Ife Journal of Agric Vol. 4 Nos 1 & 2 (1982)

Resource use productivity and efficiency in maize production in the farm settlements of western Nigeria.

A.A. ADESIMI,
Department of Agricultural Economics,
University of Ife,
Ile-Ife, Nigeria.

Abstract

The economics of resource-use productivities and efficiency in maize production were examined among selected farm settlers in western Nigeria. Using the production function approach, it was found that resource productivities fluctuated from year to year and substantial resource dis-equilibria also.existed. Measures, designed to make the needed adjustments are discussed.

Introduction

Maize is an important cereal crop in Nigeria. Its cultivation, processing and marketing provide employment opportunities for several farming and nonfarming households. These employment opportunities in turn furnish an important source of income and livelihood to growers, processors and to the market women engaged in maize marketing. From the point of view of the end-use, maize also occupies a prominent position among the staples. Fresh green maize is usually roasted or boiled and eaten on the cob. Ripe dry grains are also usually cooked with peas or beans together with oil and other condiments and eaten as a meal. The dry grains may be ground instead into flour and mixed with palm oil and other condiments to make.a delicious refreshment. Most commonly, ripe dry grains are processed and prepared into 'pap', a paste-like food which may be taken as a meal along with other complements.

Apart from being a direct human food, maize is also an important ingredient in compounding poultry feeds, thus indirectly serving as a major supply source of animal protein which is critically needed to improve the dietary standards of the people.

The demand for maize in Nigeria has risen sharply in recent years due to increased use for direct human consumption as well as for livestock feeds. However, while the annual domestic consumption has shown consistent upward trends since more than a decade ago, the supply from domestic sources has been characterised by large annual fluctuations (Table 1). The shortfall has partially been met through continual import of maize which, of course, represents a drain on scarce foreign exchange resources.

TABLE 1 – DOMESTIC PRODUCTION, IMPORTS AND TOTAL MAIZE SUPPLY IN NIGERIA (TONNES), 1966–1980.

Year	*Domestic Poroduction*	*Imports*	*Total Supply*
1966	1,116,120	151	1,116,271
1967	·711,200	110	711,310
1968	1,301,440	359	1,301,799
1969	2,039,520	96	2,039,616
1970	2,200,800	8,917	2,209,717
1971	2,125,760	3,868	2,129,628
1972	714,560	2,400	716,960
1973	1,374,240	87,843	1,462,083
1974	591,360	124,457	715,817
1975	1,620,000	n.a	–
1976	1,814,134	n.a	–
1977	1,411,428	n.a	–
1978	2,010,006	n.a	–
1979	1.986,456	n.a	–
1980	2,350,000	n.a	–

Source: (i) Federal Office of Statistics, Lagos *Economic Indicators*, 1968–79.

(ii) Federal Office of Statistics, Lagos, *Nigeria Trade Summary* Dec. 1966–74.

(iii) n.a. = not available.

(iv) Production data for 1975–80 are estimates.

The maize situation, no doubt, has been a source of concern to the Nigerian government. This is reflected in the Federal Government's policy on miaze.imports which over the years has oscillated between complete prohibition on the one hand and total liberalisation on the other hand. These extremes of policy were motivated largely by the spur of the moment. At one time, the overwhelming desire was to conserve scarce foreign exchange which inevitably necessitated import controls. At another time, the consideration was to guarantee adequate supply of maize for the growth of the livestock industry and this naturally called for liberalisation of import restrictions.

The contemporary maize supply/demand situation in Nigeria unequivocally creates an urgent need, at least from the political economy point of view, for production expansion to meet the rapidly growing requirements of the domestic economy. In this regard, it is rewarding to study the economics of resource-use productivities and efficiency in maize production because such a study is important in determining the contributions to output of the resources used in maize production and the efficiency with which they are being used.

Specifically, the objective of this study was to estimate the farm production function for maize for a group of farm settlers in Western Nigeria so as to derive the marginal productivities of resources, and discuss the latter within the context of opportunity costs of resources in maize production.

Materials and Methods

The Underlying Analytical Techniques

Microeconomic production function studies have usually been the tool for examining the problems of resource productivity and resource use efficiency at the farm enterprise levels. In this regard, attention is usually focussed on the estimates of production coefficients under the assumption tnat the production unit is mainly interested in organising and utilising available resources for the purpose of maximising profits. Using the estimated coefficients, the investigator computes the marginal value productivity (MVP) or resources. To have an indication of resource use efficiency, the ratio of MVP to the opportunity costs of resources is computed. One of the great advantages of the production function technique is that the estimated coefficients can be tested statistically for significance.

Other analytical techniques exist for empirically estimating resource productivity and efficiency. One of such techniques consists of simply computing input-output ratios, that is, individual resource productivity in any production process is measured in terms of the ratio which the total enterprise output bears to the amount of input used. Thus, we have output per hectare or output per manday of labour as measures of land and labour productivities respectively. The limitations of this technique are, however, quite obvious. For example, it ignores the quantity and quality of the other inputs used, and also the results obtained are not amenable to statistical test of reliability.

A much more powerful technique is linear programming from which the MVP of resources are derived as a by-product of the simplex method of solution. One main difficulty with this technique is that its data requirements are quite substantial and therefore difficult to generate in a largely traditional agriculture. Quite apart from this inherent difficulty, three major shortcomings are naturally associated with the technique. First, the MVP derived from the model is specific to the use of the resource in the particular situation and this frequently differs significantly from those derived from similar situations in the same environment or from actual market situations. Second, only binding resources have monzero MVP in the optimal solution. This does not permit knowledge about the MVP of resources that are not exhausted in the production process. Third, like the use of input-output ratios, the linear programming results cannot be tested statistically to know the degree of reliability.

In the present study, production function technique was used because of the type of data available and the merits the technique enjoys over alternative techniques.

The data were generated through a two-stage simple random sampling procedure. In the first stage, five farm settlements were randomly selected in Ondo and Oyo States. In the second, one hundred settlers were randomly selected for interview through structured questionnaires to obtain input-output information about early maize production. Most of these input-output data came directly from the records kept by the respondents. The study was undertaken between July and October 1978 and the distribution of the settlers are as follows: Ile-Oluji (18), Imariwo (20), Orin-Ekiti (18), Onishere (22) and Esa-Oke (22). The data collected covered operations for 1973 through 1977.

The selection of the farm settlements was based upon the following considerations: (i) they operate larger farm holdings, an attribute which makes them more amenable to economic analyses than the relatively smaller holdings of the peasant farmer, (ii) they carry out production largely with the objective of satisfying market demand; this is more in line with the postulates of economic theory, (iii) they use more of the non-conventional inputs and techniques of production, all of which are procured through the market, and (iv) they have available more accurate data concerning the running of their farm enterprises. With these advantages, the resulting evidence is expected to provide a frame of reference as to what peasant farmers might do to produce greater levels of maize output.

Results

Socio-economic characteristics of settlers

A large proportion (about 96 per cent) of the farmers were married and most of these farmers rely basically on whatever assistance they could get from the family labour. Hired labour was also found to be a common source of labour supply particularly during the peak periods of the crop season. Some of the important socio-economic characteristics of the farmers are summarised in Table 2. It is obvious from the table that the farmers are not only relatively young but are also fairly experienced in farming. In addition, all of them without exception completed at least primary six which means that they can all read and write.

TABLE 2 – SOCIO–ECONOMIC CHARACTERISTICS OF SELECTED FARM SETTLERS IN W. NIGERIA

	Mean	*Mode*	*Standard Deviation*
Age (years)	33.7	30.0	4.7
Education (years)	7.0	6.0	1.6
Length of stay in settlement (years)	9.3	6.0	4.9
Farming experience (years)	17.3	14.0	5.2
Number of wives	1.0	1.0	0.4

Enterprise combination among the sample farmers varied from one settlement to another, but maize which was common to all the respondents was being cultivated on a commercial scale. The total size of farmland available to each respondent ranged between 3.2 and 13.8 hectares, the average being about 9 hectares. The actual size of farm planted to maize averaged 2.1 ha in 1973 and 3.3ha in 1977.

Analysis of Costs and Inputs Used

The data collected revealed that the respondents used a combination of traditional and non-conventional inputs for growing maize on their farms. The traditional inputs include family labour, land and a variety of simple tools and implements such as cutlasses, matchetes, hoes, diggers and axes. The non-conventional inputs consist of spade, wheelbarrows, spraying pump and chemicals, fertilizers, hired labour and hired machinery.

The types of inorganic fertilizers used were NPK (15-15-15) and sulphate of ammonia All of the respondents grew mainly yellow maize combined with.a very small proportion of white maize.

The geometric mean values of durable assets used are presented in Table 3. To obtain their depreciation values, an appropriate useful life was assumed for each of these assets in accordance with the degree of use and the quality of each asset. A useful life of 30 years was assumed for the buildings and 30 per cent of the estimated annual depreciation was charged to maize production in proportion to the size of maize farm as a percentage of total cropped farm of the respondents. A useful life of 2 years was assumed for cutlasses/matchetes, 1 year for hoes and diggers, 5 years for wheelbarrows and 6 years for spraying pumps, axes and spades. Using straight line method, the annual depreciation expenses per farmer were computed and these are presented in Table 4 together with the other items of costs. The rent on land was computed on the basis of N25 per hactare which was the current market price charged. These costs are useful to the formulation and discussion of the production function specified subsequently.

TABLE 3 – DURABLE ASSETS OF SELECTED FARM SETTLERS IN WESTERN NIGERIA, AT THEIR GEOMETRIC MEAN VALUES

Types of Durable Assets	*Value (N) per Settler*				
	1973	*1974*	*1975*	*1976*	*1977*
Buildings	780.67	706.22	613.77	557.32	482.87
Cutlasses/Matchetes	10.31	15.69	12.43	16.08	14.22
Hoes/Diggers	17.33	21.32	24.71	19.42	26.06
Axes/Spade	20.66	23.63	15.47	11.00	21.12
Wheelbarrows	50.20	46.78	38.31	60.02	55.31
Spraying pump	33.38	35.76	30.45	28.63	39.72
Total	912.55	860.40	753.14	692.47	639.30

TABLE 4 – GEOMETRIC MEAN VALUES (N) OF COSTS OF SELECTED FARM SETTLERS IN WESTERN NIGERIA.

Items of Costs	*1973*	*1974*	*1975*	*1976*	*1977*
Depreciation	62.45	56.35	59.11	48.62	46.07
Repairs & Maintenance	3.20	5.46	7.33	8.41	6.18
Rent on land	52.50	67.50	75.00	80.00	82.50
Hired Labour	46.17	43.00	58.24	64.35	68.48
Fertilizer	17.08	22.90	21.22	25.32	32.20
Seed	4.18	3.32	4.57	5.15	5.00
Machinery (Hired)	11.95	15.45	16.06	17.45	20.23
Spraying Chemicals	1.12	3.18	2.07	4.10	3.44
Total	186.53	217.16	243.60	253.40	263.66

Specification of the Production Function

A production function describes the mathematical relationship existing between the quantities of the input of resources and the quantities of output of products. In order to subject the technical relationship to economic analysis, the researcher needs to formulate an economic model relating to the production process by allowing economic and statistical considerations to bear on the model.

The major problems raised by these considerations are four. In the first place, the researcher has to decide whether a single equation or a system of equations is appropriate. Second, he has to choose the set of variables that are considered relevant to the model. Third, the hypothesis has to be made as to the most appropriate algebraic form of the model. Fourth, the model has to be not only logically sound, but also computaionally feasible.

In deciding whether to specify a single equation or system of equations for this study it is necessary to know whether the explanatory variables in the model are exogenously or endogenously determined. If these variables are believed to be generated exogenously relative to the production units being studied, a case is made for a single equation approach; otherwise, a system of equations would best characterise the production process. In the present study, it was decided to specify a single equation model.

In selecting the set of variables to include in the model, the choice was based on the underlying mechanics of maize production process in the farm settlements as well as on the realities of the situation in terms of what is feasible within the limits of available statistical data and the amount of resources at the command of the researcher. The ultimate number of explanatory variables specified is indicated in equations (1) and (2).

The criterion for choosing an algebraic form of the function should ideally be based upon the knowledge of the logic of production. But at the same time, consideration must be given to the need to have a function that is computationally manageable, both for estimation and testing (Heady and Dillon, 1966). Thus, most researchers estimating production functions from farm samples have used power and/or linear forms because of the relative ease of computation and the fact that a multiplicative model has seemed logically appropriate (Heady and Dillon *op. cit.*). Two functional forms are therefore postulated, namely, simple linear and a Cobb – Douglas power function as expressed in equations (1) and (2).

$$Q = a_o + a_1 X_1 + a_2 X_2 + a_3X_3 + a_4X_4 + U_1 \text{ .... Linear .... } (1)$$

$$Q = AX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} e^{U_2} \text{ .... Cobb-Douglas .... } (2)$$

where

Q = Naira value of maize output.

X_1 = Operating costs (N) on seeds, fertilizer, hired farm machinery and spraying chemicals.

X_2 = Hectares of land planted to maize.

X_3 = Mandays of labour hired in respect of maize production.

X_4 = Expenses on services of durable assets.

a's, b's and A = Constants.

U_1,U_2 = disturbance terms expected to fulfill all OLS assumptions except that of homoskedasticity which breaks down when cross-section data are used.

To estimate the Cobb-Douglas function, the parameters of the function were first linearised by taking the logarithms of the variables. The 'best' fit was selected on the basis of R^2 the "t" and "F" ratios, the "reasonableness" of the magnitudes of the coefficients and the signs on the estimated parameters. On the basis of these criteria, the

Cobb-Douglas function, linearised in logarithms was selected as the "best fit" and is presented as the results of the regression in Table 5.

TABLE 5 – MULTIPLE REGRESSION RESULTS FOR MAIZE PRODUCTION BY SELECTED FARM SETTLERS IN W. NIGERIA.

Year	*Constant*	*LogX_1*	*LogX_2*	*LogX_3*	*LogX_4*	*R^2*
1973	0.42	0.31**	0.24*	0.19*	0.08**	0.58
		(0.10)	(0.11)	(0.09)	(0.03)	
1974	0.67	0.24*	0.42*	0.22**	0.12*	0.62
		(0.10)	(0.18)	(0.08)	(0.05)	
1975	0.82	0.26*	0.34*	0.26*	0.09*	0.65
		(0.11)	(0.14)	(0.11)	(0.04)	
1976	1.08	0.21*	0.28*	0.28*	0.13*	0.55
		(0.10)	(0.13)	(0.12)	(0.06)	
1977	2.25	0.27**	0.19*	0.26**	0.19**	0.66
		(0.06)	(0.08)	(0.10)	(0.06)	

Note: Figures in brackets represent standard errors.
* significant at 5%.
** significant at 1%.

The magnitude of R^2 implies that between 55 and 66 per cent of the variance in output is explained by the included explanatory variables. The coefficients of all the variables are significant at either 1% or 5%, implying that much reliability could be placed on these coefficients.

Marginal Value Productivities and Opportunity Costs of Resources

The MVP of each resource input indicates the expected increase in output that is forthcoming from the use of an additional unit of the resource, the levels of other inputs being held constant. Two factors, in general, determine the productivity of any input, namely, the quantity of it already used in the production process and the levels of the other resources with which it is combined. For this reason, Heady and Dillon (1966) pointed out that the estimates with the widest applicability are those derived at geometric mean input levels, especially when the

Cobb-Douglas function is being fitted. Thus, the MVP calculations are derived from the geometric mean input levels as indicated in Tables 3 and 4.

For the various resource inputs included in the model, the opportunity costs used are the market prices that prevailed during the production season. The market price of land services was taken as the cost of renting one hectare of farmland which was assumed to be N25 per annum. Since the gestation period of early maize from the time of land preparation in late March to harvesting in about September is about 6 months, one half of the annual rent is used.

Assuming that the employment of additional labour would imply the purchase of hired labour, the prevailing wage rate per manday of hired farm labour was taken as the opportunity cost of labour. However, in reality, this assumption probably over-values the opportunity cost of farm labour since additional family labour might be available at a cheaper price. This should be borne in mind when interpreting the results obtained.

Following the practice of how the farmers finance additional inputs, it was assumed that currently used services of land and labour are purchased out of current funds and thus, involve no interest burden.

However, the opportunity cost of one naira expenditure on durable capital as well as that expended on operating inputs was taken as one naira plus the relevant interest charge. The annual interest charge was taken as the lending rates of the commercial banks. For the overall model, the population of the farm settlers was assumed to operate under free competition so that the individual settler had no control over the prices he paid and those that he received.

With this body of assumptions, the MVP and the opportunity costs of resources were obtained and are as presented in Table 6.

TABLE 6 – MVP AND OPPORTUNITY COSTS OF RESOURCES (N) OF SELECTED FARM SETTLEMENTS IN W. NIGERIA.

Year	X_1 (Operating Cost)		X_2 (ha of land)		X_3 (hired labour)		X_4 (Durable Assets)	
	MVP	O.C.	MVP	O.C.	MVP	O.C	MVP	O.C.
1973	1.80	1.05	22.80	12.50	1.26	1.50	0.24	1.10
1974	1.34	1.05	38.89	12.50	1.92	1.50	0.50	1.10
1975	1.17	1.04	22.44	.12.50	1.77	2.00	0.27	1.09
1976	0.84	1.04	18.20	12.50	2.72	3.00	0.47	1.09
1977	1.20	1.05	15.55	12.50	3.07	3.00	0.98	1.10

Note: (i) O.C. means opportunity cost; one-half of the annual interest rate is used in respect of X_1 only.

(ii) The lending interest rate of commercial banks which was used as the O.C. for X_1 and X_4 were obtained from *Central Bank of Nigeria Economic and Financial Reviews Vol. 12 No. 1, June 1974 and Vol. 15 No. 1, June 1977.*

Table 6 shows that the MVP of the resources varied from year to year. Two important factors determine the magnitude of the MVP viz: technical efficiency in production and movements in the price of product output. Several factors, in turn, influence technical efficiency over time. Some of the major determinants are technological progress, changes in the quantity of the resouce input that is already being used and variations in the levels of the other resource inputs with which it is combined. Movements in the price of the product output exert their influence through the fact that the MVP of a resource input is a product of its marginal physical product and the unit price of the product output.

In the present study, the price of maize (the product output) showed consistent secular increase as obtained from the respondents. The producer prices averaged N100 per tonne in 1973, N110 in 1974, N120 in 1975, N132 in 1976 and N150 in 1977. These secular price increases imply that if technical progress in the production of maize in the farm settlements did not fall during this period, we should expect consistent increase in the MVP of these resources. Contray to this expectation, the MVP did not show any consistent pattern of increase. However, the lack of consistent increase in the value of the MVP of resources may be due to the vagaries of farm production as characterised by the effects of weather, diseases, etc. on crop production.

Based upon the information in Table 6, the ratios of MVP to opportunity costs of resources were calculated ,and presented in Table 7. Within the limits of statistical reliability, these ratios provided a measure of the efficiency of resource use prevailing, on the average, throughout the population of farms studied.

TABLE 7 – RATIOS OF MVP TO OPPORTUNITY COST OF RESOURCES OF SELECTED FARM SETTLEMENTS IN WESTERN NIGERIA.

Year	X_1	X_2	X_3	X_4
1973	1.71	1.83	0.84	0.22
1974	1.28	3.11	1.28	0.45
1975	1.25	1.80	0.88	0.25
1976	0.81	1.46	0.91	0.43
1977	1.14	1.24	1.02	0.89

*See Table 6 for connotations of $X_1 - X_4$.

A ratio less than one indicates that too much of the particular resource in a given period is being used under the existing price conditions and degree of availability of other resources. A ratio greater than one indicates that too little of the resource is being used. Maximum efficiency in resource use occurs when the ratio is one. Under such conditions, entrepreneurial profits are maximized.

From the ratios presented in Table 7, the existence of resource use disequilibria is apparent. This is nearly true for all the four categories of inputs considered. In regard to X_1 (operating costs), for example, the average settler could have increased profits substantially by expanding the amounts of seeds, fertilizers, hired farm machinery and spraying chemicals used per hectare of planted maize except in 1976 when too much of these inputs were used. It is also observed that it would have been more profitable for the settlers to use much more land that they planted to maize for the entire 5-year period, less mandays of hired labour (except in 1974 when near optimal levels were used), and less of capital services for all the five years covered by the study. However, if the assumption in respect of the opportunity cost of labour were relaxed, a different result would emerge. For instance, adopting the assumption that additional family labour might be available at a cheaper price will mean that the opportunity cost of labour would be lower than the price used. The difficulty however, is that it is not certain what the opportunity cost of family labour is. Some feel it is zero in underdeveloped agriculture, but it is tenuous to accept this view because of the wide range of employment opportunities existing in the non-agricultural sectors of contemporary Nigeria. Whatever the case, some caution need be exercised in interpreting the results with respect to labour utilisation.

It is worth mentioning however, that capital services (X_4) showed consistently that too much of it was used during the period of study. This evidence is in harmony with the observations expressed by earlier scholars such as Kreinin (1963) and Lewis (1964), both of whom criticised the entire farm settlement set-up as being over capitalised.

Summary and Implications

This study has revealed that the expected increases in the naira value of maize output from the use of additional units of resource inputs, ranged between 0.84 and 1.80 for operating costs, 15.55 and 38.89 for land, 1.26 and 3.07 for hired labour, and 0.24 and 0.98 for capital services for the years 1973 through 1977. This means that all the resource inputs would have contributed positively to the value of output if additional units of them were required in maize production.

The study also revealed that resource productivities fluctuated from year to year, exhibiting lack of consistent increase over the study period, which was presumed to be due to the vagaries surrounding the farm production environment. Thus, to mitigate the problem, the government should step up efforts to make available to farmers, improved seeds that are high yielding, pest and disease resistant, and responsive to fertilizer application. In addition, crop protection chemicals and fertilizers should be made available to the farmers at reasonable prices.

From the resource-use efficiency standpoint, substantial resource use disequilibria was found to exist in maize production. Profit could be increased for most years by making various adjustments in the levels of resource use, given the prevailing price conditions and the levels of the stock of resources. Specifically, profitable adjustments are required with respect to: (i) expanding the amounts used per hectare of seeds, fertilizeers, hired machinery and spraying chemicals, (ii) expanding the hectarage of land planted to maize, (iii) reducing the amount of mandays of hired labour used in respect of 3 out of the 5 years covered by the study, and (iv) reducing the amount of capital services employed in maize production.

The expansion in the amounts of the operating inputs such as seeds, fertilizers, hired machinery and spraying chemicals is very crucial to the needed increase in maize output and the government should undertake to make these inputs available. The expansion of hectarage planted to maize could be achieved if the respondent can procure the resources that combine with land to produce maize. Already extra land is available to the settlers.

Instead of high level of hired labour which seems to be unprofitable in maize production, labour-saving technology appears necessary if maize output were to be expanded substantially on the settlements. The government should therefore increase its tractor-hiring services and provide these services very timely and at prices that are attractive to the farmers. A strategy of selective mechanisation should also be worked out so that the need for hired farm labour will be reduced. The use of devices such as the walking stick planter and small-scale shelling machines, could also be encouraged.

References

Heady, E.O. and Dillon, J.L. 1966. *Agricultural Production Functions,* Iowa St. Univ. Press, Iowa.

Krenin, M.E. 1963. Introduction of Israeli land settlement plan to Nigeria. *J. Farm Econ.* 45: 535-546.

Lewis, W.A. 1964. Thoughts on Land Settlement. pp. 299-310 In C. Eicher and L. Witt (Eds.) *Agriculture in Economic Development,* McGraw Hill Book Co.