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The Effect of Price Liberalization Policy on Agricultural Production Instability in Rahad Agricultural Corporation

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Abstract: The study was conducted to measure the extent of instability in the production of the main crops grown in the Rahad scheme and determine the contribution of different components to agricultural production instability before and after adoption of prices liberalization policy. The main crops included in the study were cotton, sorghum and groundnuts. The instability of area, yield and production were measured, in addition to the analysis of different components of the sources of change in the mean and variance of production. The results of the study revealed that sorghum witnessed a continuous increase in instability during the periods before and after adoption of prices liberalization policy. The instability in groundnuts and cotton production was observed after the adoption of liberalization policy. The instability in area and productivity of the three crops moved in the same direction and their increasing/decreasing trend resulted in increase/decrease in instability. The decomposition analysis of sources of change in mean production indicated that the main contribution in change of mean production of sorghum and groundnuts was due to change in mean yield and due to change in mean area in case of cotton. The analysis of decomposition of variance showed that in case of sorghum the changes in the variance of yield accounted for large shares of changes in variance of production whereas in case of cotton and groundnuts the large shares were due to area. The changes in the residual term were important in explaining the changes in the variance of production in groundnuts. Programs and policies such as rehabilitation of irrigation canals, provision of inputs and strengthening the agricultural research and extension can play a vital role in achieving stability in the agricultural production in Rahad Agricultural Corporation.

Key words: Price liberalization, production instability, Rahad Agricultural Corporation, Sudan

INTRODUCTION

The agricultural sector dominates the economy of Sudan, it provides livelihood for over 80% of the population, accounts for about 45% of Gross Domestic Product (GDP) and provides a big share of inputs for the country's agro-industries (Bank of Sudan, 2003). The total arable land in Sudan is estimated at 84 million hectare, and only about 7.14 million hectare are utilized in agricultural production (Ministry of Agriculture and Forestry, 2006). The agricultural sector is divided into two main sub-sectors, namely, irrigated sub-sector and rain-fed sub-sector. The area of the irrigated sub-sector is about 1.8 million hectare and includes Gezira, Rahad, New Halfa, Elssuki, White Nile, Blue Nile schemes. Gezira, Rahad and New Halfa schemes are considered the most important schemes in the sub-irrigated sector and the most important crops grown in these schemes are cotton, groundnuts, wheat, sorghum and vegetables. The agricultural sector's share of exports declined from 73.4% in 1998 to only 8% in 2006 due to decline in agricultural production and increase in the petroleum export (Ministry of Finance and National Economy, 2006).

The Rahad Agricultural Corporation was established in 1977. The total area of the scheme is 126 thousand ha. The main field crops grown in the scheme are wheat, cotton, groundnuts and sorghum, in addition to horticultural crops. The scheme is divided into three regions, the southern, central and the northern. The main objectives of the Rahad scheme were to increase the export value of medium stable cotton and groundnuts, to increase quantity and quality and value of domestically consumed crops, to provide employment for national agricultural labour and improve the welfare of the population in the area (Benedict and Hurmeide, 1982).

The productivity of crops in irrigated agricultural sub-sector is low and fluctuating due to low producer prices, lack of foreign currency and import regulations which have limited the availability of vital production inputs and spare parts (IFAD, 1992). The spatial variations have been an important dimension of the spectacular growth of agriculture in Sudan caused by

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differences in agro-climatic situations, levels of infrastructural facilities and inherent socio-economic characteristics of different regions of the country (Mahir, 2004). The instability of economic phenomena is generally understood as the departure from what may be considered to be a stable passage through time (FAO, 1998). Its measurement has been developed in order to quantify the risk of insecurity resulting from fluctuating levels of economic phenomena such as production, trade, income, prices etc., Instability measurement with respect to agricultural production is of interest to food issues or to issues arising from the influence of fluctuations in output on agricultural prices and returns to the producers (FAO, 1998).

The objectives of this study were to measure the extent of instability in the production of the principal crops in the Rahad scheme and to determine the contribution of different components to agricultural production instability during two periods (pre-prices liberalization policy 1970/71 to 1991/92 and post-prices liberalization policy (1992/93 to 2007/08).

MATERIALS AND METHODS

The study was conducted in 2009 using secondary data collected from the records of the Rahad Agricultural Corporation. The data covered the period from 1970 to 2008. Additional source of the data was the Ministry of Agriculture and Forestry.

The standard deviation and coefficient of variation were used by many economists for estimating the instability in agricultural production. Hazell (1982) estimated the instability in Indian food production using the coefficient of variation, Farih (1996) adopted the standard deviation and coefficient of variation for studying the instability in agricultural production in Sudan. Singh (1989) used the coefficient of variation when investigating agricultural instability and farm poverty in India.

The contribution of different components to agricultural production was analyzed following Goodman (1960) and Bohrnstedt and Goldbreger (1969), the variance of agricultural production V(P), can be expressed as:

$$V(P) = \bar{A}^2 V(Y) + \bar{Y}^2 V(A) + 2\bar{A}\bar{Y}\,\mathrm{cov}(A,Y) - \mathrm{cov}^2(A,Y) + R \quad (1)$$

where $\bar{A}$ and $\bar{Y}$ denote the mean area and yields and R is a residual term. Clearly, a change in any one of these components will lead to a change in V(P) between two periods in time. Similarly, average production, E (P) can be expressed as:

$$E(P) = \bar{A}\,\bar{Y} + \mathrm{cov}(A,Y) \quad (2)$$

It is affected by changes in the covariance between area and yield and by changes in mean area and mean yield. The objective of the decomposition analysis is to partition the changes in V(P) and E(P) between the first and the second periods into constituent parts, which can be attributed separately to changes in the means, variances and covariances of area and yields.

Method of decomposition of average production: Using Eq. (2), average production in the first period is:

$$E(P_1) = \bar{A}_1\,\bar{Y}_1 + \mathrm{cov}(A_1, Y_1) \quad (3)$$

and in the second period is:

$$E(P_2) = \bar{A}_2\,\bar{Y}_2 + \mathrm{cov}(A_2, Y_2) \quad (4)$$

Each variable in the second period can be expressed as its counterpart in the first period plus the change in the variable between the two periods. For example:

$$\bar{A}_2 = \bar{A}_1 + \Delta\bar{A}$$
$$\bar{Y}_2 = \bar{Y}_1 + \Delta\bar{Y}$$
$$\mathrm{Cov}(A_2,Y_2) = \mathrm{Cov}(A_1,Y_1) + \Delta\,\mathrm{Cov}(A, Y)$$

Equation (4) can, therefore be written as:

$$E(P_2) = (\bar{A}_1 + \Delta\bar{A})(\bar{Y}_1 + \Delta\bar{Y}) + \mathrm{Cov}(A_1,Y_1) + \Delta\,\mathrm{Cov}(A,Y)$$
$$= \bar{A}_1\bar{Y}_1 + \bar{A}_1\Delta\bar{Y} + \bar{Y}_1\Delta\bar{A} + \mathrm{Cov}(A_1,Y_1) + \Delta\,\mathrm{Cov}(A,Y) \quad (5)$$

The change in average production, $\Delta E(P)$ is then obtained by subtracting Eq. (3) from Eq. (5). Thus:

$$\Delta E(P) = E(P_2) - E(P_1) \quad (6)$$
$$= \bar{A}_1\Delta\bar{Y} + \bar{Y}_1\Delta\bar{A} + \Delta\bar{A}\,\Delta\bar{Y} + \Delta\,\mathrm{Cov}(A,Y)$$

which can be arranged as in Table 1.

Methods of decomposition of the changes in variance of production: In this section, we will construct a method to partition the changes in variance of production (V(P)) between the first and the second periods into constituent parts.

As shown in Eq. (1), the variance of production, V(P) can be expressed as:

$$V(AY) = \bar{A}^2 V(Y) + \bar{Y}^2 V(A) + 2\bar{A}\bar{Y}\,\mathrm{Cov}(A,Y) - \mathrm{Cov}^2(A,Y) + R$$

Table 1: Components of change in average production

Sources of change	Symbol	Components of change
Change in mean yield	$\Delta \bar{Y}$	$\bar{A} \Delta \bar{Y}$
Change in mean area	$\Delta \bar{A}$	$\bar{Y} \Delta \bar{A}$
Interaction between changes in mean yield and Mean area	$\Delta \bar{A} \Delta \bar{Y}$	$\Delta \bar{A} \Delta \bar{Y}$
Change in area-mean covariance		Δ cov(A,Y)

Using equation (1), variance of production in the first period is:

$$V(P_1) = \bar{A}^2_1 V(Y_1) + \bar{Y}^2_1 V(A_1) + 2\bar{A}_1 \bar{Y}_1 cov(A_1,Y_1) - cov^2(A_1,Y_1) + R_1 \quad (7)$$

and in the second period is:

$$V(P_2) = \bar{A}^2_2 V(Y_2) + \bar{Y}^2_2 V(A_2) + 2\bar{A}_2 \bar{Y}_2 cov(A_2,Y_2) - cov^2(A_2,Y_2) + R_2 \quad (8)$$

each variable in the second period can be expresses as its counterpart in the first period plus the change in the variable between the two periods, i.e.,

$$\bar{A}_2 = \bar{A}_1 + \Delta \bar{A}$$
$$\bar{Y}_2 = \bar{Y}_1 + \Delta \bar{Y}$$
$$V(A_2) = V(A_1) + \Delta V(A)$$
$$V(Y_2) = V(Y_1) + \Delta V(Y)$$
$$Cov(A_2,Y_2) = Cov(A_1,Y_1) + \Delta cov(A,Y)$$

Equation (8) can, be written as:

$$V(P_2) = \{\bar{A}_1 + \Delta \bar{A}\}^2\{V(Y_1) + \Delta V(Y)\} + \{\bar{Y}_1 + \Delta \bar{Y}\}^2\{V(A_1) + \Delta V(A)\} + 2\{\bar{A}_1 + \Delta \bar{A}\}\{\bar{Y}_1 + \Delta \bar{Y}\}\{Cov(A_1,Y_1) + \Delta cov(A,Y)\} - \{Cov(A_1,Y_1) + \Delta cov(A,Y)\}^2 + \{R_1 + \Delta R\} \quad (9)$$

Which can be expressed as:

$$V(P_2) = \bar{A}_1^2 V(Y_1) + 2\bar{A}_1 \Delta V \bar{A}(Y_1) + \Delta \bar{A}^2 V(Y_1) + \bar{A}_1^2 \Delta V(Y) + 2\bar{A}_1 \Delta \bar{A} \Delta V(Y) + \Delta \bar{A}^2 \Delta V(Y) + \bar{Y}^2_1 V(A_1) + 2\bar{Y}_1 \Delta \bar{Y} V(A_1) + \Delta \bar{Y}^2 V(A_1) + \bar{Y}_1^2 \Delta V(A) + 2\bar{Y}_1 \Delta \bar{A} \Delta V(A) + \Delta \bar{A}^2 \Delta V(A) + 2\bar{A}_1 \bar{Y}_1 Cov(A_1,Y_1) + 2\bar{A}_1 \Delta \bar{Y} Cov(A_1,Y_1) + 2\Delta \bar{A} \bar{Y}_1 Cov(A_1,Y_1) + 2\Delta \bar{A} \Delta \bar{Y} Cov(A_1,Y_1) + 2\bar{A}_1 \bar{Y}_1 \Delta cov(A,Y) + 2\bar{A}_1 \Delta \bar{Y} \Delta Cov(A,Y) + 2\Delta \bar{A} \bar{Y}_1 \Delta cov(A,Y) + 2\Delta \bar{A} \Delta \bar{Y} \Delta Cov(A,Y) - Cov^2(A_1,Y_1) - 2Cov(A_1,Y_1)\Delta cov(A,Y) - \Delta cov^2(A,Y) + R_1 + \Delta R \quad (10)$$

The change in variance of production, $\Delta V(P)$ is then obtained by subtracting Eq. (7) from Eq. (10). Thus:

$$\Delta V(P) = V(P_2) - V(P_1)$$
$$= 2\bar{A}_1 \Delta \bar{A} V(Y_1) + \Delta \bar{A}^2 V(Y_1) + \bar{A}_1^2 \Delta V(Y) + 2\bar{A}_1 \Delta \bar{A} \Delta V(Y) + \Delta \bar{A}^2 \Delta V(Y) + 2\bar{Y}_1 \Delta \bar{Y} V(A_1) + \Delta \bar{Y}^2 V(A_1) + \bar{Y}^2_1 \Delta V(A) + 2\bar{Y}_1 \Delta \bar{A} \Delta V(A) + \Delta \bar{A}^2 \Delta V(A) + 2\bar{A}_1 \Delta \bar{Y} Cov(A_1,Y_1) + 2\Delta \bar{A}_1 \bar{Y}_1 Cov(A_1,Y_1) + 2\Delta \bar{A} \Delta \bar{Y} Cov(A_1,Y_1) + 2\bar{A}_1 \bar{Y}_1 \Delta Cov(A,Y) + 2\bar{A}_1 \Delta \bar{Y} \Delta Cov(A,Y) + 2\Delta \bar{A} \bar{Y}_1 \Delta Cov(A,Y) + 2\Delta \bar{A} \Delta \bar{Y} \Delta Cov(A,Y) - 2Cov(A_1,Y_1)\Delta cov(A,Y) - \Delta cov^2(A,Y) + \Delta R \quad (11)$$

which can be arranged as in Table 2.

RESULTS AND DISCUSSION

Measurement of instability in area and productivity: Instability in production of principal crops is expected to be caused by instability in area and productivity. If the instability in both components declined, the instability in production has to declined. The standard deviations (SD) of area and productivity of principal crops were computed and is presented in Table 3. It is interesting to observe that instability in area and productivity in some of the crops fluctuated in the same direction, i.e., if there is an increase/decrease in instability in the area of particular crop, the instability in productivity also increases/decreases. It has been observed that the instability in the area and productivity of cotton in Rahad declined continuously during period II (post-prices liberalization policy). Some crops showed fluctuations in the opposite direction, i.e., if there is an increase/decrease in instability in the area of a particular crop, the instability in productivity decreases/increases. The instability in area of sorghum and groundnuts in Rahad decreased in the second period, while instability of productivity increased in the same period.

As discussed earlier, the instability in area and yield generally move in the same direction, but area instability is generally lower than the yield instability for most crops.

Measurement of instability in production: Instability in production of principal crops is expected to be caused by instability in area and productivity. Table 4 indicates that the standard deviation (SD) of sorghum production in the first period recorded (39.58%) and increased to (54.22%) in the second period. The standard deviation (SD) of cotton production in the first period recorded (66.59%) and decreased to (33.85%) in the second period. Fluctuations of groundnuts production declined in period II, which recorded (63.48%) in the first period and declined further to (33.78%) in second the period.

Table 2: Components of change of the variance of agri. production

Source of change	Symbol	Components of change
Change in mean yield	$\Delta \bar{Y}$	$2\bar{A}_1 \Delta \bar{Y} \operatorname{cov}(A_1,Y_1)+\{2\bar{Y}_1 \Delta \bar{Y} +(\Delta \bar{Y})^2\}V(A_1)$
Change in mean area	$\Delta \bar{A}$	$2\bar{Y}_1 \Delta \bar{A} \operatorname{cov}(A_1,Y_1)+\{2\bar{A}_1 \Delta \bar{A} +(\Delta \bar{A})^2\}V(Y_1)$
Change in yield variance	$\Delta V(Y)$	$\bar{A}_1^2 \Delta V(Y)$
Change in area variance	$\Delta V(A)$	$\bar{Y}_1^2 \Delta V(A)$
Interaction between changes in mean yield and mean area	$\Delta \bar{Y} \Delta \bar{A}$	$2\Delta \bar{Y} \Delta \bar{A} \operatorname{cov}(A_1,Y_1)$
Change in area-yield covariance	$\Delta \operatorname{cov}(A,Y)$	$\{2\bar{A}_1 \bar{Y}_1 -2\operatorname{cov}(A_1,Y_1)\}\Delta \operatorname{cov}(A,Y)-\{\Delta \operatorname{cov}(A,Y)\}^2$
Interaction between changes in mean area and yield variance	$\Delta \bar{A} \Delta V(Y)$	$\{2\bar{A}_1 \Delta \bar{A} +(\Delta \bar{A})^2\}\Delta V(Y)$
Interaction between changes in yields and area variance	$\Delta \bar{Y} \Delta V(A)$	$\{2\bar{Y}_1 \Delta \bar{Y} +(\Delta \bar{Y})^2\}\Delta V(A)$
Interaction between changes in mean area and yield and changes in area-yield covariance	$\Delta \bar{Y} \Delta \bar{A}$ $\Delta \operatorname{cov}(A,Y)$	$\{2\bar{Y}_1 \Delta \bar{A} +2\bar{A}_1 \Delta \bar{Y} +2\Delta \bar{A} \Delta \bar{Y}\}\Delta \operatorname{cov}(A,Y)$
Change in residual	ΔR	$\Delta(AY)$ – sum of the other components

On the basis of the above results, it may be concluded that crop production fluctuation declined in the second period for cotton and groundnuts and increased for sorghum.

Sources of changes in mean production: The decomposition analysis identified four sources of change in the mean production. These sources were change in mean yield, change in mean area, interaction between changes in mean yield and mean area, and change in area-yield covariance (Table 1).

Components of change in mean production for individual crops in Rahad Agricultural Corporation are presented in Table 5. The increase of production was observed only in sorghum. The increase of production of sorghum was mainly attributed to increase in mean yield. Increase in mean yield accounted for 95.08% of the increase in sorghum production, whereas the increase in mean area accounted for 9.73%. The decrease in production of cotton was mainly attributed to decrease in mean area and mean yield. It accounted for 51.66% in mean yield and 64.34% in mean area. The decrease in production of groundnuts was mainly attributed to decrease in mean yield. It accounted for 75.70% incase of groundnuts. The contribution of interaction term between mean yield and mean area was negative in case of cotton and groundnuts and positive in case of sorghum. Changes in covariance between areas and yield were not important in accounting for increases in mean production.

Sources of change in variance of production: The components of change of variance of production of individual crops in Rahad scheme were presented in Table 6, which have been obtained by using the equations in Table 2. Changes in the variance of areas accounted for

Table 3: Instability in area and productivity of principal crops in the Rahad scheme (%)

Crop		Period I	Period II
Sorghum	A*	19.13	19.12
	Y**	21.20	46.12
Cotton	A	37.36	14.72
	Y	37.37	23.12
Groundnuts	A	33.08	20.47
	Y	40.50	82.90

*: A = area; **: Y = yield

Table 4: Instability in crop production (%)

Crop	Period I	Period II
Sorghum	39.58	54.22
Cotton	66.59	33.85
Groundnuts	63.48	33.78

large shares in variance of production for cotton and groundnuts. They accounted for 52.17 and 253.96% of increase in the variance of production for cotton and groundnuts, respectively. Changes in mean yields had little effect on the stability of production of all crops. They accounted for 31.17, 65.89 and 41.66% of the increase in variance of production of cotton, groundnuts and sorghum, respectively. Changes in mean area had a de-stability effect on all crops. They accounted for 18.63, 33.04 and 5.93% in case of cotton, groundnuts and sorghum, respectively. Changes in yields variance accounted for large share in variance of production for sorghum. It accounted for 197.12%, but they had little effect on the stability of cotton, they accounted for 8.77%. Changes in yield variance acted to reduce the variability in case of groundnuts, which was -129.51%. Changes in area-yield covariance had large effect on the stability of production of groundnuts and sorghum and little effect on the stability of cotton production. Interaction terms had little effects on the stability of production of all crops, except the interaction between changes in mean area

Table 5: Contribution of different sources to change in mean production during the study period (%)

Source of change	Sorghum	Cotton	Groundnuts
Change in mean yield	95.08	51.66	75.70
Change in mean area	9.73	64.34	29.03
Change in area-yield covariance	- 7.67	1.53	- 2.58
Interaction between changes in mean yield and mean area	3.04	- 17.50	- 2.15

Table 6: Components of change in the variance of production of individual crops in Rahad Agricultural Corporation during the study period (%)

Source of change	Cotton	Groundnuts	Sorghum
Change in mean yield	31.17	65.89	41.66
Change in mean area	19.63	33.04	5.93
Change in yield variance	8.77	- 129.51	197.12
Change in area variance	52.17	253.96	- 13.60
Interaction between changes in mean yield and mean area	- 1.58	- 0.57	0.62
Change in area, yield covariance	7.23	- 43.44	- 63.24
Interaction between change in mean area and yield covariance	- 4.94	7.27	12.32
Interaction between change in mean yield and area covariance	- 24.53	- 36.37	- 9.84
Interaction between change in mean area and yield and change in area yield covariance	- 3.81	4.45	- 22.35
Change in residual	16.89	- 54.73	- 48.85

mean yield covariance which accounted for 7.27 and 12.32% in case of and groundnuts and sorghum, respectively. The residual term acted to reduce the variability of groundnuts and sorghum and increase the variability of cotton.

CONCLUSION

The study of instability indicated that sorghum witnessed a continuous increase in instability over the two sub-periods under study. The instability in groundnuts production witnessed a decrease during post-liberalization period. It is worth pointing out that groundnut, cotton witnessed sharp decrease in instability from pre-liberalization period to post-liberalization period. It is also worth pointing out that the instability in area and productivity of almost all crops moved in the same direction and their increasing/decreasing trend resulted in increase/decrease in instability. Hence, it may be said that the increase in production of a particular crop due to a spectacular increase in area and yield would accompany the increase in instability also, but an increase in production largely due to the increase in yield would help declining production instability.

The decomposition analysis of sources of change in mean production of principal crops indicated that, the main contribution in change of mean production of sorghum and groundnuts was due to change in mean yield, but it was due to change in mean area in case of cotton.

The analysis of decomposition of variance indicated that changes in the variance of yield accounted for large shares of the changes in variance of production for sorghum. Changes in the variance of area accounted for large shares for groundnuts and cotton. The changes in the residual term were important in explaining the changes in the variance of production in case of groundnuts.

It is clear from the above discussion that the change in the base (mean area and mean yield), yield variability and simultaneous changes in area and yield led to increase in the absolute production instability (variance). Individually, yield variability was an important source of instability in most of the crops. The changes in yield might have caused the changes in area and this led to higher area-yield covariability. The larger contribution of interaction terms indicated that the simultaneous changes in area and yield further accentuated the production instability.

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