The Impact of Agricultural Policy Reforms on the Output of Selected Crops in Niger

by

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August 1990

Abstract

This paper analyzes the effects of recent agricultural policy reforms on the output of millet-sorghum and cowpeas in Niger. The methodology consists of specifying supply-demand models of the millet-sorghum and cowpea markets, using these models to derive equations which show how the output of each crop is determined, estimating the equations with data from 1970-86, using these estimated equations to predict output during the post-reform years beginning with 1987, and comparing the predictions with actual levels of output.

Considered together, the results for millet-sorghum and cowpeas provide plausible evidence that the reforms had a significantly positive effect on output. The paper concludes with some proposals for improving the quality and quantity of data used in the analysis.

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THE IMPACT OF AGRICULTURAL POLICY REFORMS ON THE OUTPUT OF SELECTED CROPS IN NIGER

Larry Herman and Robin Barlow*

August 1990

I. EXECUTIVE SUMMARY

1. This paper analyzes the effects of recent agricultural policy reforms on the output of millet-sorghum and cowpeas in Niger.

2. The methodology consists of specifying supply-demand models of the millet-sorghum and cowpea markets, using these models to derive equations which show how the output of each crop is determined, estimating the equations with data from 1970-86, using these estimated equations to predict output during the post-reform years beginning with 1987, and comparing the predictions with actual levels of output. If actual output is consistently above the predicted level, this suggests that the liberalization reforms have stimulated output.

3. The variables used for the predictions of millet-sorghum output include early-season rainfall, nonagricultural GDP (a demand-side factor), and a trend term. Variables in the cowpea output equation include late-season rainfall, food prices in Nigeria, and a trend term.

4. The actual output of millet-sorghum in 1987 was below the predicted level, but this might be explained by serious insect infestations rather than by any failure of the reforms. In 1988, actual output was 20 per cent above the predicted level, and in 1989 it was 3 per cent above, despite the depressive effects of naira devaluations.

5. The actual output of cowpeas exceeded the predicted levels in all three post-reform years -- by 19 per cent in 1987, by 9 per cent in 1988, and by 52 per cent in 1989.

6. Considered together, the results for millet-sorghum and cowpeas provide plausible evidence that the reforms had a significantly positive effect on output. The paper concludes with some proposals for improving the quality and quantity of data used in the analysis.

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II. OBJECTIVES AND METHODOLOGY

In 1984 the Government of Niger with the support of USAID embarked on a program of agricultural policy reform which was designed to promote several objectives. These included raising rural incomes, improving efficiency in resource use, promoting food security, boosting export revenues, and reducing the deficits of agricultural parastatals. The measures to achieve all this were mostly in the direction of "liberalization", and included removing restrictions on internal trade, disseminating price information, establishing "cereal banks" at the village level, encouraging cooperatives to participate in agricultural input markets, reducing input subsidies, simplifying the export licensing system, and making more competitive the purchasing procedures used by the government cereal board (OPVN).

What has been the impact of these policy reforms? In this paper we look at the short-run impact on the quantities produced of two major crops: millet-sorghum and cowpeas. A full evaluation of the reforms would of course examine impacts on a wide variety of variables, including these two and many others. But it is clear that millet-sorghum output and cowpea output are key variables in assessing the reforms, the former being by far the main source of cereal consumption within Niger, and the latter being the main source of agricultural export revenues.

To make an initial assessment of the effects of the reforms, we can look at data on the evolution of output since a pre-reform period. The following picture is obtained:

	Output in thousands of metric tons	
	Millet-sorghum	Cowpeas
1984	1,007	195
1985	1,779	115
1986	1,743	293
1987	1,363	209
1988	2,327	302
1989	1,755	321

At first glance, this performance suggests that the reforms may have had a positive effect. By the end of the selected period, cowpea output had increased significantly, and the 1989 crop set an alltime record. The millet-sorghum picture is less clear. The high levels of output in 1985 and 1986 can hardly be attributed to the reforms, which were then at a very early stage. However, the bumper crop of 1988 raises the possibility that by that time the reforms were having a dramatic effect. That crop, after all, was no less than 33 per cent larger than anything Niger had ever known -- an off-the-scale phenomenon rivaling Beamon's Olympic long jump.

Such speculations are of course premature. Estimating the effect of the reforms is bedeviled by the fact that they coincided with changes in various other factors affecting agricultural output. In the specific case of millet-sorghum and cowpea output

in Niger, other factors of major importance include rainfall, pest attacks, and the naira-FCFA exchange rate (which particularly affects the profitability of cowpea production). Perhaps, for example, the impressive output of cowpeas in 1989 was due to good rains, an absence of pests, and a favorable exchange rate -- and had nothing to do with the reforms. Assessing the reforms properly requires that these other factors be specifically taken into account.

To meet this requirement, the following methodology is proposed. For millet-sorghum and cowpeas separately, a model is specified which shows how output is determined. One important determinant in both models, for example, is rainfall. Each model is estimated econometrically from data for a pre-reform period. Each model is then used to predict output in the post-reform years. If actual output in these years is significantly greater than what is predicted, this suggests that the reforms have had a positive effect.

The remaining sections of this paper deal respectively with the specification of the models, their econometric estimation, the comparison of actual and predicted output in the post-reform years, and some suggestions for future improvements in this methodology.

III. MODELS OF MILLET-SORGHUM AND COWPEA PRODUCTION

Millet-sorghum

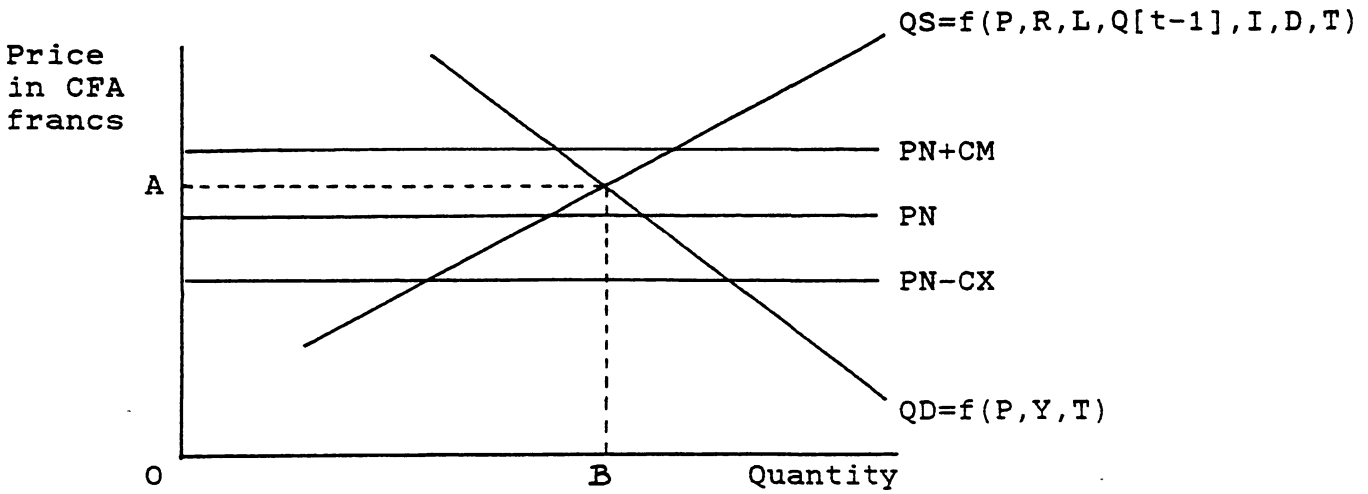
An equation showing the determinants of millet-sorghum output in Niger can be derived from a supply-demand model of the kind illustrated in Figure 1a. The quantity supplied (QS) is a function of retail price (P), a series of variables representing the temporal and spatial distribution of rainfall (R), an index of pest activity (L), the previous year's output (Q[t-1], a negative relationship being expected, since high output in one year may exhaust the soil and lower the following year's output), input prices (I), distribution costs like transportation and dealers' margins (D), and a trend variable reflecting technological change and other dynamic factors (T). The quantity demanded (QD) is a function of retail price (P), real income (Y), and a trend variable reflecting changes in tastes and other dynamic factors (T).

The retail price in Nigeria is PN, and is assumed independent of the Nigerien market, in line with the very large size of Nigeria's market in relation to that of Niger. The unit cost of exporting from Niger is CX, and the unit cost of importing into Niger is CM.

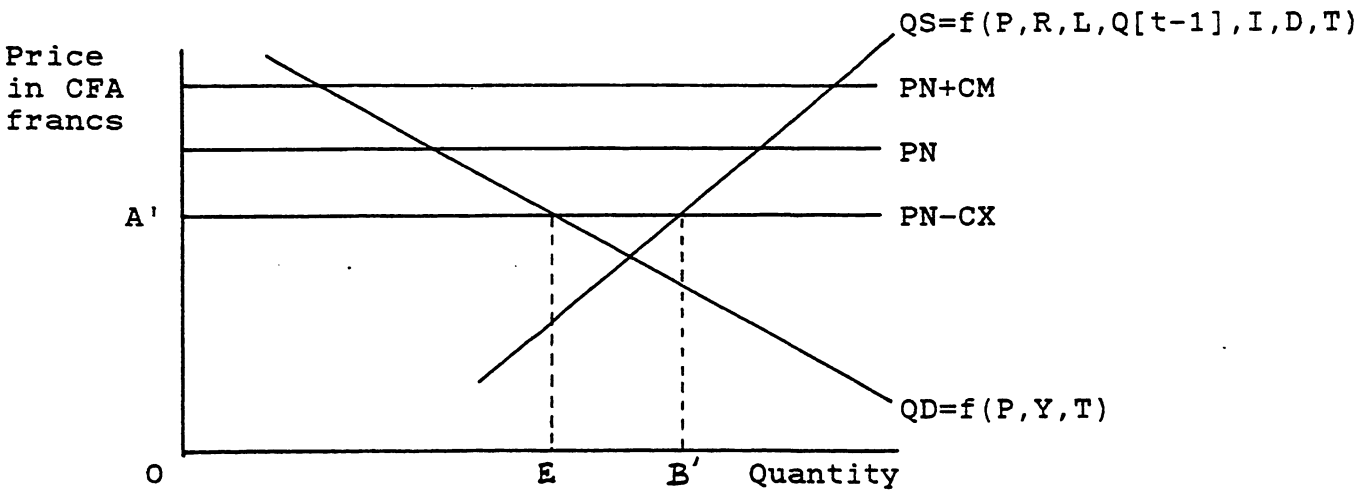
With the configuration of supply, demand, and Nigerian price shown in Figure 1a, no exporting or importing of millet-sorghum will occur. This situation approximates that found in Niger, at least in the pre-reform period. The retail price in Niger will be that which equates domestic supply with domestic demand, namely

Figure 1: MODELS OF AGRICULTURAL MARKETS IN NIGER

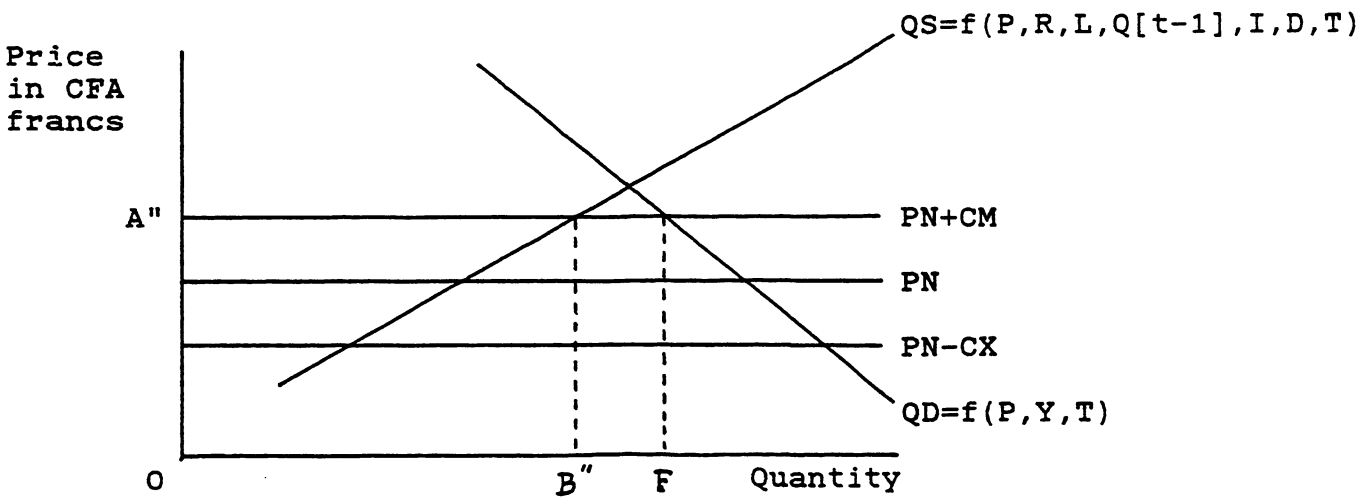
a. MILLET-SORGHUM MARKET WITH NO IMPORTING



b. COWPEA MARKET



c. MILLET-SORGHUM MARKET WITH IMPORTING



OA. This price is higher than what producers could obtain from exporting (PN minus CX), hence no exporting will occur. And the price is lower than what importers would charge (PN plus CM), hence there will be no importing.[1]

The functioning of the millet-sorghum market can therefore be described by the following system of equations:

$$QS = f (P, R, L, Q[t-1], I, D, T) \quad (1)$$

$$QD = f (P, Y, T) \quad (2)$$

$$QS = QD \quad (3)$$

From this system a single equation can be obtained expressing the quantity supplied (or production) as a function of exogenous determinants only, an equation that can therefore be directly estimated by econometric methods. This equation, which is known as a "reduced form" of the system, is as follows:

$$QS = f (R, L, Q[t-1), I, D, T, Y) \quad (4)$$

Through promoting competition, the policy reforms in Niger may cause reductions in input prices I and distribution costs D. Hence the equation provides a framework for measuring effects of the policy reforms.

Unfortunately, I and D are not readily measurable. Among the remaining determinants, the same is true of L, the pest index. But a second-best procedure can be used instead. The variables I, D, and L can be dropped, and a truncated version of equation (4) can be estimated from pre-reform data, using only R, Q[t-1], T, and Y as independent variables. As explained above, this estimated equation can then generate annual predictions of millet-sorghum output in the post-reform period. Comparing these predictions with actual output values for those years will provide some evidence about the effects of the reforms.

Cowpeas

The supply-demand model for cowpeas in Niger is shown in Figure 1b. The quantities supplied and demanded have the same determinants as for millet-sorghum, but the relationship between the supply and demand curves and the price of cowpeas in Nigeria is such that exports from Niger take place. The price of cowpeas in Niger is not given by the intersection of the supply and demand curves, as is the case with millet-sorghum, but is equal to the price in Nigeria (PN) minus the unit cost of exporting from Niger (transportation, export taxes, licenses, etc., represented by CX). The price in Niger is OA', Nigerien production is OB', and EB' is exported to Nigeria.

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[1] It is assumed here that the operations of OPVN are too small to have a significant effect on price and quantity in this market as a whole.

Since in these conditions the price in Niger is wholly determined by the Nigeria price (PN) and the unit cost of exporting (CX), the supply function for cowpeas can be rewritten as follows:

$$QS = f (PN, CX, R, L, Q[t-1], I, D, T) \quad (5)$$

In this equation, all of the right-hand-side variables are exogenous, and a direct econometric estimation of the equation will therefore provide unbiased estimates of the relationships between cowpea production and its determinants.

It will be noted that, in contrast to the millet-sorghum market, Nigerien demand has no effect on the level of output, but influences only the division of output between exports and domestic sales.

The agricultural policy reforms affect CX (exporting costs), I (input prices), and D (distribution costs). Data are lacking on these three variables, as well as on L (the pest index). However, as in the case of the millet-sorghum model, it will be useful to estimate a regression equation based on the remaining independent variables. As before, this equation can then be used for predicting cowpea output during the reform period, and the divergences between predicted and actual values during that period may provide some clues about the effects of the reforms, the effects of selected external factors having been systematically allowed for.

IV. ECONOMETRIC ESTIMATION OF THE MODELS

Millet-sorghum

As noted above, the equation to be estimated for millet-sorghum production is as follows:

$$QS = f (R, Q[t-1], T, Y) \quad (6)$$

The first issue to be resolved concerns the appropriate form of the rainfall variables (R). It is obvious that the total annual amount of rainfall is an important factor in the generally arid conditions of Niger, but our conversations with agricultural specialists suggest that other dimensions of rainfall are important too. In particular, the millet-sorghum crop seems to benefit from an even distribution of rain during at least part of the growing season. In our analysis, rainfall is therefore represented by both its annual total and its temporal distribution. The distribution factor is described by two variables: the number of ten-day periods in the early part of the rainy season (June and July) when rainfall exceeds a certain minimum, and the corresponding number of ten-day periods in the late part of the season (August and September). Experimentation with the data suggested that a ten-day rainfall of 25 mm. is critical in the case of millet-sorghum.

The rainfall data should, of course, apply to the particular zones where millet-sorghum is cultivated. Eight reporting stations representative of these zones are selected, and all rainfall data used here are unweighted averages for these eight stations. The data on the three rainfall variables -- the annual total, the number of early-season periods with adequate rain, and the corresponding number of late-season periods -- are shown in Table 1. The series start in 1970 in order to provide our subsequent regression equations with enough degrees of freedom.

The other issue to be resolved before we proceed to estimate equation (6) is the appropriate form of the real income variable (Y), which affects millet-sorghum output from the demand side. The obvious candidate is real gross domestic product (GDP) or some similar macroeconomic aggregate like national income. But in the case of Niger, where millet-sorghum is the main food crop in a basically agrarian economy, the value of millet-sorghum output constitutes an appreciable fraction of GDP. Hence GDP cannot be said to be statistically independent of millet-sorghum output. This problem is solved here by using nonagricultural GDP as the aggregate-income variable in equation (6). Values of nonagricultural GDP beginning in 1970 are shown in Table 2.

The full version of equation (6) includes six independent variables: annual rain, early-season rainy periods, late-season rainy periods, lagged millet-sorghum output, nonagricultural GDP, and a trend term. In our least-squares multiple regression analyses, three of these variables are consistently weak predictors: annual rain, early-season rainy periods, and lagged output. They are therefore dropped from our preferred form of the millet-sorghum equation, which is as follows:[2]

$$\underset{}{QMS} = \underset{}{-\ 126} + \underset{(98)}{196}*LATE25 + \underset{(15)}{17}*TREND + \underset{(1.44)}{3.53}*NONAG \qquad (7)$$

where QMS is the annual output of millet and sorghum in thousands of metric tons;
LATE25 is the number of ten-day periods in August and September with at least 25 mm. of rainfall;
TREND has the value of 1 in 1970, 2 in 1971, 3 in 1972, etc.;
NONAG is nonagricultural GDP in billions of CFA francs at 1980 prices.

Following our methodology, the regression equation is estimated from data for a pre-reform period. This period is defined here as starting in 1970 and ending in 1986. Although some of the reforms

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[2] Numbers in parentheses below the coefficients are standard errors. The coefficients on LATE25 and NONAG are significantly different from zero at the 95 per cent confidence level. The R-squared is 0.67, there are 13 degrees of freedom, and the Durbin-Watson statistic is satisfactory. Regressions were also run with all four variables in equation (7) expressed in logarithms, with similar results as regards the signs and significance levels of the regression coefficients.

Table 1

RAINFALL IN NIGER, 1970-89

All data are unweighted averages for the following reporting stations: Birni-Nkonni, Tillabery, Niamey, Dosso, Tahoua, Keita, Maradi, and Zinder

Year	Total annual rainfall in mm.	Number of ten-day periods with at least 25 mm. of rain	
		June & July (EARLY25)	August & Sep. (LATE25)
1970	419	2.625	3.5
1971	393	1.75	3.375
1972	316	2.375	2
1973	328	2	2.75
1974	471	2.75	3.625
1975	464	2.625	3.375
1976	527	3.625	3.375
1977	467	3	3.375
1978	604	3.375	3.75
1979	473	4.25	2.875
1980	460	3.875	2.625
1981	383	2.625	2.625
1982	329	1.625	3.125
1983	373	2.5	2.875
1984	300	1.875	2
1985	374	1.75	3.625
1986	430	3.25	3.75
1987	309	1.875	3
1988	506	3.375	4.625
1989	482	2.25	3.75

Source: Ministry of Agriculture

Table 2

SELECTED ECONOMIC SERIES FOR NIGER, 1970-89

Year	Nonagricultural GDP of Niger (billions of CFA francs at 1980 pr.) (NONAG)	Index of food prices in Nigeria (1980=100)	Parallel market exchange rate (CFA fr. per naira)	Consumer price index for Niger (1980=100)	Real CFA franc-denominated price of food in Nigeria (PFN = 3*4/5)
(1)	(2)	(3)	(4)	(5)	(6)
1970	126	20	163	35	93
1971	136	26	235	36	169
1972	139	26	267	40	174
1973	157	25	270	45	150
1974	144	31	270	46	182
1975	178	44	242	50	213
1976	196	55	280	62	248
1977	192	73	236	77	224
1978	218	86	198	85	201
1979	265	93	203	92	206
1980	281	100	232	100	232
1981	291	126	297	124	302
1982	289	137	288	137	288
1983	261	169	200	134	252
1984	210	242	140	145	234
1985	203	251	117	144	204
1986	214	252	86	139	155
1987	242	273	68	130	143
1988	233	420	49	128	161
1989	213	578	31	124	147

Sources: For Column (2), 1970-87, World Bank, World Tables; data for 1988 and 1989 are estimated by subtracting estimated real agricultural GDP from estimated real GDP; the former is obtained from a regression equation relating real agricultural GDP in 1971-87 to current and lagged millet-sorghum and cowpea output and a trend term, and the latter from a regression equation relating real GDP in 1970-87 to real GNP and a trend term (data on real GNP in 1988 and 1989 being available from World Bank sources).
For Columns (3) and (5), United Nations, Statistical Yearbook and Monthly Bulletin of Statistics.
For Column (4), Pick's Currency Yearbook.

were enacted as early as 1984, it is assumed that they had no significant effect until 1987.

According to the equation, an extra ten-day period in August or September when rainfall exceeds 25 mm. adds 196,000 tons to millet-sorghum production. An extra billion CFA francs of real nonagricultural GDP adds 3,530 tons to millet-sorghum production as a result of a demand stimulus. The coefficient on the trend term is not significantly different from zero, which means there is no significant net upward or downward trend in the technological and consumer taste factors represented by this term.

In the next stage of the analysis, equation (7) will be used in predicting millet-sorghum output during the post-reform period (beginning in 1987), and these predictions will be compared with actual output levels.

Cowpeas

Our earlier discussion of the cowpea market yielded the following equation for econometric estimation:

$$QS = f (PN, R, Q[t-1], T) \qquad (8)$$

As regards the rainfall variables, the same procedures are followed as for millet-sorghum production. Variables are defined in terms of annual total rainfall and the number of ten-day periods with adequate rain in the early season and late season respectively. The data are unweighted averages for the same eight reporting stations used for millet-sorghum. As with millet-sorghum, a ten-day rainfall total of 25 mm. is found to be a critical minimum in the determination of cowpea output.

The Nigerian price variable is supposed to be one which is relevant for cowpea producers in Niger. In principle, it should be constructed in the following way: the price of cowpeas in Nigeria, which is expressed in naira, is converted to CFA francs at the relevant exchange rate (i.e., the parallel market rate), and is then deflated by a general cost-of-living index for Niger (since all monetary variables in our supply-demand models are defined in real terms). Although we have been able to obtain information on the parallel exchange rate and a general cost-of-living index for Niger, our efforts to find the necessary data on cowpea prices in Nigeria have so far not been successful. We therefore use a proxy for cowpea prices, in the form of a general index of food prices in Nigeria. This index, along with the exchange rate series and the general cost-of-living series, is shown in Table 2. The behaviorally relevant variable -- the real CFA franc-denominated price of food in Nigeria -- is derived from these three series.

As in the case of the millet-sorghum model, multiple regression estimates of equation (8) show some of the independent variables to be consistently weak as predictors of cowpea output. These include, as before, lagged output and annual rainfall. However, in contrast to the millet-sorghum situation, early-season rains are important for the cowpea crop, and late-season rains

are not. Our preferred equation for cowpea output, estimated from data for 1970-86, is as follows:[3]

$$QC = -133 + \underset{(0.218)}{0.604}*PFN + \underset{(12)}{56}*EARLY25 + \underset{(2.2)}{6.5}*TREND \qquad (9)$$

where QC is the annual output of cowpeas in thousands of metric tons;
PFN is the real CFA franc-denominated price of food in Nigeria, represented by the product of (a) an index of food prices in Nigeria, (b) the parallel exchange rate between the CFA franc and the naira, and (c) the reciprocal of the Niger consumer price index;
EARLY25 is the number of ten-day periods in June and July with at least 25 mm. of rainfall;
TREND has the value of 1 in 1970, 2 in 1971, 3 in 1972, etc.

According to equation (9), an increase of one unit in the real Nigerian food price index raises cowpea output by 604 tons. Since the index is scaled arbitrarily, this manner of describing the responsiveness of supply to price is not particularly illuminating. The responsiveness is better expressed in the familiar terms of the price-elasticity of supply. At the means of the two relevant variables (cowpea output and the Nigerian price index), the price-elasticity of supply equals 0.62, which is a plausible enough figure.[4]

It should be noted here that this estimate of the price-elasticity of cowpea supply provides useful information for assessing the impact of naira devaluations on the Niger economy. Since the price relevant for Nigerien cowpea producers is, according to our model, directly proportional to the exchange rate (expressed as CFA francs per naira), a reduction in that rate due to a naira devaluation will depress output to the degree indicated by the price-elasticity of supply. Hence a ten per cent devaluation of the naira can be expected to cause a 6.2 per cent reduction in cowpea output in Niger.

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[3] Numbers in parentheses below the coefficients are standard errors. The coefficients on all three independent variables are significantly different from zero at the 95 per cent confidence level. The R-squared is 0.81, there are 13 degrees of freedom, and the Durbin-Watson statistic is satisfactory. A log-linear version of equation (9) yielded broadly similar results.

[4] The mean value of the index over the 1970-86 period is 207.5, and a one per cent increase in this value would equal 2.075 index points. According to equation (9), an increase of this magnitude raises cowpea output by 2.075 times 0.604, or by 1.253 thousand tons. This latter increase represents a gain of 0.62 per cent over the mean value of cowpea output, which is 201.8 thousand tons. Hence the price-elasticity of supply in this region of variable values is 0.62.

Returning to equation (9), we observe that an extra ten-day period of adequate rainfall in June or July raises cowpea output by 56,000 tons, and that trend factors on the supply side bring about an annual increase of 6,500 tons in output.

Like the millet-sorghum equation, the cowpea equation succeeds in explaining a major part of the annual fluctuations in output. The two equations can therefore be used with some confidence to generate counterfactual predictions of what would have happened after 1986 if no policy reforms had been instituted. This is the subject of the next section.

V. EFFECTS OF POLICY REFORMS

Millet-sorghum

Column (1) of Table 3 shows actual levels of millet-sorghum output in 1970-89. Column (2) shows output predicted with equation (7), that is, taking into account late rainfall, nonagricultural GDP, and a trend factor. The difference between the actual and predicted values appears in Column (3).

Since equation (7) was estimated from pre-1987 data, the differences between the actual and predicted values for 1987-89 should reflect the effects of the policy reforms (as well as the effects of all other factors omitted from the equation). The initial difference (or "residual") for the post-reform period, that for 1987, shows a large negative value, the actual level of output being 16 per cent less than predicted. How might this be explained? One possibility is that the reforms had a perverse effect on output in that year. But a more likely explanation lies with another unmeasured factor, namely pest attacks, which were particularly severe in 1987.

Aware that attacks by locusts, grasshoppers, and other pests are often blamed for production shortfalls in Niger, we attempted to incorporate this factor in our econometric model, but were unable to assemble a relevant series extending back to 1970. Information on a shorter period was, however, obtained. An analyst associated with the Famine Early Warning System (FEWS) offers the following assessments of pest damage in Niger, using a scale going from 1 (no significant damage) to 5 (severe damage):[5]

1985	1
1986	5
1987	4
1988	1
1989	1

Hence pest damage may indeed explain an appreciable part of the negative residual on 1987 output.

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[5] Cited by C. A. May of the FEWS Project in a personal communication to the authors, August 8, 1990.

Table 3

ACTUAL AND PREDICTED MILLET-SORGHUM AND COWPEA OUTPUT IN NIGER

Output in thousands of metric tons

	Millet-sorghum			Cowpeas		
	Actual (1)	Predicted (2)	Actual minus predicted ("residual") (3)	Actual (4)	Predicted (5)	Actual minus predicted ("residual") (6)
Pre-reform years						
1970	1,101	1,023	78	84	77	8
1971	1,226	1,051	175	72	81	-8
1972	1,127	810	317	144	125	20
1973	753	1,037	-284	92	96	-4
1974	1,102	1,181	-79	133	163	-31
1975	835	1,270	-435	219	182	37
1976	1,306	1,351	-45	216	265	-49
1977	1,472	1,355	117	207	222	-15
1978	1,494	1,538	-44	272	235	36
1979	1,606	1,550	56	304	294	10
1980	1,732	1,574	157	266	295	-29
1981	1,636	1,626	10	275	274	1
1982	1,650	1,737	-87	272	216	55
1983	1,654	1,604	50	271	250	21
1984	1,007	1,271	-264	195	210	-16
1985	1,779	1,583	196	115	192	-76
1986	1,743	1,662	81	293	253	40
Post-reform years						
1987	1,363	1,632	-269	209	175	34
1988	2,327	1,938	389	302	276	26
1989	1,755	1,710	44	321	211	110

Sources: For Columns (1) and (4), Ministry of Agriculture (BASDONAG).
For Column (2), equation (7).
For Column (5), equation (9).

The other two post-reform years, 1988 and 1989, exhibit positive residuals, and hence provide some evidence in favor of the reforms. As already noted, 1988 was the annus mirabilis of millet-sorghum in Niger, if the figures are to be believed. The late rains were better than in any other year analyzed (see Table 1), so predicted output, which takes account of these rains, was at an alltime high. But actual output exceeded even this exceptional figure by 389,000 tons. The positive residual for 1988 has a high level of statistical significance. As for 1989, the residual is positive but not highly significant.

Besides the reforms, are there other factors unrepresented in equation (7) which might have some bearing on the 1988 and 1989 results? One factor much discussed in Niger is the effect of recent devaluations of the naira on the millet-sorghum market. As noted above, during the pre-reform period the relationship between Nigerien supply and demand and Nigerian price (expressed in CFA francs) was such that imports and exports were negligible in the Nigerien market. But devaluations of the naira have been substantial in recent years, and there is evidence that Niger now imports significant amounts of millet-sorghum from Nigeria. In terms of our supply-demand models, the millet-sorghum market in Niger is no longer represented by Figure 1a but by Figure 1c. The devaluations have lowered the Nigeria price (PN) to a sufficient degree that imports (of B"F) now take place. The price available to Nigerien producers is now only A" -- lower than that implied by the model (Figure 1a) which generated equation (7). Hence their output is reduced, as they move down their supply curve.

The fact that the output residuals for 1988 and 1989 are positive in spite of these contrary effects from the naira devaluations provides additional support for a favorable judgment about the policy reforms.

Cowpeas

In the case of the cowpea model, the naira devaluations are taken fully into account, since the Nigeria price (reflecting the exchange rate) is one of the three variables generating the predictions of output. The other two variables are early rains and a trend term. The predictions thus obtained are shown in Column (5) of Table 3, and Column (6) shows the residuals.

In all three post-reform years, cowpea output was higher than what could be predicted on the basis of the Nigeria price, early rains, and the trend factor. In 1977 output was 19 per cent higher than predicted, in 1988 it was 9 per cent higher, and in 1989 it was no less than 52 per cent higher. As noted earlier, the 1989 cowpea crop set a alltime record. Apart from the reforms, there are no other obvious factors excluded from the equation used for prediction purposes which might explain these positive residuals. One prominent excluded factor is the serious pest invasion of 1987, but that would have tended to produce a negative residual.

Conclusion

FIVE OF THE SIX PREDICTIONS OF MILLET-SORGHUM AND COWPEA OUTPUT DURING THE POST-REFORM PERIOD WERE EXCEEDED BY THE ACTUAL LEVELS OF OUTPUT. THE PREDICTIONS WERE BASED ON RELATIONSHIPS PREVAILING IN THE PRE-REFORM PERIOD. THIS PATTERN OF RESIDUALS SUGGESTS THAT THE REFORMS STIMULATED OUTPUT, ESPECIALLY WHEN IT IS CONSIDERED THAT THE POST-REFORM PERIOD WAS CHARACTERIZED BY SOME NEGATIVE INFLUENCES NOT REFLECTED IN THE PREDICTION MODELS -- NAIRA DEVALUATIONS IN THE CASE OF MILLET-SORGHUM AND PEST ATTACKS IN THE CASE OF BOTH MILLET-SORGHUM AND COWPEAS.

VI. NEXT STEPS

Assessing the impact of recent reforms must necessarily be an ongoing process, as new information comes to light and as experience is gained with the methodology of impact assessment. In the case of the output effects of the Niger reforms, the present report is intended as a provisional assessment which should be improved and updated in the future. In this section we list the major areas where future revisions should be undertaken.

1. Add more years to the post-reform period analyzed

In the present report we have analyzed the post-reform years 1987, 1988, and 1989. It is quite possible that this is too short a period to permit a fair judgment about the reforms, in part because the implementation of some of them may have been delayed, in part because their success depends on behavioral changes which cannot be immediate. When data become available for 1990 and 1991, the residuals for those years should also be calculated, using equations (7) and (9).

2. Obtain Nigeria cowpea price data

In our cowpea output model, an important role is played by the price of cowpeas in Nigeria. We have been unable to obtain information on this variable, and have been forced to use as a proxy a general index of food prices in Nigeria. Our efforts to obtain the information were restricted to Niger and the United States, and now it is obviously necessary to go to the source and make inquiries in Nigeria itself.

3. Correct the series on nonagricultural GDP

At the time of writing, the data on nonagricultural GDP, a demand-side variable in the millet-sorghum model, are available only through 1987. The numbers for 1988 and 1989 have been estimated using a technique described in Table 2. When the 1988 and 1989 data become available, the millet-sorghum residuals for those years should be recalculated with equation (7).

4. Compile a pest index

There is some controversy about the scale of the damage caused by pests to West African crops. A revisionist view enjoying some current popularity claims that the damage is slight even in years of high infestation, and that efforts to control the damage through insecticidal spraying do more harm than good.[6] But it is a reasonable hypothesis to say that output may be affected by pests, in which case a pest variable should be included in our output models. The statistical analysis will then determine whether the pest factor is important or not. As noted above, we were not able to compile a pest prevalence index of sufficient duration, despite several enquiries and literature searches, but further efforts in this direction should be made.

5. Confirm the accuracy of existing data

The data used in our statistical analysis should be rechecked for accuracy. Some of the numbers we have used seem open to challenge. As a major example, we should cite the astonishing figure for millet-sorghum output in 1988. Is that a real event, or is it an illusion, caused perhaps by some change in the field surveying techniques used by the agricultural statistical services, or by some typing error in recording the data?

6. Check findings on timing of rains and size of crop

Our results indicate that agricultural output is sensitive to the timing of rainfall. In particular, millet-sorghum output depends on the late rains (the number of ten-day periods in August and September with over 25 mm. of rain), while cowpea output depends on the early rains. It will be worthwhile to report here the multiple regression equations showing for each crop the importance of one part of the rainy season and the unimportance of

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[6] See, for example, Ann Gibbons, "Overkilling the Insect Enemy," Science (August 10, 1990), p. 621.

the other. The relevant equation for millet-sorghum output is as follows:

$$QMS = -139 + 45*EARLY25 + 180*LATE25 + 21*TREND + 3.12*NONAG$$
$$(78) \qquad (105) \qquad (17) \qquad (1.65)$$

Equation (10)
R-squared = 0.68
17 observations (1970-86)

while that for cowpea output is as follows:

$$QC = -125 + 56*EARLY25 - 2*LATE25 + 6.5*TREND + 0.596*PFN$$
$$(13) \qquad (19) \qquad (2.4) \qquad (0.239)$$

Equation (11)
R-squared = 0.81
17 observations (1970-86)

Standard errors are shown in parentheses below the coefficients, and indicate the nonsignificance of early rains in the case of millet-sorghum, and of late rains in the case of cowpeas. These results are merely statistical associations, and may or may not represent agricultural reality. They should be discussed with agronomists and others familiar with conditions "sur le terrain".

The University of Michigan

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