Agricultural Economics, 4 (1990) 287 – 296
Elsevier Science Publishers B.V., Amsterdam

A test of whether millet acreage in Niger is determined by official or private market prices

B. Wade Brorsen[1] and Akinwumi A. Adesina[2]

[1]*Department of Agricultural Economics, Purdue University, West Lafayette, IN 47907 (U.S.A.)*
[2]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), B.P. 320, Bamake (Mali)*

(Accepted 23 October 1989)

ABSTRACT

Brorsen, B.W. and Adesina, A.A., 1990. A test of whether millet acreage in Niger is determined by official or private market prices. *Agric. Econ.*, 4: 287 – 296.

Niger has two separate marketing channels for grain: one is the official system operated by the government; the other is a parallel channel of private traders. Researchers or policy-makers wanting to study effects of price policies on producers are faced with two sets of prices. This paper seeks to answer the question, which prices matter? Non-nested hypothesis tests are conducted for millet-acreage response equations. The results show that prices from the larger private market are the prices that matter.

Introduction

Niger has an official grain market operated by the Office de Produits Vivriers du Niger (OPVN) and a parallel grain-marketing channel of private traders. The OPVN, set up in 1970 as the officially recognized grain-marketing agency, is an official monopoly for the marketing of grains in Niger (Enger, 1979; Cullen and Waldstein, 1983; Scott et al., 1983; Adesina, 1985). The activities of the OPVN include (a) setting uniform nationwide producer prices, (b) setting uniform nationwide consumer prices, and (c) balancing grain supplies between the six agricultural departments in Niger. In doing this, the OPVN subsidizes the transportation of grains from the major grain-production zones (Maradi and Zinder) to all parts of the country. The private grain-marketing channel, although not officially recognized, is an important part of the marketing system. The government of Niger, although aware of its existence, allows it to operate. This network of private

0169-5150/90/$03.50

traders controls a major share of the total volume of grains marketed in Niger. Elliot Berg Associates (1983) estimated that the OPVN handles between 15% and 35% of the grain marketed in Niger. Borsdorf (1979) estimated that the official market handles 15% of total grains marketed.

The reason for the low market share of the OPVN is that the uniform producer prices are set lower than the corresponding prices on the private grain markets (Cullen and Waldstein, 1983; Proulx et al., 1983; Elliot Berg Associates, 1983; Adesina, 1985). How relevant are the OPVN prices in grain production? Opinions of researchers vary from that of non-relevance to scepticism. Borsdorf (1979) contends that grain production is not responsive to the official prices. Maina (1982), in an econometric estimation of production responses, asserted that Nigerien farmers do not respond to official market prices. The study concluded that farmers grow crops to satisfy subsistence requirements. However, Adesina (1985), in a mathematical-programming analysis of grain production, indicated that farmers should generate marketed surpluses, given the adoption of fertilizer technology. The study indicated that private market prices should be important in production and marketing decisions. Maina (1982) estimated acreage responses econometrically using only official producer prices, while Adesina and Brorsen (1987) estimated acreage response using private-market prices.

Although past research has argued for or against the relevant prices, no attempt has been made to determine which prices affect acreage decisions. The objective of this study is to test whether Nigerien millet farmers respond to private market prices and/or official prices. These hypotheses are tested using non-nested hypotheses tests. Given the different views on which prices are relevant for producers, non-nested test procedures are appropriate in testing for the relevant prices in grain production (Godfrey and Pesaran, 1983). Policy-makers in Niger need information about the relevant prices in grain-producers' decisions. Such information can be useful in designing official pricing policies.

Theoretical model

Millet is the major crop in Niger, accounting for 85% of the total area cultivated in 1983. The other crops – sorghum, cowpeas and peanuts – represent a small fraction of total production. Sorghum and cowpea acreage were 10% and 8% respectively of total acreage cultivated in 1983. Peanuts have become a minor crop. Only millet acreage equations are considered in this study, since millet is the most widely cultivated crop. Sorghum is grown on higher-quality land, and thus only cowpeas and millet compete for the same land.

Let Y_j ($j = 1, \ldots, n$) represent the output of the n crops produced on

the farm, and X_{jk} ($k = 1, \ldots, K$) represent the quantity of input k used in production of crop j. The fixed amount of land available for production is $\bar{X}_1$. The assumption of a fixed quantity of land is appropriate for Niger, where most of the land is sandy and the amount of arable land is limited.

The production possibility set for the farm can be written following Varian (1982) as:

$$Y(X) = [X, Y: F(X) \geqslant Y; X_1 = \bar{X}_1] \tag{1}$$

where $Y(X)$ represents the restricted production possibility set with a fixed amount of land available for production.

Following Just et al. (1983), p. 772), inputs are assumed to be allocatable among production activities (i.e., inputs used in producing Y_1 do not affect the production of Y_2). Thus, the production technology derived from (1) can be written as:

$$Y_j = f_j(X_{1j}, X_{2j}, \ldots, X_{kj}) \qquad j = 1, \ldots, n$$

and (2)

$$X_k = \sum_{j=1}^{n} X_{kj} \qquad k = 1, \ldots, K$$

$$X_1 = \bar{X}_1$$

The derived production function in (2) will display decreasing returns to scale since the amount of one input (land) is limited (Varian, 1982, p. 20).

Various researchers have argued that the grain-marketing system in Niger satisfies the requirements of a competitive market (Kohler, 1977; Elliot Berg Associates, 1983). Elliot Berg Associates (1983) asserted that 'the structural characteristics of Niger's markets give a strong presumption of competitiveness. There exist many buyers and sellers, and barriers to entry are few.' Therefore, the farmer can be viewed as a profit maximizer, operating with perfectly elastic output and input markets. Let P_j ($j = 1, \ldots, n$) represent crop prices at harvest. The farmer's decision can then be represented as:

$$\underset{Y\,X}{\text{Max}} \sum_{j=1}^{n} P_j Y_j - \sum_{k=2}^{K} W_k X_k$$

where $\Sigma_{j=1}^{n} P_j Y_j$ represents the total revenue from all the crops produced, and $\Sigma_{k=2}^{k} W_k X_k$ represents the total variable costs of production. The firstorder conditions for this maximization problem yield the unconditional output supply and input demand equations:

$$X_{kj}^* = f_{kj}(P_1, P_2, \ldots, P_n, \bar{X}_1, W_2, W_K) \qquad \begin{matrix} j = 1, \ldots, n \\ k = 2, \ldots, K \end{matrix} \qquad (3)$$

$$X_j^* = F_j(P_1, P_2, \ldots, P_n, \bar{X}_1, W_2, \ldots, W_K) \qquad j = 1, \ldots, n \qquad (4)$$

Equation (3) is the input or factor demand function, while (4) is the supply function. Since we are investigating acreage decisions, (3) is the relevant portion of the farmer's maximization problem. The farmer decides on the acreage of the crops to cultivate, based on market output prices and factor prices. Equation (3) is used to specify the acreage demand equation for millet.

The question addressed in this paper is, what set of prices are relevant? Alternative specifications of millet acreage demand equations are specified, using official and private market output prices. The major inputs in grain production are labor and fertilizer. Labor constraints during the critical weeding periods have been found to limit millet production in Niger (Adesina, 1985). No satisfactory price for labor could be obtained, and so price of labor could not be included. Fertilizer is important in grain production (Reeser, 1980; Adesina, 1985). Soils in Niger are low in nitrogen (N) and phosphorous (P). Most fertilizer is applied as simple superphosphate (P) or urea (N). Jomini (1989) found that phosphorous limits yields when rainfall is not a constraint. Therefore, the price of simple superphosphate is used as the price of fertilizer.

Empirical model specifications and non-nested hypothesis testing procedures:

Based on the previous theoretical considerations, the following alternative empirical model specifications are hypothesized for the millet acreage demand equations. These equations are estimated with ordinary least squares:

$$\mathrm{AM}_t = a_0 + a_1\,\mathrm{OMP}_t + a_2\,\mathrm{OCP}_t + a_3\,\mathrm{FD}_t + e_{1t} \qquad (5)$$

$$\mathrm{AM}_t = b_0 + b_1\,\mathrm{PMP}_{t\text{-}1} + b_2\,\mathrm{PCP}_{t\text{-}1} + b_3\,\mathrm{FD}_t + e_{2t} \qquad (6)$$

where AM_t is the acreage of millet harvested in time period t (1000 ha), OMP_t official millet price at time t (FCFA/kg), OCP_t official cowpea price at time t (FCFA/kg), PMP_{t-1} private market price for millet at time $t-1$, (FCFA/kg), PCP_{t-1} private market price for cowpeas at time $t-1$ (FCFA/kg), and FD_t official fertilizer price at time t (FCFA/kg of P_2O_5). Equation (5) specifies millet acreage as a function of official market grain prices (i.e., OPVN prices), and fertilizer price. The alternative model specifies acreage as a function of private market output prices, and fertilizer

price. Neither equation is a special case of the other and, therefore, non-nested testing procedures can be used (Pesaran, 1980; Davidson and MacKinnon, 1981; MacKinnon et al., 1983).

A number of statistics have been proposed to test non-nested hypothesis tests (Cox, 1961, 1962; Pesaran, 1974; Pesaran and Deaton, 1978; Davidson and MacKinnon, 1981; Godfrey and Pesaran, 1983). These tests include the Cox Non-Nested Test (Cox, 1961, 1962), the J-test (Davidson and MacKinnon, 1981), the orthodox test and the Adjusted Cox Test (Godfrey and Pesaran, 1983). Non-nested tests allow rejecting or accepting both alternative model specifications. Let the first hypothesis (H_1) be that official prices are the relevant prices in millet production. Let the second hypothesis (H_2) be that private market prices are the relevant ones in production.

The orthodox test is the least powerful of the three tests. For the J-test procedure, the predicted values in equation (5) and equation (6) are obtained. The predicted values from these equations are denoted by $\hat{A}_{m0}$ and $\hat{A}_{m1}$, respectively. To perform the J-test: $\hat{A}_{m0}$ is included as an additional explanatory variable in (6), while $\hat{A}_{m1}$ is included as an additional explanatory variable in (5). A *t*-test is used to test the coefficients on $\hat{A}_{m0}$ and $\hat{A}_{m1}$.

Suppose the coefficient on $\hat{A}_{m1}$ in the millet acreage equation specified with official market prices is statistically significant, while the coefficient on $\hat{A}_{m0}$ in the alternate model is not significant. The conclusion will be to reject the official price specification and fail to reject the private market price specification (i.e., private market prices are the relevant prices in millet acreage decisions).

In this study, the two test procedures used are the J-test and the Cox non-nested test procedures. Monte Carlo studies have shown that the J-test has low power in small samples (Godfrey and Pesaran, 1983). The Cox non-nested test may reject more often than it should in small samples. The two tests are used in this study because of the possible fragility of results to alternative test procedures. The data for crop area and private market output prices were obtained from the Niger Ministry of Rural Development *Rapport Annuel Statistiques* (1976, 1981, 1986) and the FAO *Production Yearbooks* (1970 – 1982). The official market prices are from Elliot Berg Associates (1983). The data for the retail price index used in deflating the output and input prices were obtained from International Monetary Fund (IMF, 1988) and *World Tables* (World Bank 1976). Fertilizer prices are from the FAO *Fertilizer Yearbook* (1978 – 1986). Exchange rates to convert some of the fertilizer data to the Niger currency are from International Monetary Fund (IMF, 1988).

Data from different sources are not perfectly consistent. This is especially true for the fertilizer price data. To aid later researchers in reproducing the results, the data used in the study are displayed in Table 1. The private-

market prices shown in the table are substantially higher than the official prices. The private-market millet and cowpea prices are calendar average prices for Niamey, which is basically a retail market. Private-market prices away from Niamey would be less due to transportation costs and marketing margins. In most, but not all, years official market prices were the same at all locations. Prices in Niger are also highly seasonal. Thus, even though the private-market prices shown in Table 1 are substantially larger than official prices, official prices could still be higher during the seasonal low following harvest or in remote areas.

Empirical model results and discussion

Use of the private market gives estimates of the structural parameters consistent with theoretical expectations (Table 2). In the official price acreage equation, neither coefficient on the lagged official prices is statistically significant. Millet and cowpeas are competing crops in production. Economic theory suggests that the cross-price effect between millet acreage and price of cowpeas should be negative.

Based on the correct signs on the coefficients of the explanatory variables,

TABLE 1

Acreage and price data for Niger, 1972 – 1983

Year	Acreage millet harvested (1000 ha)	Private millet price (FCFA/kg)	Private cowpea price (FCFA/kg)	Official millet price (FCFA/kg)	Official cowpea price (FCFA/kg)	Fertilizer price = (FCFA/kg P_2O_5)	Retail price inex (1980 = 100)
1971	2356	29.5	45	10	20	105.9	36.4
1972	2370	45.9	60	13	20	111.8	40.0
1973	2007	45.4	72	25	25	111.8	44.7
1974	2230	37.5	90	25	40	123.1	46.2
1975	1623	45.7	74	25	40	93.3	50.4
1976	2527	60.7	64	25	40	117.0	62.3
1977	2728	81.8	82	25	30	98.3	76.8
1978	2747	96.3	123	35	30	85.0	84.5
1979	2922	91.5	102	40	45	100.0	90.7
1980	3072	97.0	123	40	45	106.1	100.0
1981	3037	178.0	246	45	45	143.1	122.9
1982	3066	167.0	246	70	90	184.2	137.2
1983	3135	113.0	210	80	85	175.0	133.8

FCFA, 275.02 French Community Francs per Standard Drawing Rate (1980 conversion code).

TABLE 2

Econometric estimates of alternative specifications of Niger millet acreage equations, 1972 – 1983.

Equation		Intercept	Official millet price	Official cowpea price	Fertilizer price price	Parallel millet price	Parallel cowpea price	A_{m0}	A_{m1}
(5)	Millet acreage specification with official prices	3799.5 (6.52)[a]	– 142 (– 0.09)	– 728 (– 0.70)	– 375.7 (– 2.11)[b]	N A	N A	N A	N A
(6)	Millet acreage specification with private market access	2661.8 (3.74)[a]	N A	N A	– 300.6 (– 2.25)	1334 (2.12)[b]	– 597 (– 2.13)[b]	N A	N A
(7)	Millet acreage specification with official prices and Am_1 as additional explanatory variable in (5)	– 374.0 (– 0.19)	– 1325 (– 0.97)	815 (0.73)	– 10.7 (– 0.05)	N A	N A	N A	1.198 (2.23)[b]
(8)	Millet acreage specification with private market prices and Am_0 as additional explanatory variable in (6)	1742.2 (0.29)	N A	N A	– 193.8 (– 0.27)	1310 (1.91)[b]	– 525 (– 0.95)	0.24 (0.15)	N A N A

N A_a, Not applicable; values in parentheses are computed *t*-values of the coefficients.
[a] Significant at 5% level.
[b] Significant at 10% level.

it seems the private-market price specification is more appropriate for modelling millet acreage demand decisions. The two non-nested hypotheses considered are:

H_1: The official price specification provides sufficient information in explaining acreage decisions.
H_2: The private-market price specification provides sufficient information in explaining millet acreage decisions.

Using the J-test procedure the official price specification is rejected at the 10% level (5% level if a one-tailed test is used), but the private price specification could not be rejected. This implies that the private-market price specification has important information relevant in explaining acreage decisions. To validate this conclusion, an alternative test procedure – the Cox Non-Nested Test – is used. The test statistics, which have an asymptotic Z-distribution for official and private markets, are -0.29 and -4.42, respectively. The conclusion is the same as for the J-test. The implication is that private-market prices provide important information in explaining millet acreage decisions and that official market prices are not necessary to explain acreage decisions.

The elasticity of millet acreage demand to market prices is important for policy analyses in Niger. The millet acreage elasticities with respect to private market prices are 0.53 for millet prices and -0.33 for cowpea prices. This inelastic response of millet acreage to price may be due to technological constraints in production. The amount of arable land in Niger is limited. Since the available fertile land is already in use, acreage is increased by cultivating less-fertile land. Long-run acreage elasticity estimates from Maina (1982) (official price elasticities) were 0.03 for millet prices. The supply elasticity computed from yield and area elasticities was 0.06. This study's results indicate that Nigerien farmers are more responsive to market prices than was asserted by Maina (1982).

Summary and conclusions

This study was undertaken to determine whether Nigerian millet producers respond to private market prices and/or official market prices. Alternative specifications of millet acreage equations were hypothesized and non-nested hypothesis test procedures were used to test the hypotheses. The model with official market prices was rejected, and the null hypothesis that private market prices were sufficient for explaining acreage demand could not be rejected. The private market specification also gave results closer to theoretical expectations than did the official market specification.

The conclusion from this study is that private market prices are relevant for Nigerian millet production. Past research has often not considered the role of these prices in grain production. In specifying millet acreage equations, researchers may need to consider only private market prices. Farmers respond to private market prices rather than official market prices.

Acknowledgement

The authors wish to than Patrick Jomini, B.I. Shapiro and W.H.M. Morris for helpful comments and for help in collecting data.

References

Adesina, A.A., 1985. A mathematical programming analysis of cereal production, marketing policy in Niger and the cross-border trade with Nigeria. M.S. thesis. Purdue University, West Lafayette, IN.

Adesina, A.A. and Brorsen, B.W., 1987. A risk responsive acreage response function for millet in Niger. Agric. Econ., 1: 229–239.

Borsdorf, R., 1979. Marketing profile: cereals and cash crops. Niger Agricultural Sector Assessment, Vol. II, Part F. U.S. Agency for International Development, Niamey, Niger.

Cox, D.R., 1961. Tests of Separate families of hypothesis. In: Proc. 4th Berkeley Symp. Mathematical Statistics and Probability, I. University of California Press, Berkeley, CA, pp. 105–123.

Cox, D.R., 1962. Further results on tests of separate families of hypothesis. J. R. Stat. Soc., 24: 406–424.

Cullen, M. and Waldstein, A., 1983. Grain markets in Niger. U.S. Agency for International Development Niamey, Niger, 74 pp.

Davidson, R. and MacKinnon, J.G., 1981. Several tests for model specification in the presence of alternative hypotheses, Econometrica, 49: 781–793.

Elliot Berg Associates, 1983. Joint programme Assessment of grain marketing in Niger. A report prepared for the Government of Niger and the U.S. Agency of International Development. Vol. I, Main Report.

Enger, W., 1979. The government of Niger's agricultural strategy and the potential for meeting long-term goals. Niger Agricultural Sector Assessment, Vol. II, Part B. U.S. Agency for International Development, Niamey, Niger.

FAO, 1978–1986. Fertilizer Yearbook. Food and Agriculture Organization of the United Nations.

FAO, 1970–1982. Production Yearbook. Food and Agricultural Organization of the United Nations.

Godfrey, L.G. and Pesaran, M.H., 1983. Tests of non-nested regression models: small sample adjustments and Monte Carlo evidence. J. Econometrics, 21: 133–154.

IMF, 1988. International Financial Statistics, 41. International Monetary Fund.

Jomini, P.A., Deuson, R.R. and Lowenberg-Deboer, J., 1989. Making commercially viable fertilizer recommendations for Niger. Staff Pap. 89-10, Department of Agricultural Economics. Purdue University, West Lafayette, IN.

Just, R.E., Zilberman, D. and Hochman, E., 1983. Estimation of multicrop production functions. Am. J. Agric. Econ., 65: 770–780.

Kohler, D., 1977. Country studies: Niger. In: Marketing Price Policy and Storage of Food Grains in the Sahel, II. University of Michigan, Ann Arbor, MI.

MacKinnon, J.G., White, H. and Davidson, R., 1983. Tests for model specification in the presence of alternative hypotheses: some further results. J. Econometrics, 21: 53 – 70.

Maina, S., 1982. On food security in Niger Republic: an exonomic analysis of millet and sorghum yield and acreage responses. M.S. thesis, Michigan State University, East Lansing, MI, 121 pp.

Niger Ministry of Rural Development 1976, 1981, 1986. Rapport Annuel Statistiques. Niamey.

Proulx, Y. et al., 1983. La securité et la stabilité des approvisionnements cerealier au Niger. Study commissioned by the Canadian Agency of International Development.

Pesaran, M.H., 1974. On the general problem of model selection. Rev. Econ. Stud., 41: 153 – 171.

Pesaran, M.H., 1980. Comparison of local power of alternative tests of non-nested regression models. Econometrica, 50: 1287 – 1305.

Pesaran, M.H. and Deaton, A.S., 1978. Testing non-nested non-linear regression models. Econometrica, 46: 677 – 694.

Reeser, R.M., 1980. Economics of crop production and improved agricultural practices in Niger based on synthesized budgets. Consortium for International Development, Niger Cereals Project, Niger.

Varian, H.R., 1982. Microeconomic Analysis (2nd Edition). Norton, New York.

World Bank, 1976. World Tables, Vol. I. Johns Hopkins University Press, Baltimore, MD.