the palm fruits and with the low quality of the extracted oil with very high free fatty acid (f.f.a.) content (Idusogie et al, 1973). Second, the low quality of the processed products always results in substantial wastes arising from the low nutritive values and bad storage quality of foodstuffs. This is manifest in high toxicity, rancidity and considerable spoilage due to deterioration. Third, insufficient or non-utilization of the by-products and/or waste products from processing often results in significant wastes to the economy (Thieme, 1963, 1966). By not utilizing these products, much potential wealth is wasted. Furthermore, instead of being a source of income, waste products are often a nuisance, and sometimes constitute sources of epidemics such as plagues, cholera, small-pox and even spoil rivers and streams.

From the standpoint of these negative side effects arising from the operation of primitive food storage policy, it is now mandatory for various progressive governments, the world over, to urgently and effectively address the problem of inefficient storage and preservation of farm commodities for increased productivity and growth.

For Nigeria, a meaningful investment in modern storage facilities located in the various food producing areas of this country remains a viable alternative option for government decision on farm commodity storage and preservation policy. Such a move will encourage private investment in agricultural production as well as eliminate the wastage of scarce food and agricultural resources. It is in this spirit that the establishment of an adequate or effective institutional framework for pricing and hiring of available storage facilities becomes urgent for inclusion and execution in the policy set.

Government funding and necessary statutory support and backing are a necessary input in the effort to encourage sustained research into improving the existing technology of storage and processing of those agricultural products that essentially have high percentage of water (moisture) content.

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